

Geophysical Abstracts 186 July-September 1961

By JAMES W. CLARKE, DOROTHY B. VITALIANO, VIRGINIA S. NEUSCHEL, and others

G E O L O G I C A L S U R V E Y B U L L E T I N 1 1 4 6 - C

*Abstracts of current literature
pertaining to the physics of
the solid earth and to
geophysical exploration*



UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price 40 cents (single copy). Subscription price: \$1.75 a year; 50 cents additional for foreign mailing. Use of funds for printing this publication has been approved by the Director of the Bureau of the Budget (June 23, 1960).

CONTENTS

	Page
Introduction -----	351
Extent of coverage -----	351
List of journals -----	351
Form of citation -----	353
Abstracters -----	353
Age determinations -----	353
Cosmogony -----	366
Earth currents -----	385
Earthquakes and earthquake waves -----	387
Earth tides and related phenomena -----	413
Elasticity -----	416
Electrical exploration -----	431
Electrical logging -----	437
Electrical properties -----	439
Exploration summaries and statistics -----	441
General -----	442
Geodesy -----	446
Geotectonics -----	447
Glaciers -----	457
Gravity -----	458
Heat and heat flow -----	464
Internal constitution of the earth -----	469
Isostasy -----	476
Isotope geology -----	477
Magnetic field of the earth -----	482
Magnetic properties and paleomagnetism -----	489
Magnetic surveys -----	494
Microseisms -----	498
Radioactivity -----	501
Radioactivity surveying and logging -----	503
Seismic exploration -----	504
Strength and plasticity -----	513
Submarine geology -----	516
Volcanology -----	517
Index -----	523

By James W. Clarke, Dorothy B. Vitaliano, Virginia S. Neuschel, and others

INTRODUCTION

Extent of Coverage

Geophysical Abstracts includes abstracts of technical papers and books on the physics of the solid earth, the application of physical methods and techniques to geologic problems, and geophysical exploration. The table of contents, which is alphabetically arranged, shows the material covered.

Abstracts are prepared only of material that is believed to be generally available. Ordinarily abstracts are not published of material with limited circulations (such as dissertations, open-file reports, or memorandums) or of other papers presented orally at meetings. Abstracts of papers in Japanese and Chinese are based on abstracts or summaries in a western language accompanying the paper.

List of Journals

Lists of journals published in Geophysical Abstracts 160 (January-March 1955, Bulletin 1033-A) and subsequent issues through 184 (January-March 1961, Bulletin 1146-A) have been compiled into a single list, which may be obtained by writing to the U. S. Geological Survey, Washington 25, D. C.

Supplements to this master list have been published in each issue since Geophysical Abstracts 184. The following is an additional supplement that lists references cited in Geophysical Abstracts 186 that have not been listed previously.

- Akad. Nauk SSSR Lab. Hidrogeol. Problem, Trudy -- Akademiya Nauk SSSR Laboratoriya Hidrogeologicheskikh Problem Trudy [Academy of Sciences U. S. S. R., Laboratory of Hydrogeological Problems Transactions]. Moskva (Moscow).
- Akita Univ. Mining Coll., Research Inst. Underground Res. Rept. -- Report of the Research Institute of Underground Resources, Mining College, Akita University. Akita, Japan.
- Astron. Jour. -- Astronomical Journal. American Astronomical Society. New Haven, Connecticut.
- Balneol. Soc. Japan Jour. -- Journal of the Balneological Society of Japan. The Chemical Institute of Tokyo University. Tokyo, Japan.
- De Re Metallica -- De Re Metallica [Concerning Noble Metals]. Montana School of Mines. Butte, Montana.
- Fiji Geol. Survey Dept. Ann. Rept. for 1960 -- Geological Survey Department Annual Report for the Year 1960. Legislative Council of Fiji. Suva, Fiji.
- Geol. Soc. Glasgow Trans. -- Transactions of the Geological Society of Glasgow. Geological Society of Glasgow. Glasgow, Scotland.
- Geol. Soc. India Jour. -- The Journal of the Geological Society of India. Bangalore, India.
- Grønlands Geol. Undersøgelse Misc. Papers -- Grønlands Geologiske Undersøgelse Miscellaneous Papers. København, Denmark.
- Illinois State Geol. Survey Circ. -- Illinois State Geological Survey Circular. State of Illinois Department Registration and Education, Division of the Illinois State Geological Survey. Urbana, Illinois.
- Inst. Physique du Globe Paris Annales -- Annales de l'Institut de Physique du Globe de Strasbourg, Université de Strasbourg. Strasbourg, Germany.

- Internat. Assoc. Geomagnetism and Aeronomy Bull. -- Bulletin of the International Association of Geomagnetism and Aeronomy. International Union of Geodesy and Geophysics. Paris, France.
- Irish Naturalists' Jour. -- The Irish Naturalists' Journal. Irish Naturalists' Journal Committee. Belfast, Northern Ireland.
- ISA Jour. -- ISA Journal. Instrument Society of America. Pittsburgh, Pennsylvania.
- [Japan] Kakioka Magnetic Observatory Rept. -- Kakioka Magnetic Observatory Report. The Kakioka Magnetic Observatory. Kakioka, Japan.
- Jour. Mines, Metals, and Fuels -- Journal of Mines, Metals, and Fuels. Books and Journals Private Ltd. Calcutta, India.
- Lunar and Planetary Explor. Colloquium Proc. -- Proceedings of the Lunar and Planetary Exploration Colloquium. Space and Information Systems Division. North American Aviation, Inc. Downey, California.
- Minnesota Geol. Survey Bull. -- Minnesota Geological Survey Bulletin. Minnesota Geological Survey. Minneapolis, Minnesota.
- Minno-Geol. Inst. Godishnik -- Minno-Geolozhkiya Institut Godishnik [Yearbook of the Mining-Geological Institute]. Sofia, Bulgaria.
- Nauka i Zhizn -- Nauka i Zhizn. Vsesoyuznoye Obshchestvo po Rasprostraneniyu Politicheskikh i Nauchnykh Znaniy [Science and Life. All Union Society for the Dissemination of Political and Scientific Knowledge]. Moskva (Moscow).
- Norsk Geog. Tidsskr. -- Norsk Geografisk Tidsskrift. Norske Geografisk Selska. [Norwegian Geographical Journal. Norwegian Geographical Society]. Oslo, Norway.
- Observatoire d'Utrecht Recherches Astron. -- Recherches Astronomiques de l'Observatoire d'Utrecht [Astronomical Research of the Observatory of Utrecht]. Utrecht, Netherlands.
- Papers in Meteorology and Geophysics -- Papers in Meteorology and Geophysics. Meteorological Institute. Tokyo, Japan.
- Pochvovedeniye -- Pochvovedeniye. Akad. Nauk SSSR V. V. Doluchayev Institut Pochvovedenii [Soil Science, Academy of Sciences, U. S. S. R., V. V. Doluchayev Institute of Soil Science]. Moskva (Moscow).
- Portugal Servicos Geol. Mem. -- Memoire Servicos Geologicos de Portugal [Memoirs of the Geological Survey of Portugal]. Lisbon, Portugal.
- Shui-Wen Ti-chih Kung-ch'eng Ti-chih -- Shui-Wen Ti-chih Kung-ch'eng Ti-chih [Hydrogeology and Engineering Geology]. Peiping, China.
- Sky and Telescope -- Sky and Telescope. Harvard College Observatory, Sky Publishing Corporation. Cambridge, Massachusetts.
- Soc. Chim. France Bull. -- Bulletin de la Société Chimique de France. [Bulletin of the Chemical Society of France]. Paris, France.
- Soc. Française de Minéralogie et de Cristallographie Bull. -- Société Française de Minéralogie et de Cristallographie Bulletin. Centre National de la Recherche Scientifique [Bulletin of the French Society of Mineralogy and Crystallography. National Center of Scientific Research]. Paris, France.
- Soc. Vaudoise des Sci. Nat. Bull. -- Bulletin de la Société Vaudoise des Sciences Naturelles, Société Vaudoise des Sciences Naturelles [Bulletin of the Vaudoise Society of Natural Sciences. Vaudoise Society of Natural Sciences]. Lausanne, Switzerland.
- Tasmania Dept. Mines Tech. Repts. -- Tasmania Department of Mines Technical Reports. Hobart, Tasmania.
- Univ. Sheffield Geol. Soc. Jour. -- Journal of the Geological Society of the University of Sheffield. Sheffield, England.
- Yellowstone Nature Notes -- Yellowstone Nature Notes. Yellowstone Library and Museum Association, Yellowstone National Park. Yellowstone Park, Wyoming.

Form of Citation

The abbreviations of journal titles used are those used in the U. S. Geological Survey publications and in many geological journals. For papers in most languages other than English, the title is given in the original language as well as in translation. Slavic names and titles have been transliterated by the system used by the United States Board of Geographic Names. This system of transliteration for Russian is given in Geophysical Abstracts 148 (January-March 1952, Bulletin 991-A) and in the new "List of Journals" announced above. Titles of papers in Japanese and Chinese are given in translation only.

Abstracters

Abstracts in this issue have been prepared by V. G. Gabriel, and A. J. Shneiderov, as well as by the principal authors. Authors' abstracts are used in many instances. The initials of an abstracter following the notation "Author's abstract" indicates a translation from the original language.

AGE DETERMINATIONS

- 186-1. Evernden, J[ack] F[oord], Curtis, G[arniss] H., Obradovich, J., and Kistler, R. [W.]. On the evaluation of glauconite and illite for dating sedimentary rocks by the potassium-argon method: *Geochim. et Cosmochim. Acta*, v. 23, no. 1/2, p. 78-99, 1961.

A stratigraphically well controlled sequence of glauconite and illite K-Ar dates was compared with a time scale controlled by biotite dates. The results show that when samples are selected carefully with regard to geologic history and prepared properly, glauconite and illite dates are almost as accurate as those determined on igneous biotite.

A tentative Tertiary time scale is presented, with lower boundaries as follows (in 10^6 yr): Pliocene-Miocene 12, Miocene-Oligocene 25, Oligocene-Eocene 33, Eocene-Paleocene 55, Paleocene-Cretaceous (Montian-Danian) 62, and Paleocene-Cretaceous (Danian-Maestrichtian) 67. — D. B. V.

- 186-2. Polevaya, N. I. Shkala absolyutnoy geokhronologii [The absolute geochronological scale]: *Akad. Nauk SSSR Doklady*, v. 134, no. 5, p. 1173-1176, 1960.

An absolute geochronological scale that incorporates the results of recent argon dating of glauconite in sedimentary rocks in the U. S. S. R. is presented and compared graphically with Holmes' new scale. Agreement with Holmes' scale is good, especially for the Cenozoic and most of the Mesozoic; disagreement involves mainly the subdivisions of the Paleozoic. The oldest of these rocks that can be dated paleontologically are 550×10^6 yr old according to the glauconite age. The lower boundary of the Cambrian is set, also on the basis of glauconite, at 600×10^6 yr. — D. B. V.

- 186-3. Shestakov, G. I., and Ivanov, I. V. K voprosu o graficheskom sposobe issledovaniya raskhozheniya vozrastov po svintsovo-uranovym otnosheniyam [On the problem of the graphic method of investigating the discordance in ages according to the lead-uranium ratios (with English summary)]: *Geokhimiya*, no. 3, p. 239-242, 1961.

A simple proof is offered of the correctness of the Ahrens-Wetherill graphic method of investigating discordant Pb-U ages (see *Geophys. Abs.* 162-164,

163-131, 166-11, 167-28). This proof permits a simple visual solution of some geochemical problems relevant to the metamorphism of uranium-bearing minerals. — D. B. V.

186-4. Danilevich, S. I. O dostovernosti "svintsovykh" vozrastov monazitov [On the reliability of the "lead" ages of monazites (with English abstract)]: *Geokhimiya*, no. 8, p. 736-747, 1960.

Analysis of the lead isotope ages of 59 ancient monazites from the Ukrainian S. S. R. shows that their reliability depends on the values of the coefficient A , defined as $A = (\text{Pb}^{207} \times 100) / (\text{Pb}^{\text{H}} \times \text{Th} / \text{U})$ (with nonradiogenic lead content Pb^{H} in percent by weight and the Pb^{207} content in atomic percent). Where $A \gg 1$, ages are usually concordant and where $A < 1$ they are not. It is shown that the analytical error is much smaller in cases where $A > 1$ than where $A < 1$. (See also *Geophys. Abs.* 183-9.) — D. B. V.

Vinogradov, A. P., Zykov, S. I., and Tarasov, L. S. Isotopic composition of admixtures of lead in ores and minerals as an indication of their origin and of time of formation. See *Geophys. Abs.* 186-462.

186-5. Stern, T[homas] W., and Rose, H. J., Jr. New results from lead-alpha age measurements: *Am. Mineralogist*, v. 46, no. 5/6, p. 606-612, 1961.

Improvement in the spectrochemical method for determining lead in zircon increases the usefulness of the lead-alpha (Larsen) age method. Good agreement is found between the lead-alpha ages and those obtained by isotope dilution analyses on twelve samples. These samples have calculated ages ranging from 400 to 1,200 million years. New lead analyses and revised lead-alpha ages are presented for 19 samples previously analyzed. — Authors' abstract

186-6. Fairbairn, H[arold] W., Hurley, P[atrick] M., and Pinson, W[illiam] H., [Jr.]. The relation of discordant Rb-Sr mineral and whole-rock ages in an igneous rock to time of subsequent $\text{Sr}^{87}/\text{Sr}^{86}$ metamorphism: *Geochim. et Cosmochim. Acta*, v. 23, no. 1/2, p. 135-144, 1961.

Interpretation of discordant Rb-Sr ages of coexisting biotite and K-feldspar in igneous rocks, mostly from Sudbury, Ontario, has been attempted using supplementary whole-rock ages. Following a model proposed by Compston and Jeffery (see *Geophys. Abs.* 180-250), it is postulated that, if the igneous body is a closed system, and a post-crystallization thermal event interrupts the accumulation of Sr^{87} in biotite and K-feldspar, the whole-rock analysis will give the true age and, owing to diffusion of radiogenic Sr out of biotite and K-feldspar, the apparent ages of these two minerals would be less than the whole-rock age. The common intersection of the three radiogenic growth lines ($\text{Sr}^{87}/\text{Sr}^{86}$ plotted against age) gives the time of metamorphism. For the majority of the 12 examples the model offers an apparently valid explanation of the discrepant ages in terms of known field relations and two orogenic events at 1.2×10^9 and 1.6×10^9 yr. — Authors' abstract

186-7. Ovchinnikova, G. V. Opredeleyeniye konstanty β -raspada rubidiya-87 geokhimicheskim metodom [Determination of the β -decay constant of Rb^{87} by the geochemical method (with English abstract)]: *Geokhimiya*, no. 5, p. 392-398, 1960.

The Rb^{87} and Sr^{87} contents of two micas of known ages were determined by the isotopic dilution method in order to calculate the β -decay constant of Rb^{87} .

A value of $\lambda = 1.38 \pm 10^{-11} \text{yr}^{-1}$ was obtained; this agrees well with the value of $1.39 \pm 0.05 \times 10^{-11} \text{yr}^{-1}$ previously determined by Aldrich and others (see Geophys. Abs. 167-231). Curves are given that show the relative errors in determination of Rb^{87} and Sr^{87} as a function of the isotopic composition of the mixture. — D. B. V.

- 186-8. Hart, Stanley R. The use of hornblendes and pyroxenes for K-Ar dating: Jour. Geophys. Research, v. 66, no. 9, p. 2995-3001, 1961.

The K-Ar ages of 12 hornblendes, 1 actinolite, and 2 pyroxenes were determined. When these ages are compared with ages of associated biotite, feldspar, or zircon, good agreement is found in most cases. No evidence is found for the existence of "excess" radiogenic argon in these hornblendes. A maximum limit of 5×10^{-7} cc STP/g can be placed on possible "excess" radiogenic argon in one sample. The potassium content of the amphiboles and pyroxenes is high enough so that Paleozoic or older samples can be easily dated, using present techniques. The rubidium content of the hornblendes is too low to be generally utilized for Rb-Sr dating. — Author's abstract

- 186-9. McDougall, Ian. Determination of the age of a basic igneous intrusion by the potassium-argon method: Nature, v. 190, no. 4782, p. 1184-1186, 1961.

The relative argon retention properties of minerals from a Tasmanian dolerite have been investigated in order to determine whether argon age measurements would be possible on rocks of low K content. The presence of chilled margins also suggested the possibility of dating whole rock samples. Results obtained on duplicate analyses of 2 sanidines, 2 plagioclases, and 1 pyroxene and on a single analysis of chilled dolerite are tabulated. The agreement between the duplicate analyses is better than 2 percent except in the case of the pyroxene. The range of calculated ages is $159-168 \times 10^6$ yr for the plagioclase and pyroxene, suggesting that argon retention is high in both minerals. Sanidine ages are lower (down to 143×10^6 yr), suggesting argon leakage. The chilled dolerite gave an age of 148×10^6 yr, which is surprisingly good considering that the rock is composed mainly of devitrified glass, from which argon loss should be high.

It is concluded that the dolerites were intruded some 167×10^6 yr ago (Early-Middle Jurassic boundary), and that minerals with low K content, such as occur in mafic igneous rocks, can be used for K-Ar dating purposes. — D. B. V.

- 186-10. Polevaya, N. I., Kazakov, G. A., and Murina, G. A. Glaukonity, kak indikator geologicheskogo vremeni [Glauconites as an indicator of geologic time (with English abstract)]: Geokhimiya, no. 1, p. 3-10, 1960.

The ages of 40 glauconites of known stratigraphic age, dated by the K-Ar method (using the decay constants $\lambda_k = 0.557 \times 10^{-10} \text{yr}^{-1}$ and $\lambda_\beta = 4.72 \times 10^{-10} \text{yr}^{-1}$), agree well with the existing time scale for the Meso-Cenozoic but not so well for the Paleozoic. The results confirm the possibility of argon dating of unfossiliferous strata on the Russian platform, and of comparing sedimentation rates in platform and geosynclinal areas. The oldest sediments of the central part of the Russian platform are dated by glauconites as $732-753 \times 10^6$ yr, and those of the southern Urals as 932×10^6 yr.

The effect of acids and heavy liquids used in treatment of the samples is discussed. It is concluded that glauconite is suitable for dating purposes, but that the mobility of K and Ar in different types of glauconite should be investigated systematically. (See also Geophys. Abs. 184-9.) — D. B. V.

- 186-11. Tamers, M[urry] A., Stipp, J. J., and Collier, J. High sensitivity detection of naturally occurring radiocarbon—pt. 1: Chemistry of the counting sample: *Geochim. et Cosmochim. Acta*, v. 24, no. 3/4, p. 266-276, 1961.

The most promising method of increasing the sensitivity of C^{14} dating is the use of radiation detection techniques capable of counting large quantities of carbon; one of these is the use of the liquid scintillation spectrometer. This paper presents a means by which the entire counting solution can be synthesized from the sample to be dated, using benzene as the solvent. The chemistry and the procedure are described in detail. The chemical steps involve no special equipment or training; a 20-ml sample can be produced by 2 man-days of work, and the entire procedure can be completed in less than a week. — D. B. V.

- 186-12. Nygaard, K. J. A liquid scintillation counter for radiocarbon: *Appl. Sci. Research*, sec. B, v. 9, no. 2, p. 89-92, 1961.

Measurements have been made of the radiocarbon counting performance of a liquid scintillation coincidence counter used in conjunction with an anticoincidence shield counter at the Trondheim (Norway) dating laboratory. At room temperature the system has a counting efficiency of 59 percent at a background of 16 counts per minute. — D. B. V.

- 186-13. Straka, Herbert. Relative und absolute Datierungen quartärer Ablagerungen [Relative and absolute datings of Quaternary deposits]: *Naturwissenschaften*, v. 48, no. 9, p. 324-332, 1961.

Quaternary chronology as determined by various methods is reviewed. Pollen analysis and tephrochronology are relative methods; their results must be confirmed by absolute dating either by varve chronology (limited mainly to Scandinavia) or by radiocarbon dating. Quaternary chronology is a striking example of interdisciplinary cooperation between botany, geography, geology, mineralogy, physics, and even prehistory and zoology. A 72-item bibliography is given. — D. B. V.

- 186-14. Pellas, Paul. Métamictisation des allanites. Possibilité de déterminer des âges géologiques. [Metamictization of allanites. Possibility of determining geologic ages]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 21, p. 3280-3282, 1961.

Study of the crystalline state and radioactivity of 53 allanites from pegmatites from different parts of the world shows that the spacing of the (211), (113), and (300) planes increases upon exposure to radiation, and that this increase is a function of time. With the aid of a curve constructed for allanites of known age, the ages of other allanites were calculated and found to fit well with other evidence.

It is concluded that if the method is applied carefully, the geologic age of allanites can be determined from their lattice expansion. The age thus obtained is the true age only if the mineral has not been subjected to heating subsequent to the original crystallization; metamict allanites are more sensitive to thermal effects than are zircons. The method should be a useful semiquantitative measure of the age of allanites in thin sections of granites and other igneous rocks. A precision of ± 10 percent is attainable under favorable conditions. — D. B. V.

- 186-15. Pasteels, Paul. L'âge des halos pleochroïques du granite d'Habkern et de quelques roches du massif de l'Aar [Age of pleochroic haloes

of the Habkern granite and of some rocks of the Aar massif]: Schweizer. Mineralog. Petrog. Mitt., v. 40, no. 2, p. 261-266, 1960.

The effect of metamorphism on pleochroic haloes in biotite in rocks of the Aar massif and in the Habkern granite is investigated. The halos in the north part of the Aar massif were weakened during the Alpine orogeny; this demonstrates that a weak epimetamorphism can have an effect on the halos. The halos in the Habkern granite are 300 million years old and appear to have been effected very little by the Alpine orogeny; this conclusion agrees well with the fact that no metamorphic effects are apparent in thin sections. — J. W. C.

- 186-16. Goldich, Samuel S., Nier, Alfred O., Baadsgaard, Halfdan, Hoffman, John H., and Krueger, Harold W. The Precambrian geology and geochronology of Minnesota: Minnesota Geol. Survey Bull. no. 41, 193 p., 1961.

Radioactivity dating of a large number of igneous and metamorphic rocks by the K-Ar and Rb-Sr methods is the basis for revision of the classification of the Precambrian rocks of Minnesota. The major divisions of the three-fold classification are made at time boundaries of 2.5 and 1.7 billion years corresponding to the time of two major orogenies, the Algoman and the Penokean, respectively; the eras are referred to as Early, Middle, and Late Precambrian. The analytical methods used are explained in detail and include a comparison of the results by the two methods and a discussion of some of the problems in evaluating radioactivity ages. The principal Precambrian rock units described in earlier geologic investigations are reviewed, new field and laboratory observations presented, and the geologic history interpreted with the aid of the K-Ar and Rb-Sr ages. The geologic results are presented on a geographic basis dictated by the distribution of outcrops in Minnesota. The general problems of correlation and development of a quantitative time scale are considered, and the geologic succession and chronology of the Minnesota Precambrian are shown in a table. Locations and brief descriptions of the dated samples are included in the appendix. — V. S. N.

- 186-17. Miller, Robert D., and Scott, Glenn R. Late Wisconsin age of terrace alluvium along the North Loup River, central Nebraska: a revision: Geol. Soc. America Bull., v. 72, no. 8, p. 1283-1284, 1961.

A radiocarbon age of $10,500 \pm 250$ yr on shell material near the base of a terrace along the North Loup River in Howard County, Nebr., dates the alluvial sequence as late Wisconsin rather than Kansan and Yarmouth as previously reported. — D. B. V.

- 186-18. Williams, John R., and Ferrians, Oscar J., Jr. Late Wisconsin and recent history of the Matanuska Glacier, Alaska: Arctic, v. 14, no. 2, p. 83-90, 1961.

The Matanuska Glacier is one of the largest of the glaciers that extend north from the snow and ice fields of the central Chugach Mountains of southern Alaska; it terminates in the upper Matanuska Valley. A C^{14} date of $8,000 \pm 300$ yr for peat from an undisturbed surface deposit 2.5 to 5 miles downstream from the terminus and overlying the innermost channel associated with glacial advances implies that more than 8,000 years ago the glacier terminated no more than 2.5 miles down-valley from its present position. An organic silt horizon of a soil, overlying outwash gravel associated with a pre-8,000

before present advance, is $3,620 \pm 250$ yr old and is correlated with the Alti-thermal; it represents a period of glacial retreat to a position southeast of the present terminus. In the last 4,000 years the glacier readvanced as much as one mile beyond its present position. — V. S. N.

- 186-19. Tupper, W. M., and Hart, S[tanley] R. Minimum age of the Middle Silurian in New Brunswick based on K-Ar method: Geol. Soc. America Bull., v. 72, no. 8, p. 1285-1288, 1961.

Five stratigraphically dated granitic bodies in New Brunswick have a K-Ar age between 380 and 400 million years. Four of the granites are post-Middle Silurian and pre-Pennsylvanian in age. The fifth granite body is post-Middle Silurian and pre-Late Devonian. This indicates a minimum age of 380 million years for Middle Silurian time in New Brunswick. — Author's abstract

- 186-20. Herz, Norman, Hurley, P[atrick] M., Pinson, W[illiam] H., [Jr.], and Fairbairn, H[arold] W. Age measurements from a part of the Brazilian shield: Geol. Soc. America Bull., v. 72, no. 7, p. 1111-1120, 1961.

The K-Ar age determinations on micas from Precambrian granitic rocks of the Quadrilátero Ferrífero, Minas Gerais, Brazil, suggest three ages of intrusion: $2,400 \times 10^6$ yr (gneiss within the Bação complex), $1,350 \times 10^6$ yr (rocks in the northern part of the Bação complex and also in a region 7 km north of the nearest known Minas series metasediments of late Precambrian age); and $450-550 \times 10^6$ yr (gneiss in the eastern part of the area, granitized beds in the Minas series, and granite between Minas beds and the $1,350 \times 10^6$ yr old granite). Other ages, ranging between 595 and $1,080 \times 10^6$ yr, may represent the effects of a younger metamorphism. — D. B. V.

- 186-21. Heusser, Calvin J. American Geographical Society southern Chile expedition 1959; Final report: New York, American Geographical Society, 22 p., 1961.

As a sequel to the long-term research program of the American Geographical Society on late-Pleistocene (late glacial and post glacial) climates, work was undertaken in the Laguna de San Rafael, western Patagonia, Chile, to establish chronological data that might be correlated with climatic fluctuations in other parts of South America and the Southern Hemisphere and with those of northwestern North America. The ancient moraines forming the laguna rim, the palynology and stratigraphy of related radiocarbon-dated peat sections, and the ages of modern morines provide the basis for interpreting the environments that have prevailed since the last glaciation. The late Pleistocene chronology from the Pacific Northwest based on C^{14} dates and on peat and pollen stratigraphy is reviewed. Evidence from northwestern North America and from Patagonia and related regions including Australia shows a general accord, compatible with the belief that climatic events of the late and post glacial are in phase; the harmonious glacier variations since the middle of the nineteenth century are particularly noted. The need for supplementary data for increased understanding of polar hemispheric relations is emphasized. — V. S. N.

- 186-22. de Waard, H., and Straka, H[erbert]. C^{14} -Datierung zweier Torfproben aus Madagascar [C^{14} -dating of two peat samples from Madagascar]: Naturwissenschaften, v. 48, no. 2, p. 45, 1961.

Two Madagascan peat samples from a depth of 780-800 cm in borehole B 25 south of Sanganoro Sud and from a depth of 900-930 cm in borehole B 127 east

of Soavinandriana have been dated by radiocarbon at $4,200 \pm 80$ yr and $8,165 \pm 90$ yr, respectively. From this, the rate of peat accumulation in this tropical area is calculated as 10.5-15 cm per century, compared to 5.1-9.4 cm per century for similar peats (swamp and forest) from central Europe. — D. B. V.

- 186-23. Leakey, L. S. B., Evernden, J[ack] F[oord], and Curtis, G[arniss] H. Age of Bed I, Olduvai Gorge, Tanganyika: *Nature*, v. 191, no. 4787, p. 478-479, 1961.

Olduvai Gorge in Tanganyika is famous for its unique Pleistocene section carrying a rich fossil fauna and long sequences of stages of evolution of early Stone Age cultures. In order to clarify the age relations of Bed I and Bed II (both have been considered by some to be lower middle Pleistocene, whereas others claim that Bed II is lower Pleistocene), K-Ar ages were determined on samples of biotite and oligoclase from tuffs in the top and on 7 anorthoclases from tuffs in the bottom of Bed I. The decay constants $\lambda_{\beta} = 4.72 \times 10^{-10} \text{ yr}^{-1}$ and $\lambda_{\kappa} = 0.584 \times 10^{-10} \text{ yr}^{-1}$ were used. The anorthoclases range between 1.6 and 1.9×10^6 yr, averaging 1.75×10^6 yr. The samples from the top of the bed average 1.23×10^6 yr. It is concluded that the Olduwan culture and Villafranchian fauna are synchronous and about 1.75×10^6 yr old.

An age of 360,000 yr has been obtained on a post-Chellean II tuff in Bed II. — D. B. V.

- 186-24. Bonhomme, Michel. Âges absolus dans le massif granitique de Bouna en Haute-Volta et dans le granite de Windéné en Côte-d'Ivoire [Absolute ages in the Bouna granitic massif in Upper Volta and in the Windéné granite in the Ivory Coast]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 25, p. 4016-4017, 1961.

The ages of biotites from the Kosso migmatite and granite, the Bouna massif in Upper Volta, and the Windéné granite in the Ivory Coast were determined by the Rb-Sr method as $2,057 \pm 69 \times 10^6$ yr, $2,032 \pm 46 \times 10^6$ yr, and $2,050 \pm 35 \times 10^6$ yr, respectively. All three, therefore, belong to the same orogenic cycle. If, as has been suggested, the Kosso migmatite is actually older than the Kosso granite, the age obtained is that of recrystallization in the course of granitization. — D. B. V.

- 186-25. Bonhomme, Michel, Mendès, Francisco, and Vialette, Yves. Âges absolus par la méthode du strontium des granites de Sintra et de Castro Daire au Portugal [Absolute ages of the Sintra and Castro Daire granites in Portugal by the strontium method]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 21, p. 3305-3306, 1961.

Biotites from two Portuguese granites have been dated by the Rb-Sr method as follows: Sintra granite, in the vicinity of Lisbon (intruded into Jurassic and overlain by Oligocene)— $85 \pm 8 \times 10^6$ yr, or Late Cretaceous; Castro Daire granite, in Beira-Alta province (intruded into Stephanian but pre-Autunian)— $282 \pm 7 \times 10^6$ yr or late Stephanian. — D. B. V.

- 186-26. Longinelli, A. Age of the pleochroic-halos of the quartz-monzonite of eastern Elba: *Experientia*, v. 16, no. 10, p. 439, 1960.

Study of the pleochroic haloes in biotite in the quartz monzonite stock near Porto Azzurro in eastern Elba suggests that the stock belongs to the same magmatic phase as the Monte Capanne pluton (see also *Geophys. Abs.* 169-22). — D. B. V.

- 186-27. Chessex, Ronald, and Vuagnat, Marc. L'âge du massif de Traversella (Piémont, Italie) par la méthode des "dommages dus à la radioactivité" [The age of the Traversella massif (Piedmont, Italy) by the method of damage due to radioactivity]: Soc. Vaudoise des Sci. Nat. Bull., v. 67, pt. 7, no. 303, p. 395-406, 1961.

Age determinations on zircons from the Traversella diorite massif in Turin Province, Italy, are reported. The composition of the massif varies from diorite to quartz monzonite; samples to be dated were chosen from both phases. The age of the quartz monzonite was found to be $26 \pm 3 \times 10^6$ yr and for two quartz diorite samples to be $29 \pm 4 \times 10^6$ and $31 \pm 4 \times 10^6$ yr. The 31 million year date is thought to be the minimum age of the time of crystallization of the Traversella massif; this is further confirmed by two $31 \pm 1 \times 10^6$ yr K-Ar dates determined at the University of California on biotite from the quartz monzonite and diorite phases. Geologic data suggest that the massif was probably intruded immediately following the Alpine movements of middle Oligocene; although in other areas these movements continued after the Oligocene, the character of the Traversella massif indicates that important tectonic movements in this region had ceased at the time of its intrusion. — V. S. N.

- 186-28. Krummenacher, D[aniel], Evernden, J[ack] F[oord], and Vuagnat, M[arc]. Sur l'âge absolu de la peridotite micacée de Finero (zone d'Ivrée) [On the absolute age of the Finero mica-peridotite (Ivrea zone)]: Archives Sci. (Genève), v. 13, no. 3, p. 369-373, 1960.

The apparent age of phlogopite from a peridotite near Finero in the Ivrea zone of the Alps has been determined by the K-Ar method as $246 \pm 4 \times 10^6$ yr, or Middle Permian according to the new geochronological scales. The mafic and ultramafic complex to which this rock belongs is therefore definitely pre-Alpine and unrelated to the Alpine ophiolites. The age is somewhat lower than that of the Baveno granite (see also Geophys. Abs. 180-13, 182-43), but field observations suggest that the mafic rocks of the Ivrea zone are older than the granite; the discrepancy could be due to differential argon loss during a phase of reheating, probably the result of intrusion of the Tertiary granodiorites. — D. B. V.

- 186-29. Grünfelder, M., and Hafner, S. Das Zirkon-Alter granitischer Gesteine aus dem Gotthardmassiv [The zircon age of granitic rocks from the Gotthard massif (with English summary)]: Experimentia, v. 15, no. 7, p. 295, 1961.

The U^{238}/Pb^{206} , U^{235}/Pb^{207} , and Pb^{207}/Pb^{206} ages of zircons from the Fibbia gneiss and the Rotondo granite in the Gotthard massif in the Alps have been measured using isotope dilution techniques. The results on the Fibbia gneiss give evidence of Hercynian orogenic events some 300×10^6 yr ago, confirming conclusions based on field and petrologic studies. The Rotondo granite, formerly considered to be Hercynian, is only $140-170 \times 10^6$ yr old, or Alpine (post-Triassic phase); this agrees with the results of petrofabric studies that showed the Rotondo pluton to be devoid of the foliation and lineation imparted to other rocks of the massif during the Alpine orogeny. — D. B. V.

- 186-30. Bonhomme, Michel; Philibert, Josette; Roques, Maurice; and Viallette, Yves. Âges absolus dans le Viséen et dans le Stéphaniens du Massif Central français [Absolute ages in the Viséan and Stephanian of the French Massif Central]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 20, p. 3084-3086, 1961.

Four samples from 3 tuffs interbedded in the Carboniferous of the Massif Central of France have been dated by the Rb-Sr method, using a decay constant of $\lambda = 1.47 \times 10^{-11} \text{ yr}^{-1}$. The results are as follows: Malavaus tuff (biotite), $328 \pm 5 \times 10^6$ yr; Châteauneuf tuff (biotite), $324 \pm 4 \times 10^6$ yr; Châteauneuf tuff (chlorite), $334 \pm 36 \times 10^6$ yr; mean of latter two (both from the uppermost Viséan), $328 \pm 3 \times 10^6$ yr; biotite from the Brassac tuff (base of Upper Stephanian), $288 \pm 8 \times 10^6$ yr. — D. B. V.

186-31. Vialette, Yves. *Âge absolu du granite viséen de Gien-sur-Cure (Nièvre) dans le Massif Central français [Absolute age of the Viséan granite of Gien-sur-Cure (Nièvre) in the French Massif Central]*: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 25, p. 4018-4019, 1961.

Biotite from the Gien-sur-Cure granite in the Morvan has been dated by the Rb-Sr method as $334 \pm 7 \times 10^6$ yr; this fixes the limit between the lower and upper Viséan and fits well with earlier determinations of the base of the upper Stephanian and top of the Viséan (see Geophys. Abs. 186-30). — D. B. V.

186-32. Butcher, N. E. Age of the orogeny and granites in southwest England: Nature, v. 190, no. 4772, p. 253, 1961.

As the Dartmoor and related granites form one of the key points of the revised geological time scales of Holmes (see Geophys. Abs. 180-1) and Kulp (see Geophys. Abs. 183-2), their stratigraphic relations need to be determined as precisely as the field evidence will allow. The granites intrude a folded and faulted sequence in which the youngest paleontologically datable sediments are lower Westphalian; it is reasonable to suppose, however, that younger Westphalian or perhaps even Stephanian sediments, now removed by erosion, could have been present in the invaded section. Therefore, on the present evidence, it is preferable to regard the main orogenic movements in Devon and Cornwall as being of essentially the same age as those in the nearby Somerset coalfield, where they affect lower Stephanian strata. If the intrusions are indeed Permian rather than Late Carboniferous, the length of time allotted to the Carboniferous in the time scales would be affected. — D. B. V.

186-33. Dodson, M. H., Miller, J[ohn] A., and York, D. Potassium-argon ages of the Dartmoor and Shap granites using the total volume and isotopic dilution techniques of argon measurement: Nature, v. 190, no. 4778, p. 800-802, 1961.

The results of new K-Ar measurements on biotites from the Shap and Dartmoor granites of England are reported. Both the total volume and the isotopic dilution techniques were used, the former at Cambridge and the latter at Oxford. The mean values, weighing all determinations equally, are $265 \pm 5 \times 10^6$ yr for the Dartmoor granite and $397 \pm 8 \times 10^6$ for the Shap. These figures are in good agreement with the K-Ar and Rb-Sr ages obtained by Kulp and others (see Geophys. Abs. 181-1) and confirm the fact that the results of Mayne and others (see Geophys. Abs. 176-1) are too high. There is a small systematic difference between the results obtained by the two techniques, but it is not large enough to be investigated easily at separate laboratories. The Cambridge apparatus is being modified to permit the use of both techniques on the same sample of gas.

It is concluded that the total volume technique can give good results on Paleozoic materials. In general, however, the isotopic dilution technique is preferable as its accuracy can be maintained for much younger samples. — D. B. V.

- 186-34. Dodson, M. H., and Moorbath, S. Isotopic ages of the Weardale granite: *Nature*, v. 190, no. 4779, p. 900, 1961.

The Rb-Sr and K-Ar ages have been determined on muscovite from Weardale granite recovered from a borehole in West Durham, England. The results all agree within limits of error. The weighted mean of $362 \pm 6 \times 10^6$ yr (Middle or Late Devonian) must correspond closely to the true age and supports the borehole evidence for a pre-Carboniferous age. This granite, therefore, is not connected with the Pennine mineralization ($280 \pm 30 \times 10^6$ yr) (see *Geophys. Abs.* 177-8) and is significantly younger than the Shap granite. — D. B. V.

- 186-35. Miller, J[ohn] A., and Green, D. H. Preliminary age determinations in the Lizard area: *Nature*, v. 190, no. 4784, p. 159-160, 1961.

A petrological examination of the Lizard Peninsula area in Cornwall, England, has led to an attempt to date the igneous and metamorphic assemblages by the K-Ar method. Measurements were made on 4 muscovites from the Old Lizard Head series and 2 biotites from the Kennack gneiss. The ages obtained are not consistent with the established sequence of geological events. The results are interpreted as follows: the mean age of 391×10^6 yr for the Kennack gneiss is the true age of the intrusion (Caledonian); the mean age of 356×10^6 yr for the Old Lizard Head series, the oldest rock in the area on geological evidence, reflects loss of argon due to retrograde metamorphism during later (Hercynian?) thrusting. — D. B. V.

- 186-36. Owen, T. R. Age of the orogeny and granites in south-west England: *Nature*, v. 191, no. 4787, p. 486, 1961.
Butcher, N. E. Age of the orogeny and granites in south-west England: *ibid.*, p. 486-487, 1961.

Owen maintains that Butcher's case for a very Late Carboniferous orogeny in southwest England and for a Permian granitic injection (see *Geophys. Abs.* 186-32) has not been proved. Evidence is cited to support an earlier (late Westphalian) age for the main deformation of the Devonian and Culm of Devon and Cornwall; the granite intrusions probably accompanied this deformation.

Butcher replies that the evidence cited by Owen does not necessarily support a late Westphalian age for the orogeny and granites; he prefers to correlate the main orogeny with that in adjacent regions to the north, in agreement with Kulp and others (see *Geophys. Abs.* 181-1), but agrees that the case has not been proved. — D. B. V.

- 186-37. Cobb, James C., and Kulp, J. Laurence. Isotopic geochemistry of uranium and lead in the Swedish kolm and its associated shale: *Geochim. et Cosmochim. Acta*, v. 24, no. 3/4, p. 226-249, 1961.

The uranium and lead concentration and isotopic composition in a variety of samples of kolm and associated black shale from the Peltura beds (Franconian stage) of the Upper Cambrian of Sweden have been determined by isotope dilution techniques. In addition Th^{230} , Ra^{226} , Pb^{210} and radon leakage values have been determined on certain samples. All samples show discordant U-Pb isotopic ages. It appears that two processes have been at work: selective removal of Pb^{206} resulting from the movement of an intermediate member of the U^{238} - Pb^{206} series, and removal of bulk radiogenic lead. The absolute age of the formation is concluded to be greater than 500 million years with the most probable age near this lower limit. This is in good agreement with the latest results on the absolute geologic time scale. The stratigraph-

ically well-dated kolm cannot, however, be considered a calibration point in the absolute time scale. It does show that uranium-lead dating on bituminous shales will lead to minimum ages for these formations. — Authors' abstract

- 186-38. Byström-Asklund, A[nn]e M[arie], Baadsgaard, H[alf]dan, and Folinsbee, R. E. K/Ar age of biotite, sanidine, and illite from Middle Ordovician bentonites at Kinnekulle, Sweden: *Geol. Fören. Stockholm Förh.*, v. 83, no. 1, p. 92-96, 1961.

Bentonite beds with excellent biostratigraphic control occur in the Middle Ordovician limestones and shales at Kinnekulle, Sweden. The bentonites consist mainly of illite-montmorillonite "mixed layer" clays. Datable biotites and zircons were recovered from the grit fraction from 3 beds and sanidines from 2. The 3 biotites give K/Ar dates averaging 440×10^6 yr and the sanidines 447×10^6 yr; their overall average of 444×10^6 yr is in good agreement with the 447×10^6 yr average age determined by Adams and others (see *Geophys. Abs.* 184-29), using the U-Pb method on zircon from Middle Ordovician bentonites in the Appalachians. This may be low; an average of 475×10^6 yr obtained by Adams and others (1958) using the Rb-Sr method has been accepted by Holmes for his revised time scale.

The illite yields an age of only 331×10^6 yr, probably because of argon loss by diffusion. — D. B. V.

- 186-39. Feyling-Hanssen, Rolf W., and Olsson, Ingrid. Five radiocarbon datings of post glacial shorelines in central Spitsbergen: *Norsk Geog. Tidsskr.*, v. 17, no. 1/4, p. 122-131, 1959-60; reprinted in *Norsk Polarinstittutt Medd.*, no. 86, 9 p., 1960.

Radiocarbon dates on five shell samples from the Late Pleistocene stratigraphic sequence at Billefjorden, central Spitsbergen, are reported. The recorded dates are too few to give detailed information about land recovery in central Spitsbergen; however, when inserted in a height-time diagram based on the stratigraphic sequence previously worked out by Feyling-Hanssen (1955) the dates provide an important fact about the curve of shoreline displacement during Post Glacial time. The curve consists of steeply and gently dipping parts. In the early part the shoreline displacement was of the order of magnitude of 200 cm per century, whereas in the late part the rate was only 15-18 cm per century. Insertion of the stratigraphic units of Blytt-Sernander with radiocarbon dates based on the recent work of Nydal and of Olsson (see *Geophys. Abs.* 182-26, -28) into the diagram shows that the Sub-Recent period of central Spitsbergen is synchronous with the Sub-Atlantic; the Post Glacial Warm period is identical with the Post Glacial Warm period in Europe (Firbas, 1954) or the Postglacial Hypsithermal Interval (Deevey and Flint, 1957), embracing the Sub-Boreal, Atlantic, and Boreal (Blytt-Sernander); and the Post Glacial Temperate period is synchronous with the Pre-Boreal time. No samples have been dated for the oldest or late Glacial Cold period but it probably is of younger Dryas age. Shorelines occur in Billefjorden up to 90 m above sea level and probably the late Glacial Cold period coincides in part with Allerød time. — V. S. N.

- 186-40. Voytkevich, G. V., and Anokhina, L. K. O vozraste nekotorykh kompleksov gornykh porodkrivoyrozhskego zheleznorudnogo rayona [On the age of some rock complexes of the Krivoy Rog iron ore district]: *Geokhimiya*, no. 2, p. 185-187, 1961.

The K-Ar ages of 8 rocks and minerals from the Krivoy Rog iron district in the Ukrainian S. S. R. are tabulated. Biotites from granitic rocks containing

xenoliths of magnetite-bearing quartzites from the Don gorge (Ingulets River) give ages of 1,900 and $1,930 \times 10^6$ yr. These ferruginous quartzites appear to be remnants of iron formations contemporaneous with the Krivoy Rog iron deposits.

An age of $2,150-2,200 \times 10^6$ yr for the Saksagan granites, obtained on whole rock samples, is in good agreement with the results of other investigations. The dark fraction of a diabase from the Frunze mine gives an age of 596×10^6 yr (Paleozoic); this agrees well with the age of basic volcanics in other parts of the Precambrian basement of the Russian platform. — D. B. V.

- 186-41. Komlev, L. V., Savonenkov, V. G., Kryukova, N. F., and Kuchina, G. N. Drevneyshiye porody dokembriya Ukrainy v izluchine Dnepra [The oldest Precambrian rocks of the Ukraine in the bend of the Dnieper]: Akad. Nauk SSSR Doklady, v. 129, no. 6, p. 1374-1377, 1959.

The results of 35 argon age determinations on micas from inclusions in the Dneprovsk migmatites are tabulated. Ages from $2,500-2,700 \times 10^6$ yr to $3,000 \times 10^6$ yr were obtained. The migmatites themselves are $1,900-2,000 \times 10^6$ yr old. Taken together with the results of earlier work, this indicates that the main magmatic complexes of the Ukraine were formed over a long interval of time, $1,500-2,100 \times 10^6$ yr. — D. B. V.

- 186-42. Vinogradov, A. P., Tugarinov, A. I., Zykov, S. I., and Stupnikova, N. I. O vozraste pegmatitov Stanovogo kompleksa [On the age of the pegmatites of the Stanovoy complex (with English abstract)]: Geokhimiya, no. 5, p. 383-391, 1960.

The results of lead isotope age determinations on 11 minerals (allanites, zircons, and monazites) from pegmatites cutting the metamorphic Stanovoy complex in the Stanovoy Range in the eastern U. S. S. R. are presented. The Pb^{207}/Pb^{206} age of $1,900 \pm 100 \times 10^6$ yr agrees with K/Ar ages obtained on micas and is probably the true age of the pegmatites. The minimum age of 430×10^6 yr, obtained from the Pb^{208}/Th^{232} ratio, indicates the lower limit of the last metamorphism. — D. B. V.

- 186-43. Ovchinnikov, L. N. K voprosu opredeleniya absolyutnogo vozrasta rudnykh mestorozhdeniy Urala [Problem of determination of the absolute age of the ore deposits of the Urals]: Geokhimiya, no. 6, p. 545-552, 1958.

The argon ages of 28 micas and feldspars from metasomatic rocks accompanying contact-metasomatic copper and iron deposits in the Ural Mountains are tabulated. Three metallogenetic epochs are recognized, reflecting stages of magmatic activity and definite phases of orogenesis: the Salair, $420-460 \times 10^6$ yr; the Caledonian, $320-360 \times 10^6$ yr; and the Hercynian (Harz), $248-270 \times 10^6$ yr. — D. B. V.

- 186-44. Zamyatin, N. I., Ivanov, A. I., Monich, V. K., and Nurlybayev, A. N. Absolyutnyy vozrast shchelochnykh porod Ishimskogo kompleksa v tsentral'nom Kazakhstane [Absolute age of alkalic rocks of the Ishim complex in central Kazakhstan]: Akad. Nauk Kazakh. SSR Izv. Ser. Geol., no. 1 (42), p. 15-20, 1961.

The igneous rocks of the Ishim complex occur in the right bank area of the Ishim River in the northwest part of central Kazakh S. S. R. The principal rock types are tuffs and porphyritic lavas; intrusive alkalic rocks; syenite,

lamprophyre, and pegmatite dikes; and granosyenite and alaskite micropegmatites. All of these belong to the same comagmatic series. The absolute age obtained on biotites from these rocks is 405-438 million years, which corresponds to the Devonian and is compatible with the pre-Early Carboniferous geologic age. The absolute age determined for whole rock specimens ranges from 5 to 15 percent lower than that obtained on biotite. — J. W. C.

- 186-45. Gerling, E. K., Yashchenko, M. L., Levskiy, L. K., and Ovchinnikova, G. V. Opredeleeniye vozrasta nekotorykh slyud po rubidiiy-strontsiyevomu metodu [Determination of the age of some micas by the rubidium-strontium method]: *Geokhimiya*, no. 6, p. 535-544, 1958.

This is virtually the same paper as published in *Akad. Nauk SSSR, Kom. Opredeleeniye Absolyut. Vozrasta Geol. Formatsiy Trudy*, 7th sess., p. 326-342, 1958 (1960) (see *Geophys. Abs.* 184-75). — D. B. V.

- 186-46. Shcherba, G. N., and Ivanov, A. I. Po povodu vozrasta nekotorykh redkometal'nykh granitnykh intruziy tsentral'nogo Kazakhstana [The age of certain rare-metal granitic intrusions in central Kazakhstan]: *Geokhimiya*, no. 6, p. 607-609, 1958.

Supplementary argon age determinations on samples of granites and their derivatives show that the latest massif of the leucocratic ore-bearing granites of the Akchatau are $240-280 \times 10^6$ yr old, and the latest granites of the Zhanet district are $207-243 \times 10^6$ yr old. These figures controvert the "incontrovertible" findings of Komlev and others, which assigned these ores to a later Caledonian rather than to the Harz cycle (see *Geophys. Abs.* 180-5), and agree better with the geologic evidence. — D. B. V.

- 186-47. Fiji Geological Survey Department. *Geochronology: Fiji Geol. Survey Dept. Ann. Rept. for 1960*, p. 7-8, 1961.

Lead-alpha age determinations on zircon of granitic rocks from various areas in Fiji are reported as follows: from Yavuna, Nausori Highlands, $560 \pm 65 \times 10^6$ yr; Tau, Malomalo, $85 \pm 10 \times 10^6$ yr; and Nakalavo, Sigatoka Valley, $100 \pm 10 \times 10^6$ yr. Geological evidence suggests that the Yavuna granite is not older than 50 million years and that the Tau and Nakalovo granites are not older than 25 million years. Results are being checked by the K/Ar method because of the possibility that zircon may have been picked up at depth by the granite. — V. S. N.

Miyake, Yasuo, and Sugimura, Yukio. Ionium-thorium chronology of deep-sea sediments of the western North Pacific Ocean. See *Geophys. Abs.* 186-603.

- 186-48. Saito, Nobufusa; Tatsumi, Tatsuo; and Sato, Kazuo. Absolute age of euxenite from Antarctica: *Antarctic Rec.*, no. 12, p. 31-36, 1961.

The Pb^{206}/U^{238} , Pb^{207}/U^{235} , Pb^{208}/Th^{232} , and Pb^{207}/Pb^{206} ages were determined on euxenite found in pegmatite in a diorite gneiss from the Skallen district, Lützw-Holm Bay, Antarctica. Except for an abnormally low Pb^{208}/Th^{232} age, the ages coincide well with each other giving an average value of 470 million years. The Rb-Sr age of biotite from the same locality was found to be about 500 million years. Absolute ages of other rocks and minerals from Antarctica, determined by many investigators and summarized in a table, fall into two groups: one at 500 million years that includes rocks from the east coast of Lützw-Holm Bay, the Mirnyy region, and the west side of

McMurdo Sound; and a second at 900-1,100 million years that includes rocks from the Knox and Budd Coasts. The occurrence in Antarctica of Paleozoic charnockites, long thought to be a characteristic rock type of the Precambrian, has been ascertained from absolute age determinations by several investigators. — V. S. N.

186-49. The Polar Record. Absolute age of Antarctic rocks: Polar Rec., v. 10, no. 68, p. 530-531, 1961.

A list of 51 age determinations by the argon method on Antarctic rocks is presented. It was compiled from papers by Ravich and others published in *Informatsionnyy Byulleten' Sovetskoy Antarkticheskoy Ekspeditsii*, nos. 19 and 20, 1960, and in *Akad. Nauk SSSR Doklady*, v. 126, no. 1, 1959 (see *Geophys. Abs.* 177-20.) — V. S. N.

186-50. Focken, C. M. Radiocarbon dating laboratory, Museum of Applied Science of Victoria: *Australian Jour. Sci.*, v. 23, no. 4, p. 127-128, 1960.

The first three preliminary determinations by the new radiocarbon dating laboratory in Melbourne, Australia, have checked the reliability and revealed the accuracy limits of the present equipment. For a sample of wood dated in the New Zealand laboratory as $9,400 \pm 120$ yr, an age of $9,200 \pm 250$ yr was obtained as 1 atm pressure and an age of $9,000 \pm 250$ yr at 2 atm. Two samples from a red gum stump dated elsewhere as $8,300 \pm 210$ yr (outer ring) and $8,720 \pm 200$ yr (inner ring) gave a mean result of $8,220 \pm 160$ yr. Wood from the Roman ship at Lake Nemi, used as an interlaboratory check sample, gave a result of $2,290 \pm 100$ yr, to which should be added the industrial correction; other dates for this sample were spread over 200 yr with a mean of 2,000 yr. — D.B. V.

186-51. Geochron Laboratories. Bibliography of geochronology: Cambridge, Mass., Geochron Laboratories, Inc., 24 p., 1961.

A bibliography containing over 450 titles covering all aspects of geological age measurements relating to radioactivity is presented. All C^{14} work is excluded. — V. S. N.

Hoyle, F. The age of the galaxy. See *Geophys. Abs.* 186-66.

Kuroda, P[aul] K. The time interval between nucleosynthesis and the formation of the earth. See *Geophys. Abs.* 186-67.

Fisher, David E. Cosmic ray ages of the Treysa and Sikhote-Alin meteorites. See *Geophys. Abs.* 186-68.

Vilczek, E[lse], and Wänke, H. The exposure age of the iron meteorites from C136 measurements. See *Geophys. Abs.* 186-69.

Stauffer, Heinz. Primordial argon and neon in carbonaceous chondrites and ureilites. See *Geophys. Abs.* 186-63.

COSMOGONY

186-52. McCrea, W. H. The origin of the solar system: *Royal Soc. [London] Proc.*, v. 256, no. 1285, p. 245-266, 1960; *Origine du systeme solaire [Origin of the solar system]: Ciel et Terre*, v. 76, no. 11-12, p. 369-385, 1960; Formation of stars from interstellar matter: *Soc. Royal Sci. Liege Mem.*, v. 3, p. 332-342, 1960.

A theory is presented that removes the classic "angular momentum difficulty" that besets most theories of star formation as well as theories of the origin of the solar system. Interstellar material in which stars are about to be formed consists of "floccules" moving at random among themselves and probably composed mainly of molecular hydrogen. The process producing condensations that grow into stars would also produce minor condensations in material that becomes trapped in the growing gravitational field of these stars to form planetary systems associated with the stars. Details of the theory account satisfactorily for the mass and number of the planets of the solar system and their rotation. — D. B. V.

- 186-53. Suworoff [Suvorov], N. P. Die Entstehung der Planeten des Sonnensystems [The origin of the planets of the solar system]: *Naturwissenschaften*, v. 48, no. 7, p. 214, 1961.

The planets originated between spectral type stages gF and dF of the sun's evolution, when the sun increased abruptly in mass and decreased in density and angular momentum, with concomitant drastic increase in gravitational acceleration at its surface and decrease in centrifugal force. Probably the flashing of a nova announces the formation of planets. The ages of the members of the solar system are tabulated as follows (in 10^9 yr): sun 4.67, Jupiter 2.05, Saturn 2.04, Uranus 2.03, Neptune 2.02, Pluto 2.01, asteroids 1.95, Mars 1.94, Earth 1.91, Venus 1.90, and Mercury 1.88. — D. B. V.

- 186-54. Omori, Keiichi. Abrupt changes of physical conditions of the earth-surface by the passing of a large star: *Tohoku Univ. Sci. Repts.*, ser. 3, v. 7, no. 1, p. 131-151, 1961.

Omori has proposed (see *Geophys. Abs.* 182-60) that saline deposits are formed as a result of sudden drastic changes in the rotation and revolution of the earth due to the passing of large stars. The sudden change in temperature and physical conditions of the earth's surface would also affect animal and plant life, and cause the revolutions of geologic history. In this paper, the distances of passing stars from the earth and the dates of their passing are calculated for 1,026 stars described in Schütte's table. Results, which are tabulated, show good agreement of the geologic epochs in general with the passage of relatively close stars. — D. B. V.

- Lomnitz, C[inna]. On thermodynamics of planets. See *Geophys. Abs.* 186-123.

- 186-55. Fisher, David E. Origin of stone and iron meteorites: *Nature*, v. 190, no. 4772, p. 244-245, 1961.

One line of experimentation bearing on the question of whether stone and iron meteorites had a common origin is the determination of their cosmic-ray exposure ages. A recent compilation of available exposure age calculations by Urey (see *Geophys. Abs.* 179-30) suggests that the stones and irons may have had a different origin and history. Uncertainties concerning helium production rates, their dependence on depth, and the effect of space erosion are discussed, and it is concluded that until further information is available on more direct radioactive-stable nuclide determinations (such as Ar^{38}/Ar^{39} , H^3/He^3), the postulation of separate origins for stone and iron meteorites is not justified. — D. B. V.

- 186-56. Dingle, Herbert. The frequency of meteorite falls throughout the ages: *Nature*, v. 191, no. 4787, p. 482, 1961.
 Pettersson, Hans. The frequency of meteorite falls throughout the ages: *ibid.*

Dingle points out that the presence of cosmic spherules in Tertiary sediments reported by Pettersson (see *Geophys. Abs.* 184-83) is not inconsistent with the assertion that no meteors fell at the time; evidence is lacking that meteors and meteorites have a common origin.

Pettersson replies that the structure of cosmic spherules definitely supports the interpretation that they were derived from nickel-iron meteors heated to superficial melting during flight through the atmosphere and that they might also be derived from meteorites. Whether meteorites and ordinary meteors are of different origin is still an open question (Whipple assumes that most meteors are of cometary origin, whereas meteorites are usually assumed to be derived from planetary fragments like the asteroids). — D. B. V.

- 186-57. Ringwood, A. E. Chemical and genetic relationships among meteorites: *Geochim. et Cosmochim. Acta*, v. 24, no. 3/4, p. 159-197, 1961.

Optical and X-ray studies of olivines, pyroxenes, and metal phases from 34 chondrites for which chemical analyses are available confirm the fact that chondrites are samples of a homogeneous parent material which varied widely in its state of oxidation. The original state probably resembled that displayed by the carbonaceous chondrites. Primary chondritic textures are tuffaceous in nature and therefore of volcanic origin. Chondrites have subsequently been exposed to varying degrees of metamorphism, causing compaction and recrystallization; the range of pressures indicated is such that at least one of the parent bodies must have been of lunar size.

The genesis of other groups of meteorites can be explained in terms of melting and differentiation of a small amount of parental chondritic material. The irons probably crystallized under high pressures (more than 30,000 atm) near the center of a parent meteoritic planet about 4.5×10^9 yr ago. Subsequent cooling below 450°C occurred within about 10^8 yr. Cooling of the small molten core of the planet occurred by adiabatic heat exchange with the outer chondritic mantle, which had been rapidly cooled to about 300°C during the endothermic volcanic phase of evolution. The meteoritic planet(s) broke up less than 10^9 yr after melting and differentiation, and the fragments have since been colliding and becoming reduced in size, forming the asteroids. — D. B. V.

- 186-58. Nomoto, Morikazu. Physical theory of meteor: *Tohoku Univ. Sci. Repts.*, ser. 1, v. 43, no. 4, p. 245-259, 1959.

The action of the atmosphere on a meteor is studied by treating the effect of the impact of individual atoms and molecules of the atmosphere on the meteor surface. Radiation damage occurs on the inside of the surface, and the average of the heat-transfer rate over the surface is estimated to be about 0.81, assuming that the surface is roughly spherical. Assuming that the medium of the meteor is continuous and making use of Mitra's data for the density of the atmosphere, variations of the meteor velocity, radius, and temperature with height are found to be functions of the initial velocity, dimension, and angle of incidence. The appearance and disappearance heights are estimated as functions of the same initial quantities, and the values are quite reasonable in comparison with observed data. — V. S. N.

- 186-59. Goles, Gordon G., and Anders, Edward. On the geochemical character of iodine in meteorites: *Jour. Geophys. Research*, v. 66, no. 9, p. 3075-3077, 1961.

The results of leaching experiments, abundance determinations on troilite and metal phases from iron meteorites, and analysis of mechanically separated

fractions of a chondrite suggest that oldhamite is the host mineral for iodine in chondrites. If this identification is valid, the iodine must have been subjected to rather extensive chemical processing after its incorporation in the meteorite parent bodies, as oldhamite could not have been present in the primordial nebula as such. The process would have resulted in the strong fractionation of iodine from any Xe^{129} that had accumulated in the primordial iodine-bearing grains.

A direct test is possible to determine whether the fractionation occurred in the primordial nebula rather than in the meteorite parent bodies. If no significant excess Xe^{129} is found in the water-soluble or fine fractions of appropriate meteorites, then I-Xe decay intervals may well refer to events in the primordial nebula (see *Geophys. Abs.* 183-71, 184-90), but if the excess Xe^{129} is largely in iodine-rich fractions, then I-Xe decay intervals probably refer to the cooling of the meteorite parent bodies (see *Geophys. Abs.* 185-95). — D. B. V.

- 186-60. Lipschutz, Michael E., and Anders, Edward. The record in the meteorites—4. Origin of diamonds in iron meteorites: *Geochim. et Cosmochim. Acta*, v. 24, no. 1/2, p. 83-105, 1961.

Study of a number of diamond-bearing specimens of the Canyon Diablo meteorite indicates that the diamond-bearing specimens, and only these, were reheated strongly after formation of the Widmanstätten pattern. The metal phase appears to have been reheated to about 950°C for 1-5 sec, and then cooled in less than 2 min. The rapid cooling rate implies that the process took place after the meteorite fragments had attained their present small size. Thermodynamic calculations and structural studies severely limit the range of possible conditions for diamond formation in meteorites.

It is considered likely that all meteoritic diamonds were produced by catastrophic events, either upon impact with the earth or during the breakup of parent bodies. This mode of origin obviates the need for postulating parent bodies of lunar or planetary dimensions with interior pressures of 3×10^4 atm or greater. — D. B. V.

- 186-61. DuFresne, E. R., and Roy, S[harat] K[umar]. A new phosphate mineral from the Springwater pallasite: *Geochim. et Cosmochim. Acta*, v. 24, no. 3/4, p. 198-205, 1961.

Farringtonite, a new anhydrous magnesium phosphate mineral, has been found in contact with iron in the Springwater pallasite meteorite. From the physical properties and chemical reactions of the two phases it can be inferred that cooling through the freezing range was rapid. This seems to rule out ideas involving a deep-seated environment within a planet as the source of pallasites. The optical, physical, chemical, and X-ray properties of the mineral are given. — D. B. V.

- 186-62. Eberhardt, P[eter], and Eberhardt, A. Ne in some stone meteorites: *Zeitschr. Naturforschung*, v. 16a, no. 3, p. 236-238, 1961.

The $\text{Ne}^{21}/\text{Ne}^{22}$ and $\text{Ne}^{20}/\text{Ne}^{22}$ ratios and the Ne^{21} content of 8 stone meteorites (4 chondrites, 3 achondrites, and 1 pallasite) were measured. Good agreement with other cosmic-ray-produced rare gas isotopes was obtained. None of the chondrites showed an excess of Ne^{20} . The Novo Urei achondrite, a ureilite, shows a high $\text{Ne}^{20}/\text{Ne}^{21}$ ratio; this certainly could be interpreted as primordial gas, but the possibility of absorbed atmospheric Ne cannot be excluded in the case of this particular meteorite as it is very porous. — D. B. V.

- 186-63. Stauffer, Heinz. Primordial argon and neon in carbonaceous chondrites and ureilites: *Geochim. et Cosmochim. Acta*, v. 24, no. 1/2, p. 70-82, 1961.

Measurements of the abundance and isotopic composition of argon and neon in 5 carbonaceous chondrites and 2 ureilites show that these meteorites contain large amounts of trapped primordial gases. At 950°K the radiogenic argon diffuses out more readily than primordial argon, and cosmogenic neon at about the same rate as primordial neon. From this it is concluded that the primordial gases are enclosed within the matrix of the crystal lattice.

K-Ar ages and Ne²¹ exposure ages are calculated. Both are affected by diffusive losses; only Felix has a K-Ar age of 4.5×10^9 yr.

A large loss of primordial argon and neon compared to silicon is observed. The loss of primordial argon is constant within a factor of 10 and is about 10-100 times smaller than the loss observed for the earth. The ratios of primordial Ne²⁰ to primordial Ar³⁶ range between 0.005 and 22, indicating large fractionation between argon and neon compared to the corresponding cosmic ratio. Fractionation by diffusive losses is discussed. Some deviations of the isotopic ratios of primordial argon and neon from the atmospheric ratios are observed. — D. B. V.

- 186-64. Levskiy, L. K. Inertnyye gazy v dvukh zheleznikh meteoritakh [Inert gases in two iron meteorites]: *Geokhimiya*, no. 2, p. 183, 1960.

The Ar and He isotopic compositions and ratios in the Chebankol and Chinge iron meteorites are tabulated and compared with published data on the Sikhotealin and Toluca meteorites (see *Geophys. Abs.* 179-269, 168-201). The He³/He⁴ and He³/Ar³⁸ ratios are considerably lower in Chinge than in the other three meteorites. — D. B. V.

- 186-65. Anders, Edward. Extinct radioactivity and the prehistory of the solar system: *Zeitschr. Naturforschung*, v. 16a, no. 5, p. 520-521, 1961.

Some of the implications of Murthy's discovery of Ag¹⁰⁷ from the decay of Pd¹⁰⁷ in the Toluca iron meteorite (see *Geophys. Abs.* 184-99) are pointed out. It is shown that the high abundance of Pd¹⁰⁷ (an amount of the order of 10^{-3} has been observed) is wholly inconsistent with the formation interval (Δt) of 10^8 yr inferred from the longer-lived nuclides Pb²⁰⁵, I¹²⁹, and Pu²⁴⁴. If the presence of excess Ag¹⁰⁷ is confirmed, either Δt must be lengthened for longer-lived nuclides, or the amount of Pd¹⁰⁷ must be increased above predicted levels.

The Δt 's for I¹²⁹ and Pu²⁴⁴ refer to the cooling of the meteorite parent bodies and planetesimals, and hence need not agree with those obtained for Pd¹⁰⁷ and Pb²⁰⁵. The Δt 's for Pd¹⁰⁷ and Pb²⁰⁵ are not necessarily in conflict with each other, as the latter is rather uncertain. If these factors cannot account for the discrepancy, it may be necessary to look for processes that will produce Pd¹⁰⁷ in preference to the longer-lived nuclides. Possible reactions are suggested. Fortunately the problem can be studied experimentally, as each nuclear process gives rise to its own distinct abundance pattern. — D. B. V.

- 186-66. Hoyle, F. The age of the galaxy: *Royal Soc. [London] Proc.*, v. 260, no. 1301, p. 201-204, 1960.

Evidence recently obtained from two quite independent sources suggests that the age of our galaxy is at least as great as 1.5×10^{10} yr. It has been

suggested that the age might be as high as 2.5×10^{10} yr, a value some five times greater than estimates quoted half a decade ago. — Author's abstract

- 186-67. Kuroda, P[aul] K. The time interval between nucleosynthesis and the formation of the earth: *Geochim. et Cosmochim. Acta*, v. 24, no. 1/2, p. 40-47, 1961.

The differences (δ_i) in the abundance ratios of the stable xenon isotopes in meteorites and in the earth's atmosphere indicate that the latter contains an excess of fissionogenic xenon. It is postulated that extinct transuranium elements such as Pu^{244} and Cm^{247} played important roles in the production of fissionogenic xenon in the atmosphere. The time interval between nucleosynthesis and the formation of the earth has been calculated from the values of δ_i as 4.8×10^8 yr for the single event model and 0.52×10^8 yr for the continuous synthesis model. — D. B. V.

- 186-68. Fisher, David E. Cosmic ray ages of the Treysa and Sikhote-Alin meteorites: *Nature*, v. 190, no. 4772, p. 225-227, 1961.

The suggestion that the cosmogenic production rate, dependent on depth, of stable nuclides in iron meteorites can be estimated from the measured rare gas ratios (see *Geophys. Abs.* 182-73, 183-65) has been criticized (see *Geophys. Abs.* 185-93) because it assigned different exposure ages to the Sikhote-Alin and Treysa meteorites, whereas direct measurements lead to approximately equal ages (see also *Geophys. Abs.* 182-64, 183-62). Reexamination of the data has shown an error in calculation of the He^3 production rate in Treysa; the corrected scheme of the apparent correlation between radioactivity and rare gas content is shown in a graph that includes new data on the He^3 content of Treysa and Sikhote-Alin. The scheme does not account for the Ar^{39} data on Treysa nor for the He^3 data on Sikhote-Alin.

Exposure ages for Treysa and Sikhote-Alin have been recalculated using all available raw data on rare gas, He^3 , Sc^{45} , and Cl^{36} measurements. The spread in ages reflects both the different experimental values for measurements of the same nuclide in the same meteorite by different investigators and the uncertainty in the necessary assumptions. The ages proposed as "best" are 0.16×10^9 yr for Sikhote-Alin and either 1.3×10^9 yr (based on the graph of nuclide production rate) or 0.35×10^9 yr (based on Ar^{39} data) for Treysa. — D. B. V.

- 186-69. Vilczek, Else, and Wänke, H. Das Strahlungsalter der Eisenmeteorite aus Chlor-36-Messungen [The exposure age of the iron meteorites from Cl^{36} measurements (with English abstract)]: *Zeitschr. Naturforschung*, v. 16a, no. 4, p. 379-384, 1961.

The Cl^{36} produced by cosmic ray particles with nuclei in meteorites was measured in 1 stone and 7 iron meteorites. The decay rate for Cl^{36} in the iron meteorites was 6.5-20.2 disintegrations per minute per kilogram. Exposure ages calculated from these values and from concentrations of stable spallation products were close to 500×10^6 yr for 6 of the meteorites; Sikhote-Alin, however, gave an age of 60×10^6 yr, considerably lower than the age found by others for the same meteorite. It is suggested that Sikhote-Alin was part of a larger meteorite that broke up about 60×10^6 yr ago on collision with another meteorite. — D. B. V.

- 186-70. Millman, P. M., Liberty, B. A., Clark, J. F., Willmore, P. L., and Innes, M. J. S. The Brent Crater: Dominion Observatory Ottawa Pubs., v. 24, no. 1, 43 p., 1960.

Brent Crater, located in Algonquin Park, Ontario, was first observed on aerial photographs as a circular depression approximately 2 miles in diameter. Geological investigations indicate that the circular area is underlain by Paleozoic sediments whereas the surrounding country rock is mainly granite gneiss; magnetic investigations that the crater is filled with material of lower magnetic susceptibility than the surrounding rock; seismic observations that the crater contains up to 1,000 feet of fairly soft rocks, and perhaps 3,000 feet of other material in which seismic waves travel more slowly than in the surrounding gneiss; and gravity observations that the crater is filled with material of relatively low density to a depth of from 1,500 to 4,000 feet depending on assumptions concerning the average density contrast. A diamond drill hole near the center penetrated a depth of 570 feet of Paleozoic sediments, and a second hole near the edge revealed the presence of large quantities of breccia. It is concluded that the crater was formed by the impact of a meteorite, possibly in late Precambrian time, and that its present state is a consequence of subsequent erosion and the deposition within it of Paleozoic sediments. — V. S. N.

- 186-71. Dietz, Robert S. Vredefort ring structure: Meteorite impact scar?: *Jour. Geol.*, v. 69, no. 5, p. 499-516, 1961.

It is suggested that the Vredefort ring structure of South Africa is a meteorite impact structure. It was found that an asteroid 2.3 km in diameter with an impact velocity of 20 kmps would provide the 6×10^{28} ergs needed to create the original crater 40 km across and 16 km deep. The theory adequately explains: (1) the apparent impulse direction; (2) the shatter cones as shock induced; (3) the bilateral symmetry as produced by oblique impact; (4) the upturned and tilted 16 km-thick collar as the effect of radial forces spreading out from the explosion focus; (5) the pressure and thermal metamorphism of the sedimentary collar; (6) the intensive fracturing and micro-shearing of the rock as shock-wave induced; (7) the pseudotachylite as "shock impactite"; and (8) the granophyre dikes as injected crater-lining "impactite". The uplifted granite plug now filling the crater was caused by a combination of elastic rebound and isostatic forces. — V. S. N.

- 186-72. Donati, Gemmarosa Levi. Catalogue of the meteorites in the mineralogical collection of the University of Modena (Italy): *Accad. Naz. Sci. Lettere e Arti Modena, Atti e Mem.*, ser. 6, v. 2, 4 p., 1960.

The meteorite collection of the University of Modena, Italy, consists of 40 specimens and small fragments, totaling about 2 kg, that represent 26 different falls in various parts of the world. The collection is listed in 5 tables according to type of meteorite—chondrites, achondrites, sideraerolites, lithosiderites, and octahedrites. — V. S. N.

- 186-73. Dey, A. K. The Valudavur meteorite: *India Geol. Survey Recs.*, v. 86, pt. 3, p. 447-454, 1960.

A meteorite weighing about 2,799 g and more or less rhomboidal in shape fell at Valudavur, 10 miles northwest of Pondicherry, South Arcot district of Madras, India, on October 30, 1944. The Valudavur meteorite is a chondritic stony meteorite that resembles the Kroonstad meteorite in general appearance and chemical composition, and is, therefore, classified as a bronzite chondrite. — V. S. N.

- 186-74. Hemenway, Curtis L., Fullam, Ernest F., and Phillips, Laurence. Nanometeorites: *Nature*, v. 190, no. 4779, p. 897-898, 1961.

High-altitude airborne particles collected in the Arctic by a U-2 aircraft at 60,000 feet included enormous numbers of ultra-small high density particles of the order of 75 \AA , in addition to the solid and "fluffy" particles larger than 0.2μ normally seen in previous collections from somewhat lower altitudes. Study of these extremely small particles and the background material by selected-area electron diffraction suggests that they represent a previously unsuspected class of meteorite bodies entering the atmosphere. As they are about a thousand times smaller in diameter than micrometeorites, and as the forces acting on them probably are critically dependent on their electric charge and velocity in the ionosphere and geomagnetic field, it is proposed that they be called "nanometeorites." A lunar dust origin is favored, but they could in part result from meteor ablation or fragmentation. A full report is forthcoming. — D. B. V.

186-75. Laevastu, Taivo, and Mellis, Otto. Size and mass distribution of cosmic dust: *Jour. Geophys. Research*, v. 66, no. 8, p. 2507-2508, 1961.

The size distribution of the cosmic spherules found in sediments shows that the total mass of particles in equal size (diameter) intervals remains constant. The size distribution of cosmic dust in space, as computed from the data obtained by impact measurements by artificial satellites, shows the same distribution in the interval of particle diameters approximately 5μ and 15μ , and as determined by indirect extrapolation the distribution is probably valid for larger particles. — Authors' abstract

186-76. Dubin, Maurice. Remarks on the article by A. R. Hibbs, "The distribution of micrometeorites near the earth": *Jour. Geophys. Research*, v. 66, no. 8, p. 2592-2594, 1961.

Hibbs, A. R. Author's reply to the preceding discussion on the article, "The distribution of micrometeorites near the earth": *ibid.*, p. 2595-2596, 1961.

Dubin states that Hibbs' analysis of the Explorer I micrometeorite data (see *Geophys. Abs.* 184-82) was incorrect. There were only 145 type A impacts recorded without redundancy, and these include 66 impacts from a cosmic dust "shower"; the Poisson distribution would not be valid for such a sample and is inconsistent with the large variation of daily impact rate.

Hibbs replies that he arrived at 166 valid nonredundant impact recordings from a review of the original data tapes, but that differences between his and Dubin's conclusions cannot be ascribed to this difference. Even if the "shower" impacts are removed completely, the strong altitude effect is still displayed, and the data still show the closed-orbit phenomenon. The apparent diurnal variations in flux rate are more than adequately accounted for on the basis of orientation of the satellite trajectory. — D. B. V.

186-77. Crozier, W. D. Micrometeorite measurements—satellite and ground-level data compared: *Jour. Geophys. Research*, v. 66, no. 9, p. 2793-2795, 1961.

Comparison is made between an annual mass accretion to the earth (3.9×10^5 metric tons) calculated on the basis of micrometeorite counts by satellites 1958 α and 1959 η , and an annual mass accretion of magnetic spherules (0.9×10^5 metric tons) determined by collections made at ground level by the Airborne Particle Study of the New Mexico Institute of Mining and Technology. Both measurements apply to the particle mass interval $3.3 \times 10^{-10} \text{ g}$ to $1.2 \times 10^{-8} \text{ g}$. On the basis of the theory of Öpik [1951, 1956] the ratio of the two amounts is

quite reasonable, but the entire interpretation becomes uncertain because of the possibility that many of the particles encountered by the satellites may be in orbit around the earth. — Author's abstract

- 186-78. Hodge, Paul W. Sampling dust from the stratosphere: *Smithsonian Contrib. to Astrophysics*, v. 5, no. 10, p. 145-152, 1961.

Of the meteoric objects that enter the earth's atmosphere from interplanetary space, the smallest and most numerous are dust particles. In order to obtain meteoritic dust from places where contamination by terrestrial dust is as slight as possible, 45 filters were flown in collectors mounted on high-altitude jet aircraft. Study of this stratospheric dust shows that at 45,000 feet there are approximately 30 particles $>6\mu$ in diameter per cu m; there is evidence that these particles are unevenly distributed in space at this altitude. Most of the particles are transparent or semitransparent and are probably of terrestrial origin. Space density of opaque particles at 45,000 feet is roughly two particles $>3\mu$ in diameter per cu m, and there is no convincing evidence that any large percentage of these particles is extraterrestrial in origin. Comparison of the number of particles found at 45,000 feet with the number found at sea level indicates that many opaque, probably high-density particles are carried up into the stratosphere. — V. S. N.

- 186-79. Fireman, E. L., and Kistner, G. A. The nature of dust collected at high altitudes: *Geochim. et Cosmochim. Acta*, v. 24, no. 1/2, p. 10-22, 1961.

Analysis of dust collected from the atmosphere at altitudes above 40,000 feet indicates that very few particles occur with nickel and cobalt concentrations similar to those in iron meteorites. Deep-sea spherules are therefore probably produced by friction during the passage of larger iron meteorites through the atmosphere. An upper limit of 30,000 tons per yr for the entire earth is calculated for the accretion rate of particles between 3μ and 30μ in size with an Fe-Ni-Co ratio similar to that of meteorites. Many of the particles could represent possible terrestrial contamination, but this explanation is improbable for the iron-manganese particles. — D. B. V.

- 186-80. Kaiser, T. R. The incidence of interplanetary dust [with French and Russian abstracts]: *Annales Géophysique*, v. 17, no. 1, p. 50-59, 1961.

Interplanetary dust can be investigated in a number of ways; these include optical and radio meteor observations, the collection at the earth's surface of accreted particles, the scattering of sunlight (the zodiacal light), as well as more direct observations with rocket and satellite borne instruments. This paper treats in some detail the reduction of radio-echo data to yield the absolute incident meteor flux. Observational data obtained by the various techniques listed above are presented, and the problems in reconciling them are discussed. — Author's abstract

- 186-81. Barnes, Virgil E. A world wide geological investigation of tektites: *GeoTimes*, v. 6, no. 2, p. 8-12, 38, 1961.

A brief account is given of a systematic and coordinated field examination of localities where tektites and other natural glasses occur. Six months were spent visiting most of the tektite-strewn fields, some meteorite craters with glass around them, tektite collections in museums, and workers on tektites and meteorites in England, Russia, Czechoslovakia, Egypt, Saudi Arabia,

India, Malay, Singapore, Australia, Indonesia, Thailand, Cambodia, South Viet Nam, and the Philippines. A few areas (Ivory Coast, Libyan Desert, Mauretania, and Peru) remain to be visited, but it is possible that the data and samples already collected may provide sufficient evidence to prove the terrestrial or extraterrestrial origin of tektites. — V. S. N.

- 186-82. Vorob'yev, G. G. O khimicheskom sostave tektitov v svyazi s problemoy ikh proiskhozhdeniya [On the chemical composition of tektites in relation to the problem of their origin (with English abstract): *Geokhimiya*, no. 5, p. 427-442, 1960.

The average composition of tektites, silica glasses, and impactites has been calculated on the basis of more than 100 published chemical analyses. The chemical character of the individual groups (moldavites, indochinites, philippinites, billitonites, Java tektites, australites, Ivory Coast tektites, bediasites, americanites, livites, tasmanites, and impactites) is also established. The distinctly hybrid character of tektites as a whole suggests that they are probably of cosmic origin. — D. B. V.

- 186-83. Watson, Kenneth, Murray, Bruce C., and Brown, Harrison. The behavior of volatiles on the lunar surface: *Jour. Geophys. Research*, v. 66, no. 9, p. 3033-3045, 1961.

A detailed theory of the behavior of volatiles on the lunar surface, based on solid-vapor kinetic relationships, is presented, according to which water should be far more stable there than the noble gases or other possible constituents of the lunar atmosphere. Numerical calculations indicate that the amount of water lost from the moon since the present surface conditions were initiated is only a few g per cm² of the lunar surface. The amount of ice eventually detected in lunar "cold traps" will thus provide a sensitive indication of the degree of chemical differentiation of the moon. — D. B. V.

- 186-84. Alter, D[insmore]: Evolution of the moon: *Lunar and Planetary Explor. Colloquium Proc.*, v. 11, no. 2, p. 1-6, 1960.

After a discussion of the George Darwin theory of the origin of the earth-moon system and of the widely accepted protoplanet hypothesis, it is suggested that the hypothesis of the capture of a small independent rigid planet more nearly meets the conditions found in the earth-moon system today. The original conditions that could have resulted in the present system would be: a moderately rapid initial rotation of the captured planet, preferably approaching the month; a first perigee not too much within a 1,000-mile surface distance; and a moderate orbital eccentricity. The skew distribution of the mare areas on the moon is further evidence of capture; if tidal forces quickly pinned the rotation of the moon and caused the maria, the concentration as found today toward the preceding limb with a general east-west spread due to libration would be expected. If bombardment caused the maria, the far side should have approximately the same mare areas as the near side; moreover, the earth should have shielded the near side from solar asteroids. The great, bright mountainous areas of the southern and southwestern parts of the near side approximate somewhat the original surface of the moon. Truly sharp pictures of the far side should show even greater numbers of these precapture features. — V. S. N.

- 186-85. Shoemaker, E[ugene] M. Ballistics of the Copernican ray system: *Lunar and Planetary Explor. Colloquium Proc.*, v. 11, no. 2, p. 7-21, 1960.

The one major feature of lunar craters observable from the earth that may permit discrimination of impact craters from volcanic craters is the distribution pattern of the ejecta. Ejecta from maar-type volcanoes are thrown out along high angle trajectories and shower down in a diffuse, more or less uniform pattern around the crater. Ejecta from large impact craters are thrown out along both high and low trajectories. Many lunar craters are surrounded by a system of rays resembling the ejecta patterns around nuclear- and high-explosion craters. The ray pattern of Copernicus is analyzed in detail. In order to reduce the ballistic problem of the Copernican rays to a series of discrete points that can be treated mathematically, a compilation of 975 secondary impact craters was made. To find trajectories for individual fragments ejected from Copernicus a theory of cratering that gives the relation between ejection velocities and angle of elevation of ejection is required. A series of approximations and an idealization of the cratering problem is used to obtain a relation in closed algebraic form. Results indicate that the bolide that formed Copernicus was probably an independent member of the solar system and not a planetesimal or moonlet orbiting the earth. Moreover, a simple genetic relationship between the main features of the Copernican ray pattern and other observable features of the lunar crust is found by use of the idealized theory of cratering; the theory accounts quantitatively for both the crater dimensions and the distribution of the ejecta. The formation of chains and compound secondary craters is a lesser manifestation of the phenomenon of the fragment clustering which is responsible for the formation of the rays. — V. S. N.

186-86. Salisbury, J. Origin of lunar domes: Lunar and Planetary Explor. Colloquium Proc., v. 11, no. 2, p. 22-26, 1960.

The three existing hypotheses for explaining the origin of lunar domes—shield-volcano, lava-bubble, and laccolith—are reviewed, and a new hypothesis—mineral phase change expansion—is suggested. Mineral phase change expansion could produce the domes observed on the moon, whether large or small, regular or irregular, cratered or uncratered. The apparent restriction of domes to the lava plains can be explained as the result of a restriction to areas where water vapor leakage might be at a maximum. — V. S. N.

186-87. MacDonald, G. J. Seismic activity of the moon: Lunar and Planetary Explor. Colloquium Proc., v. 11, no. 2, p. 45-47, 1960.

Various models of the moon were constructed to investigate possible natural seismic activity. Assuming a moon of the composition of a chondritic meteorite 4.5 billion years ago, and with an initial temperature of 0°C, then over the last billion years and at the present, strain energy would be released at a rate of 1×10^{25} ergs per year. If the moon were initially cold and has been steadily heating up due to radioactivity, and if the principal mechanisms of heat transfer are conduction and radiation, the present rate of strain energy release would be about equal to or greater than that for the earth. If the moon were initially at a higher temperature and there were different mechanisms of heat transport, the present rate of strain energy release would be less per unit area than for the earth. Additional calculations were made for varying distributions of radioactivity. Regardless of the radioactivity and thermal expansion coefficients within the lunar material, the models of the lunar history would seem to indicate a constant surface area and a constant radius. The model studies thus suggest that large horizontal movements, such as are observed on the earth, have not taken place on the moon. — V. S. N.

186-88. Gilvarry, J[ohn] J. Origin and nature of lunar surface features: Nature, v. 188, no. 4754, p. 886-891, 1960.

It is shown that the origin and nature of the major surface features of the moon can be explained in terms of the former presence of a lunar hydrosphere. It is calculated that this hydrosphere lasted 1 billion years. The level floors of the maria were formed by sediments deposited from the water in the course of dissipation. The relative dimensions of the lunar craters can be explained by the progressive change in depth of the water, in which meteors exploded to form the craters.

The theory further has a direct bearing on the origin of tektites, as it provides argillaceous sediments and quartz particles of the necessary chemical composition. The dark color of the maria could be due to a small amount of organic carbon furnished by a postulated primitive form of life that existed in the lunar hydrosphere. The pattern of light and dark color in the mare basins, following the retreat of the seas, is a positive clue that life once existed there. The inferred presence of organic carbon would also easily explain Kozyrev's observation (see *Geophys. Abs.* 177-368) as the result of sublimation of carbon by the heat of a meteorite impact. — D. B. V.

186-89. Warner, Brian. Holistic approach to selenology: *Nature*, v. 191, no. 4788, p. 586, 1961.

The limitation to both the impact and the volcanic theories of formation of the lunar craters is that neither distinguishes between primary and secondary features of the lunar surface. Consideration of the lunar grid system shows that large-scale stresses have been applied to the surface during its history and have obliterated information pertinent to the origin of the craters. In addition, completely new types of features have arisen, such as rill and valley systems, some of which have erroneously been interpreted as primary features. When it is accepted that the valleys radial to the Mare Imbrium are nothing more than a slightly more prominent element of the general grid system, the collision hypothesis for the origin of the moon loses considerable weight. — D. B. V.

186-90. Jastrow, Robert. The exploration of the moon: *Sci. American*, v. 202, no. 5, p. 61-69, 1960.

Exploration of the moon may yield answers to fundamental questions about the nature and origin of the solar system and the universe at large. Such exploration is more important than that of other planetary bodies because of the moon's dead and changeless nature unaffected by processes of erosion and mountain building. Cosmic dust, unimpeded by atmosphere, has rained for eons to produce a biographical record of the solar system. Evidence on the temperature history of the moon will settle many questions as to the origin of the sun and planets, and measurements of irregularities in shape and of the distribution of density in the moon will be of help in this respect. More detailed pictures of the surface than those obtainable from the earth are necessary to help explain the nature of the surface features. Seismometers, X-ray fluorescence spectographs, gravimeters, ionosphere and plasma probes, density gauges, magnetometers, and television cameras landed by unmanned space vehicles and controlled from the earth will be used within a few years for exploration. The ultimate in unmanned craft may be a roving vehicle piloted by remote control. With the advent of manned flights, a decade or more hence, lunar exploration will enter upon its most rewarding phase. — V. S. N.

186-91. Brereton, Roy G. The lunar surface: *Geotimes*, v. 6, no. 2, p. 22-26, 1961.

The development of the constructional landforms of the moon is discussed from the viewpoints of the two contrasting theories of catastrophism—meteor

impact or a molten moon with consequent violent and global evolution of gases. Meteor impact has probably played an important part in the development of the lunar surface, but the formation of the diverse and grand constructional landforms displayed on the surface, and the division of the moon into dark-colored depressed areas (mares) and lighter-colored elevated areas (continents) is more likely related to an internal, fundamental magmatic process associated with the moon's early thermal history. The chief sources of heat available for heating the primal moon include radioactivity, meteor aggradation, and gravitational compaction. Secondary heat sources—meteor impact and faulting—triggered the near-surface magmatic phase that formed the lunar continents and mares, and contributed to the genesis of the whole lunar surface. The sequence of events relating to the thermal history of the moon is described in a table. It seems probable that an eruptive-lava complex composes most of the lunar surface and forms the bedrock that underlies more recently formed fragmental rocks and meteor dust. Because of the absence of a completed orogenic and weathering cycle on the moon, phanero-crystalline rocks will not be found exposed at the surface. The properties of the lunar surface are given in a table. The presence of a dust layer from 7 to 10 cm thick is suggested from astronomical observations and theoretical studies. — V. S. N.

- 186-92. Öpik, Ernst J. Tidal deformations and the origin of the moon: *Astron. Jour.*, v. 66, no. 2, p. 60-67, 1961.

A provisional survey of the ellipticities of lunar craters indicates that there are small preferential components of ellipticity which are interpreted as possible aftereffects of past tidal deformations. The smallness of the preferential effects is in itself significant and suggests that the craters were formed when the moon was 30,000-50,000 km distant from the earth.

Possible modes of origin of the moon are discussed in the light of theoretical rates of accretion based on probabilities of interplanetary collisions. If the pre-mare craters mark the end of a continuous process of accretion, the observed small systematic deformations mean that the moon could only have accreted from a cloud of fragments circling the earth in direct orbits at a distance of at least 5-8 earth radii.

If the preferential ellipticities are due to other causes or to chance, it is possible to accept the alternative that the moon accreted from interplanetary material orbiting the sun. Accretion must have run simultaneously with tidal evolution following initial tidal capture, the pre-mare craters having formed at a distance of more than 200,000 km from the earth as the final stage of this accretion. — D. B. V.

- 186-93. Asimov, Isaac. *The double planet*: New York, Abelard-Schuman Ltd., 158 p., 1960.

A popular account is given of how man has probed the nature of the earth and the moon and their relationship to each other from ancient times to the present. The following chapters are included: a sphere, not quite a sphere, the layers beneath, outside the crust, outside the air, the nearness of "nearest," we are pulled, we pull back, and airlessness. In appendixes 1 and 2 are given some specific facts about the physical measurements of the earth and moon. Appendix 3 is a table of important dates in the history of scientific investigation of the earth and moon. — V. S. N.

- 186-94. Hunter, W., and Parkin, D. W. Cosmic dust in Tertiary rock and the lunar surface: *Geochim. et Cosmochim. Acta*, v. 24, no. 1/2, p. 32-39, 1961.

The remains of cosmic spherules, consisting of the outer oxide coating, have been found in a Tertiary formation on Barbados. If it is assumed that cosmic dust has been falling at the same rate throughout geologic time as at present, than a thick uniform blanket should cover the moon's level surfaces and obscure all fine detail. Such monotony is not the case in some regions, however. It is proposed that meteorites have accompanied the dust and that their impact has continually blasted out fresh lunar rock; the powdered rock thus produced smothers the cosmic dust and the composition in any locality is much the same as that of the underlying rock. — D. B. V.

186-95. Öpik, E[rnst] J. The lunar surface as an impact counter: Royal Astron. Soc. Monthly Notices, v. 120, no. 5, p. 404-411, 1960.

The dust cover of the moon sticks to mountain slopes and cannot possess any degree of fluidity. Probably only a limited migration of dust into valleys takes place, caused by meteor bombardment. The material of micrometeorites is expected to form a layer of the order of 40 g per cm², accumulating over the maria and protecting them from further erosion by small meteors. Large meteors are not stopped by dust and produce craters; at a velocity of 20 kmps the ratio of crater to projectile diameter is about 20.

The surfaces of the lunar maria can be regarded as a counter which over the ages has registered the impacts of stray bodies and from which conclusions can be drawn as to the present distribution of diameters and number density of these bodies. The frequency distribution of 812 crater diameters in the western part of the Mare Imbrium (measured over an area of 465,000 km²) suggests that since the formation of the mare the population of interplanetary space has not changed appreciably. — D. B. V.

186-96. Diggelen, J. Van. Photometric properties of lunar crater floors: Observatoire d'Utrecht Recherches Astron., v. 14, no. 2, 114 p., 1960[?].

The composition of the lunar surface is investigated by means of measurements of its radiance under various conditions of illumination, especially from the lunation curves. In chapters 2-5 the results of the reduction of a number of photographic plates of the moon are discussed. The radiance of the floor of 36 craters was measured at 5 lunar phases by photographic photometry. The results are compared with each other and with results of similar work from other sources. For each crater the radiance is tabulated as a function of the phase of lunation; good agreement is found between the lunation curves of different authors. In chapters 6-9 theoretical explanations for the form of the lunation curve of lunar objects and laboratory apparatus for observation of radiance of materials and models are discussed. The last chapter summarizes all available evidence about the lunar surface obtained by different methods. All observations indicate the existence of a very porous surface layer, very probably due to the continual impact of numerous micrometeorites that reach the surface at their full cosmic velocity of 40 kmps. Most probably this layer is not dust but a solid melting crust formed by the high temperature at the moment of impact and with holes of all sizes, deeper than their diameters. Model studies show that a simplified geometrical description should not be adhered to strictly; it may be necessary to assume that the solid melting crust is covered with a thin coat of ashes. — V. S. N.

186-97. Brockamp, B[ernhard]. Zur hypsographische Kurve des Mondes [On the hypsographic curve of the moon]: Zeitschr. Geophysik, v. 26, no. 5, p. 271-272, 1960.

If the moon has had an evolution similar to that of the earth, and particularly if its crust has cooled over a long period, continental and oceanic blocks could have become differentiated and isostatically compensated; in that case, the hypsometric curve of the moon (on whose surface light and dark areas that probably correspond to different rock materials can be distinguished) would show two maximums like that of the earth. If, however, the moon's crust consists of more or less uniform primary matter, or if extensive differentiation and (or) isostatic compensation have not taken place because of too-rapid cooling, then a single peak would be likely. The investigations of Brockhaus and Joksch (see *Geophys. Abs.* 184-119) lead to an asymmetrical one-peak distribution; but as no reliable maps of moon elevations are yet available, and only old and inaccurate observational data can be referred to, no far-reaching conclusions should be drawn as yet. — D. B. V.

- 186-98. Yakovkin, A. A. Dvizheniye, vrashcheniye i figura Luny [Movement, rotation, and figure of the moon], in *Lunar [Moon]*: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 7-55, 1960.

The assumption that the moon is a solid body without a liquid or plastic core is supported by numerous observations pertaining to the motions of the moon. It is also accepted that its radius is 1,738 km, its density is 3.33 g per cm³, and its mass is 81.53 times smaller than that of the earth. The moon has an ellipsoidal figure with deviations from a sphere (Hopmann 1952) as follows: large axis, +8.8 km; intermediate axis, +1.1 km; and small axis, -4.7 km. Other recent investigators have shown the absence of symmetry of the figure of the moon with respect to its equatorial plane.

Detailed analyses and observations have shown considerable deviation, designated as physical librations, from Cassini's laws of rotation (1693) due to the nonspherical distributions of density inside the moon and earth. Additional deviations are designated as: optical libration in latitude, optical libration in longitude, topocentric libration, and geocentric libration. Other contributions to rotational theory are mentioned.

The mass of the moon can be determined by the influence of the moon on the rotation or on the orbital revolution of the earth. The first method is expressed in precession and nutation, and the second by inequalities of the earth's latitudes. Detailed theoretical treatments are given to problems of optical librations of the moon, determination of details of the lunar surface, corrections due to the relief of lunar edges, physical librations of the moon, and the figure of the moon. Suggestions are offered on the use of lunar observations for checking geodesy; also on the use of the moon for space navigation. — V. G. G.

- 186-99. Khabibullin, Sh. T. Lunnaya kartografiya i selenograficheskiye koordinaty [Lunar cartography and selenographic coordinates], in *Luna [Moon]*: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 57-75, 1960.

Selenographic coordinates, cartographic nets suitable for mapping the moon, and physical coordinates of the moon are explained in detail by sketches and formulas. Methods for determination of selenographic coordinates are developed analytically.

Reliable methods for making detailed and accurate maps and photographic atlases of the moon have been developed through the efforts of Galileo Galilei (1610), Van Langren (1645), Jan Geveli (1647?), Cassini (1692), Mayer (1775), Schroter (1800?), Lopman (1825?), Medler and Beer (1837), Schmidt (1878), Pikerig (1903), Saunders (1911), Huudaker (1995), and Wilkins (1946).

A method by which lunar explorers can determine their position on the moon is suggested and expressed in an analytical form. Numerous figures are given. — V. G. G.

186-100. Markov, A. V. Opisaniye lunnoy poverkhnosti [Description of the lunar surface], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 77-101, 1960.

The most prominent feature of the lunar surface is the presence of annular forms with diameters ranging from 1.5 to 250 km. In general, the lunar forms can be subdivided into the following classes: rows of cirques; cirque (or crater) seas; radial cirques and craters; parasitic craters; rows of craters; and cirques and phantom craters.

A very detailed description is given of the lunar forms with respect to their dimensions, shape, color, as well as physical properties such as albedo. Changes in appearance of the lunar surface are discussed briefly.

A hypothetical map of the unseen hemisphere of the moon, a map of lunar highs and lows, and numerous photographs of the moon's surface are given. A complete table gives the names of prominent surface features and their coordinates. — V. G. G.

186-101. Sytinskaya, N. N. Problema atmosfery Lunny [Problem of the atmosphere of the moon], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 103-124, 1960.

The existence of a lunar atmosphere can be verified by reflection and refraction phenomena. The atmosphere of a planet is in a stable state if, according to Jeans, $v_k < 1/5v_p$ where v_k is the kinetic velocity of a gas particle, and v_p is the parabolic escape velocity of a gas particle. The application of this formula to the physical conditions existing, or assumed to exist, on the surface of the moon indicates the absence of relatively light gases in its atmosphere; however, the explosion of meteorites striking the surface of the moon, volcanic activity, and radioactive disintegration may be sources of a small amount of gas. The most recent radioastronomical observations indicate the presence of an atmosphere on the moon, and the recent investigations by Edwards and Borst (1958) suggest that the atmosphere of the moon may contain small amounts of xenon and krypton. Refraction phenomena, however, lead to the conclusion that there is no atmosphere on the moon. Spectrographic investigations indicate the absence of an atmosphere or, if present, of magnitudes expressed in 10^{-9} atm. — V. G. G.

186-102. Barabashev, N. P. Fizicheskiye svoystva lunnoy poverkhnosti. 1: Albedo i tsvet lunnoy poverkhnosti [Physical properties of the lunar surface. Pt. 1: Albedo and the color of the lunar surface], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 125-156, 1960.

Evaluation of the albedo, brightness, and color of the lunar rocks is significant for determination of the rock types present. These optical characteristics are usually determined by photographic, colorometric, and spectrophotometric methods. Numerous investigations beginning with Pickering (1882) in the United States to Sharonov (1956) in U. S. S. R. have given their attention to such studies. By using the identical methods for determination of these parameters for terrestrial rocks and by comparing them with those obtained from the lunar investigations, the following rock types are indicated on the lunar surface: volcanic ash, basalt, red quartz porphyry, iron quartzite, and tuff. The lunar surface has considerable variations in color and

brightness; this indicates great variation in rock composition. Numerous tables, one colored photograph of the moon, and a list of 33 references are given. — V. G. G.

- 186-103. Markov, A. V. Fizicheskiye svoystva lunnoy poverkhnosti. 2: Polyarizatsionnyye svoystva lunnoy poverkhnosti [Physical properties of the lunar surface. Pt. 2: Polarization properties of the lunar surface], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 156-174, 1960.

After Arago's discovery (1811) that lunar light has certain polarization properties, Secki (1859) established that this polarization is due to the reflection of light from the solid lunar surface. Petrushevskiy (1873) was the first to give the analytical basis for application of polarization to determination of rock composition of the lunar surface. Lyot and his students in France (1929) made a detailed study of the polarization phenomenon that takes place on the earth and moon surfaces and arrived at the following conclusions: There is no chalk or clay on the moon; granites, porphyries, basalts, and quartz sands of the earth exhibit smaller negative polarization than the average polarization computed for the moon as a whole; natural (nonpulverized) lavas of Vesuvius exhibit larger albedos and maximum polarization magnitudes than those of the moon; and volcanic ash of Vesuvius of high albedo (~ 0.17) gives a maximum positive polarization somewhat similar to that of the lunar continents. — V. G. G.

- 186-104. Zel'tser, M. S. Fizicheskiye svoystva lunnoy poverkhnosti. 3: Temperatura lunnoy poverkhnosti [Physical properties of the lunar surface. Pt. 3: Temperature of the lunar surface], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 174-202, 1960.

Radiation energy (E) received by the moon from the sun can be expressed by the following formula: $E - E_r - E_c - E_e = \eta \sigma T^4$; where E_r is the reflected radiation energy; E_c is the thermal conduction radiation energy; E_e is the radion energy of the moon; η is the coefficient of the efficiency of radiation at a given point on the lunar surface; σ is the Stefan-Boltzmann constant; and T is the temperature in K° of the surface of the moon. Apparatus for measuring lunar temperature usually consists of a spherical mirror, a filter system, and thermocouples.

Pettit and Mickelson (1930, 1934) were the first to make observations of temperatures and reflection properties (long waves) of the lunar surface as a function of the phase and height of the sun over the horizon. Van Vleck (1947), Sinton (1955, 1956), Yaroslavskiy (1957), Markov and Chistyakov (1960), Wesselnik (1948), Jaeger (1953), and others have made considerable contributions to the theory and accumulation of data.

At the onset of night the temperature of the lunar surface falls to $170^\circ K$, and after 14 days, in accordance with the theoretical considerations, should drop to $100^\circ K$. Below the surface the rate of cooling should be smaller and become negligible at depths ranging from 10 to 12 cm. It is estimated that cooling is responsible for the emission of energy equal to 109.8 calories per cm^2 in 14 days. — V. G. G.

- 186-105. Kaydanovskiy, N. L. Issledovaniye Luny pri pomoshchi radiometodov [Lunar investigations with the use of radio methods], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 203-240, 1960.

The intensity of radar signals reflected from the moon and observed on the earth depends on many factors such as intensity of the initial emission, sensitivity of the receiver, the area of the antenna, the effective areal scattering of the target, the noise powers of the receiver, the cosmic radiation, and the surface properties of the moon. Analytical formulas derived by many investigators are given here, and the data obtained are discussed.

One of the main purposes for using radar was to determine the distance to the moon with an error of less than 1 km. Detailed radar observations should also lead to correct evaluation of some of the lunar surface properties. Both the radar and radioastronomical methods in reality measure the heat waves emitted by the upper layer of the lunar surface. — V. G. G.

- 186-106. Khabakov, A. V. Kharakternyye osobennosti rel'yeva Lunny. Osnovnyye problemy genezisa i posledovatel'nosti razvitiya lunnykh formatsiy [Characteristic features of the relief of the moon. Basic problems in the genesis and gradual development of lunar forms], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 241-297, 1960.

The moon is characterized by the following features: a belt of broad depressions, traces of asymmetry in the lunar figure, and the presence of a triaxial configuration due to the gravitational attraction between the earth and moon. Lunar forms can be subdivided into the following classes according to size: planetary, megarelief, superrelief, macrorelief, mesorelief, microrelief, and infrarelief. Lunar forms can be subdivided according to age beginning with the oldest forms as follows: Ancient, pre-Altai, Altai, Ptolemaic, Oceanic, Copernican, and Recent.

The attempt is made to correlate the various lunar forms with time and mode of origin. Endogenic tectonomagmatic processes are accepted as responsible for 10 to 20 percent of the circular lunar mountains of Recent age. The Copernican period of lunar history was 2.5×10^6 - 5.0×10^6 yr in duration. — V. G. G.

- 186-107. Stanyukovich, K. P., and Bronshten, V. A. Rol' vneshnikh kosmicheskikh faktorov v evolyutsii Lunny [Role of external cosmic factors in the evolution of the moon], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 299-329, 1960.

Although the exogenic theory of the origin of lunar craters was proposed in 1846, the first basic contributions were made by Wegener in 1913. In spite of Wegener's contributions, numerous investigators such as Khabakov (1949), Spurr (1944), Bülow (1957), and others have supported the endogenic theory as responsible for the origin of the majority of the lunar surface forms. During the last decade Baldwin (1949), Urey (1956), Stanyukovich (1947, 1950, 1955), and others have contributed greatly to the support of the exogenic theory. The followers of the endogenic origin of the lunar forms, such as Khabakov, recognize the meteoric origin of the lunar "micro" craters. Numerous curves, photographs, tables, and a list of 22 references are given. — V. G. G.

- 186-108. Sharonov, V. V. Priroda lunnoy poverkhnosti [Nature of the lunar surface], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 331-364, 1960.

Some of the physical properties of the lunar surface as determined by reflected light and radar waves are: The lunar surface is covered everywhere

with black material; the differences in color on the moon are very small; the maximum intensities of reflected solar light are toward the sun independently of the angle of incidence of the solar radiation; the light reflected from the lunar surface is partially polarized; the lunar atmosphere, if existent, is physically insignificant; thermoelectrical measurements of changes in temperature during lunar eclipses indicate a very low conductivity of the uppermost layer of the lunar surface; and the lunar surface is always under the action of cosmic radiation.

Detailed descriptions and evaluations are given of the following hypotheses: fresh surfaces of lunar magmatic rocks; change in mineral coloration under the influence of radiation; lunar zone of weathering and sedimentary rocks; lunar layer of meteoric material; and the meteor-slag hypothesis. Several tables, diagrams, and a list of 74 references are given. — V. G. G.

- 186-109. Markov, A. V. Zaklyucheniye [Conclusion], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 365-377, 1960.

The space vehicles sent to the moon on January 2, 1959, September 12, 1959, and October 4, 1959 indicate the almost complete absence of a lunar magnetic field and the presence of sparse accumulations of cosmic particles at a distance of 10,000 km from the moon.

A careful study of the material collected in this book as a whole indicates: The Gold hypothesis pertaining to the presence of lunar dust layers of depths up to several tens of meters is absolutely wrong; it is probable that basic rocks are exposed in the lunar mountains; large variations in lunar temperature and the presence of certain lunar activities should generate fissures of large and small dimensions; the existence of negative polarization and poor conductivities might indicate the presence of fine-grained surface rocks with a thickness not less than 5 cm; assuming the meteor-slag hypothesis is correct, the uppermost crust of the moon must be accepted as composed of material that is harder than powder; intensive application of powerful telescopes, radar, and thermoelectric methods for lunar investigations should give valuable information; and the use of space platforms should increase the usefulness of the methods based at present on the earth. — V. G. G.

- 186-110. Lipskiy, Yu. N. Charting the hidden side of the moon: Sky and Telescope, v. 21, no. 3, p. 133-139, 1961; translated from Astron. Zhur., v. 37, p. 1043-1052, 1960.

The techniques used in photographing the hidden side of the moon are described, and the methods of evaluating these photographs are discussed. A total of 499 objects were identified, about 100 of which are observable from the earth. The outlines and coordinates of many of the latter features were obtained more precisely than those given on existing maps. The two hemispheres are unlike in that there are no extensive depressions on the hidden side such as the Oceanus Procellarum and Mare Imbrium. Features on the far side are otherwise not different in nature from those on the visible side. Regions rich in bright craters occupy a large part of the hitherto unobserved side. There are also ray systems and mountain ranges. — J. W. C.

- 186-111. Academy of Sciences of the U. S. S. R. First photographs of the reverse side of the moon: Moscow, Foreign Languages Publishing House, 35 p., 1960.

The results of a preliminary study of photographs of the reverse side of the moon are discussed and the instrumentation described. The report is in four

chapters as follows: the design of the automatic interplanetary station, the interplanetary station in flight, taking and transmitting the photographs, and the hidden side of the moon. On the basis of this study it is seen that the reverse side of the moon is dominated by mountainous areas with few seas. The crater seas in the southern and equatorial regions are very conspicuous. These topographic features are identified on one of the photographs and in a sketch. — V. S. N.

- 186-112. Barabashev, N. P. Novyy etap izucheniya Luny [The new stage in the study of the moon]: Akad. Nauk SSSR Vestnik, no. 10, p. 32-36, 1960.

Knowledge of the moon secured by optical, radioastronomical, and cosmological means is summarized. — A. J. S.

- 186-113. Mikhaylov, A. A. Pervaya karta obratnoy storony Luny [The first map of the back side of the moon]: Akad. Nauk SSSR Vestnik, no. 1, p. 39-42, 1961.

A description of the process for obtaining the data and producing the map of the back side of the moon is presented. The surface features of the back side of the moon and the difference in surface structure of the back and the front sides are discussed. A map is included. — A. J. S.

- 186-114. Lipskiy, Yu. N. Izuchaya photographii... [Studying the photographs...]: Nauka i Zhizn', no. 3, p. 27-31, 1961.

Studies and interpretations of the photographs of the distal side of the moon taken from the U. S. S. R. interplanetary rocket on October 7, 1959 are reported. The conditions under which the photographs were taken are described, the instrumentation of the rocket is discussed, and the new method of treatment of negatives—the photometric profiles method—is explained. The types of lunar formations are discussed. — A. J. S.

- 186-115. Linder, I. Simposium "Luna" [Symposium, "the moon"]: Nauka i Zhizn', no. 3, p. 17-21, 1961.

This is a popular report on the "International symposium on the moon," held in Leningrad and Pulkovo in December 1960. Various aspects of selenology discussed at the symposium are presented briefly. — A. J. S.

- 186-116. Öpik, E[rnst] J. The aeolosphere and atmosphere of Venus: Jour. Geophys. Research, v. 66, no. 9, p. 2807-2819, 1961.

A self-consistent model of the Venus atmosphere that satisfies the multitude of existing observational data is proposed. The surface temperature of 570°K requires blanketing by dust particles. The term "aeolosphere" is proposed for the region between the surface and the clouds of Venus, where wind is responsible for grinding and raising the dust as well as for the heating. The dust may consist mainly of calcium and magnesium carbonates. — D. B. V.

EARTH CURRENTS

- 186-117. Vladimirov, N. P., and Kolmakov, M. V. O razreshayushchey sposobnosti magnito-telluricheskogo metoda [On the resolving power of the magnetotelluric method]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1598-1600, 1960.

The magnetotelluric method using variations of the natural electromagnetic field of the earth is studied with regard to its application to investigations of a geoelectric profile made up of horizontal layers of thickness h_1 , h_2 , and $h_3=\infty$ and having resistivities ρ_1 , $\rho_2 > \rho_1$, and $\rho_3 = \infty$. For such a section the magnetotelluric method has a better resolving power than the d-c resistivity method, provided the layers are thick. — A. J. S.

- 186-118. Shaub, Yu. B. Ob interpretatsii rezul'tatov izmereniy ugla naklona ploskosti polarizatsii yestestvennogo peremennogo magnitnogo polya [Interpretation of results of measurements of the angle of inclination of the polarization plane of a natural alternating magnetic field]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1771-1777, 1960.

As the natural magnetic field of the earth has an approximately circular polarization in the range of sonic frequencies with the plane of polarization parallel to the surface of the earth (see Geophys. Abs. 179-151), a conducting underground body can change the inclination of the polarization plane, and a geoelectric profile of the crust can be established. Variations in the inclination angle of the polarization plane are analyzed mathematically, and formulas are derived for spherical and cylindrical conducting bodies to determine the depth of the body from the surface, the radius of the body, its specific electric conductivity, and other auxiliary parameters. — A. J. S.

- 186-119. Vladimirov, N. P., and Nikiforova, N. N. K metodike interpretatsii krivyykh magnitotelluricheskogo zondirovaniya [On the method of interpretation of curves of magnetotelluric sounding]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 111-113, 1961.

Magnetotelluric profiling uses field fluctuations less than 0.1 cycles per second in studying the profile of the basement where it is buried at depths of several kilometers. Magnetotelluric sounding utilizes frequencies greater than 0.1 cycles per second both for study of the basement and for discrimination of the sediments overlying the basement. Procedures for interpreting experimental curves are outlined. The experimental curves are plotted on the same scale as theoretical curves. This permits the same interpretive procedure as that used with the d-c resistivity method. An example is presented from the Dnieper-Donets depression; the results are in full agreement with geological and geophysical ideas on the structure of this region. — J. W. C.

- 186-120. Lipskaya, N. V., Deniskin, N. A., and Yegorov, Yu. M. Rezul'taty elektromagnitnogo zondirovaniya v tsentral'noy oblasti Dneprovsko-Donetskiy vpadiny [The results of electromagnetic sounding in the central region of the Dnieper-Donets depression]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 407-411, 1961.

Investigations of microvariations of the natural magnetic field of the earth in the frequency range 0.005-1 cycles per second in the Dnieper-Donets depression are reported. The purpose of the investigations was to examine whether or not the earth's electromagnetic impedance could be used for constructing geoelectric profiles of the crust. The geological section here consists of 5 sedimentary formations 900-1,200 m thick with apparent resistivities $\rho_1 < \rho_2 > \rho_3 < \rho_4 > \rho_5$. The observations were made with a magnetostatic microvariometer, and the horizontal components of the field E_x , E_y , H_x , and H_y were recorded. The curves of apparent resistivity of the profile calculated from the data of the electromagnetic sounding were found to agree satisfac-

torily with a theoretically constructed curve but showed considerable scattering of the impedance values. This is explained by variations in the characteristics and location of the sources of the field. — A. J. S.

- 186-121. Kolmakov, M. V., and Vladimirov, N. P. K voprosu ob ekvivalentnosti krivyykh magnetotelluricheskogo zondirovaniya [On the problem of equivalence of magnetotelluric sounding curves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 544-552, 1961.

Defining the MTZ (magnetotelluric sounding) curves as equivalent where there is a practical coincidence of apparent resistivities for identical values of T-period variations of the natural electromagnetic field of the earth, the equivalence is analyzed on the basis of the equation of the equivalence and the curves for an electrically homogeneous half-space that has a high resistivity layer. The data for MTZ are compared with the equivalence principle in the method of vertical electric soundings. A suggestion is made to complement the MTZ method with the method of vertical electric sounding and other methods of electric prospecting in order to compensate for and remove the ambiguities of the results inherent in either method separately. — A. J. S.

- 186-122. Rösler, R. Erdstromregistrierung in Nordschweden [Earth current records in northern Sweden]: Arkiv Geofysik, v. 3, no. 4, p. 331-336, 1961.

Telluric current surveys in the Skellefte district of northern Sweden revealed that when the dimensions of an orebody are large, a phase displacement appears at low frequencies, generating an alternating current that constitutes a technical difficulty. This problem has been investigated by new measurements in the Kankberg and Näsleden areas (see Geophys. Abs. 178-174), using a method that differs from the usual methods in that it measures the potential drop over a stretch containing an orebody and another over homogeneous ground on the same profile.

Results are illustrated by reproductions of segments of the records obtained on certain nights. Quasi-periodic variations were clearly recorded on the nights of October 9, 10, and 11, 1955. These curves show a definite diminution of amplitude over the orebody, and in the records of October 10 and 11 the curves obtained over the orebody and those over the control stretch are opposite in phase. Further investigations will be necessary to explain these phenomena; the magnetograms of the Kiruna and Lovö stations for the days in question show no apparent special features. — D. B. V.

Barsukov, O. M. On the problem of three "velocities" of corpuscular streams. See Geophys. Abs. 186-487.

EARTHQUAKES AND EARTHQUAKE WAVES

- 186-123. Lomnitz, C[inna]. On thermodynamics of planets: Royal Astron. Soc. Geophys. Jour., v. 5, no. 2, p. 157-161, 1961.

A thermodynamic theory of planets is outlined. General results pertaining to irreversible processes are applied to the case of a steady-state system with constant temperature distribution. An "excited state" is defined by pressure perturbation introduced by an earthquake at the surface of the planet. The resulting transient flows toward the perturbed region are analyzed, and it is shown that the energy transient is logarithmic in time. An explanation of aftershocks as caused by local stress adjustments due to the influx of energy is a natural consequence of this theory.

The seismic process may also be viewed as an intermittent regulating device; in this case temperature can no longer be assumed to be constant. A condition of realizability of the earthquake problem is defined. If heat production of a planet falls below a certain amount, all seismic activity will cease. Conversely, in a series of planets of different sizes, all having similar heat productions and heat flow rates, there will be a critical radius below which no earthquakes can occur. The surface of such planets will be smooth and free of the scars of orogeny, and they will be devoid of atmosphere, oceans, and traces of past or present volcanic activity. — D. B. V.

- 186-124. Rothé, J[ean]-P[ierre]. Tableau de la sismicité du globe pendant l'année 1957 (Chronique séismologique) [Catalogue of the seismicity of the globe during the year 1957 (seismological chronicle)]: Rev. Étude Calamités, no. 36, p. 3-37, 1959.

In 1957 the International Bureau of Seismology studied 3,044 earthquakes, for which 2,201 epicenters were determined in contrast to the 2,727 epicenters for the two years 1955-56. The increase in the number of epicentral determinations is a direct result of the more active collaboration between stations and the International Bureau at Strasbourg brought about by the International Geophysical Year. The earthquakes that resulted in loss of human life are given in a table; the greatest catastrophes were located in Turkey, Mongolia, and Iran. As in previous chronicles, the major earthquakes of the year are listed in tables and grouped according to large orogenic regions of the world. Brief descriptions are given for the 333 earthquakes listed. — V. S. N.

- 186-125. MacCarthy, Gerald R. North Carolina earthquakes, 1958 and 1959, with additions and corrections to previous lists: Elisha Mitchell Sci. Soc. Jour., v. 77, no. 1, p. 62-64, 1961.

Only one earthquake occurred (March 5) within the boundaries of North Carolina during 1958; its epicenter was just off the coast near Wilmington. No earthquakes occurred in the state during 1959. Eleven nineteenth-century shocks are added to the state list and one (April 9, 1918) deleted (see Geophys. Abs. 171-65). — V. S. N.

- 186-126. Fischer, William A. Yellowstone's living geology—Highlights of Yellowstone geology with an interpretation of the 1959 earthquakes and their effects in Yellowstone National Park: Yellowstone Nature Notes, v. 33, 1959-60 Special Issue, 62 p., 1960.

The geologic history of the Yellowstone Park area is reviewed, and the changes produced by the earthquake of August 17, 1959, in the scenery and in the thermal activity in the park are discussed. The text includes the following 13 chapters: the causes of earthquakes, the mechanics of earthquakes, a glimpse into the past, early mountain building, Yellowstone's fiery past, the modern park unfolds, Yellowstone's structural framework, earthquake history of immediate area, earthquake water table effects around the world, a tour of the earthquake area, changing geysers and hot springs, summary, and a prediction for the future. The booklet is well illustrated with maps and pictures and has a glossary of technical terms and a bibliography. — V. S. N.

- 186-127. Nile, Stephen W. The Hebgen Lake earthquakes: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone—Earthquake Area, p. 24-30, 1960; also in De Re Metallica, v. 26, no. 3, p. 2-12, 1961.

The epicenters of the strong Hebgen Lake, Mont., earthquakes of August 17-19, 1959, and of the aftershocks were located in an area 70 miles from east

to west and 35 miles from north to south. The earthquakes of 1959-60 in this region of the Rocky Mountains occurred in the same parts of eastern Idaho, southwestern Montana, and extreme western Wyoming as have most of the strong earthquakes since 1869. Tables are presented to show a comparison of intensity, magnitude, and affected area for four strong Montana earthquakes, maximum accelerations recorded for several Montana earthquakes, and epicenter determinations from August 1959 to June 1960. An isoseismal map for the 1959 earthquake is shown in comparison with that for the earthquake of November 23, 1947. The focal depth of the initial earthquake (time of origin 06:37:15.0 G. c. t., August 18, 1959, location, lat 44°50' N., long 111°05' W.) is estimated at 10-12 km. Precise leveling by the U. S. Coast and Geodetic Survey has revealed that a section of Highway 287 four miles southeast of Hebgen Dam settled 18.86 feet. This is thought to be the greatest vertical displacement from an earthquake ever detected in the western United States by precise leveling. — V. S. N.

- 186-128. Witkind, Irving J. The Hebgen Lake, Montana, earthquake of August 17, 1959: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 31-44, 1960.

Repeated dropping and tilting of fault blocks has occurred in the Hebgen Lake area, Montana, since late Tertiary time. The earthquake of August 17, 1959, occurred when two fault blocks east of the Madison Range and one west of the Range dropped and tilted, synchronously reactivating the marginal normal faults. Prominent fault scarps appear to be coincident with or closely parallel to the reactivated faults; the major scarps, north of Hebgen Lake and facing southward, have a maximum displacement of about 20 feet near their midpoints. The subsidence and northward tilting of the fault block containing Hebgen Lake displaced the lake northward and produced a seiche that lasted for 11½ hr. Damage to Hebgen Dam was extensive and parts of former Highway 287 slid into Hebgen Lake; in places along the north shore, sand spouts were formed. A large earthflow near Kirkwood Canyon began moving about a week after the main shock, toppling trees and draining a lake. — V. S. N.

- 186-129. Hadley, Jarvis B. The Madison landslide: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 45-48, 1960.

One of the effects of the Hebgen Lake earthquake of August 17, 1959, was to trigger a massive rockslide in the lower part of the Madison River canyon six miles below Hebgen Lake. Thirty-seven million cubic yards of broken rock slid from an area half a mile long on the south side of the canyon and covered a mile of the canyon floor with debris to a maximum depth of 220 feet. Its momentum was sufficient to carry the leading edge of the slide 300 vertical feet up the opposite wall of the canyon. The determining conditions were structural and physiographic centering around a dolomite wedge and its effect on the stability of the fractured and weathered rocks on the slope above. The slide dammed the Madison River and created a lake which had attained a depth of 190 feet just above the slide 3½ weeks after the earthquake. — V. S. N.

- 186-130. Woodward, F. W. Red Canyon fault, Hebgen Lake, Montana, earthquake August 17, 1959: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 49-55, 1960.

The Red Canyon fault, which extends northwest for 14 miles from near the west boundary of Yellowstone Park approximately to the Hebgen Dam on Madison River, is a normal fault on the west side of a zone of high angle reverse

faults bordering the eastern flank of a large north tilted block; the zone dates from the Laramide orogeny. The Red Canyon fault zone is described and interesting phenomena resulting from reactivation of the fault by the Hebgen Lake earthquake of August 17, 1959, are discussed. — V. S. N.

- 186-131. McAleer, Joseph F. A rotational fault block in the Madison River earthquake area: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 56-60, 1960.

One of the smaller fault scarps resulting from the Hebgen Lake earthquake is described. The feature has upper and lower limbs which when considered as a unit form a classical rotational fault block. A small movement of this nature usually is classified as slump, but the fact that bedrock was broken in the face of the upper scarp definitely classifies it as faulting. — V. S. N.

- 186-132. Marler, George D. The 1959 Hebgen Lake earthquake alters Yellowstone's hot springs: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 61-66, 1960.

The 1959 Hebgen Lake, Mont., earthquake caused a noticeable increase in thermal energy in the hot-spring areas of Yellowstone Park. Springs along the Firehole River drainage were particularly affected, and, to a lesser degree, those on the Gibbon River drainage. The eastern sections of the park were little affected. In addition to a general increase in activity of geysers with predictable patterns of play, 160 springs with no record of previous geyser functioning erupted immediately following the initial earthquake. The waters in many springs changed from clear to muddy, and there were indications of a considerable lowering of the water table. On the morning after the initial shock the water in 363 springs had ebbed from a few inches to several feet. By the end of 1959 only nine springs showed no changes attributable to the earthquake. The causes of the changes in thermal activity are discussed, and some of the new geyser activity is described. The role of earthquakes in the origin of Old Faithful geyser is also discussed. — V. S. N.

- 186-133. Ball, R. M. The Madison earthquake and its effects: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 71-77, 1960.

The major effects on both man-made and natural structures of the earthquake of August 17, 1959, at lat 44°50' N., long 111°05' W., are discussed. The major landslide below Hebgen Dam and the resulting natural lake, changes in level of Hebgen Lake, Mont., damage to the dam and nearby roads, major faulting, "tidal" waves on Hebgen Lake, and the emergency engineering work carried out to prevent further disaster are described. — V. S. N.

- 186-134. Sanford, A. R., and Holmes, C. R. Note on the July 1960 earthquakes in central New Mexico: Seismol. Soc. America Bull., v. 51, no. 2, p. 311-314, 1961.

Earthquakes were felt in the Rio Grande valley in central New Mexico on July 22, 23, and 24, 1960. The strongest had a maximum intensity of 6 at La Joya. An average epicenter at lat 34°21.7' N. and long 107°2.6' W. was obtained on the basis of 28 smaller shocks recorded at Socorro. In addition to the direct P- and S-phases, the seismographs showed sharp phases approximately 0.35, 1.95, 5.50, and 7.80 sec after the direct P-phase. — D. B. V.

- 186-135. Cameron, J. B. Earthquakes in the northern California coastal region (pt. 1): *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 203-221, 1961.

P_n and S_n velocities are determined for earthquakes originating in the northern California coastal region. The existence of station delays at the Shasta, Mineral, and Reno seismic stations is proved for these earthquakes. A method of locating epicenters in this area is described, and epicenters are found for all large earthquakes that have occurred since the installation of the Corvallis station in 1950. The crustal structure inferred from the data from these earthquakes is as follows: the sedimentary layer, $V_{P_F}=5.1$ km/s, extends to a depth of 3 km; the granitic layer, $V_{P^*}=5.95$ km/s, extends to 24 km (Conrad discontinuity); the basaltic layer, $V_{P^*}=6.93$ km/s, extends to 29 km (the M-discontinuity); and the underlying mantle has a velocity of $V_{P_n}=7.98$ km/s. — D. B. V.

- 186-136. Hirono, Takuzo. The Chilean earthquake of 1960: *Jour. Geography* [Tokyo], v. 70, no. 3, p. 122-133, 1961.

The Chilean earthquake on May 22, 1960, is discussed and its effects described. The magnitude was determined by the Matsushiro Observatory as 8.75. The large tsunami generated by the earthquake created great damage from Chile to Japan, the first phase reaching the coast of Japan 22 hr after the earthquake. The largest phase attained a height of 5 m at Hachinohe and destroyed villages from Kiritappu in Hokkaido to Ago Bay in the Kinki district. — V. S. N.

- 186-137. Tillotson, E[rnest]. The Agadir earthquake: *Nature*, v. 190, no. 4771, p. 138-139, 1961.

This is a summary of a report by P. Erimesco that appeared in the *Inst. Pêches Maritimes Bull.* (Morocco), no. 5, 1960. An earthquake of unusually high intensity for the region (9-10) devastated the town of Agadir, Morocco, during the night of February 29, 1960 (origin time 23^h40^m12^s G. m. t.). The local estimate of focal depth was 3-7 km and of magnitude, 5.75-6. Calculated according to Karník's formula relating magnitude and intensity, and using values of $I_0=10$ and $h=5$ (I_0 =intensity at epicenter, h =focal depth) the magnitude is 6.48. Reports of sea floor changes (from 900 m to 15 m and from 90 m to 10 m depth) were later proved to be unfounded.

There is evidence of a most unusual phenomenon, namely an area of intense earthquake destruction practically on the shoreline and virtually no effect at sea—neither on the bottom nor as waves—except perhaps the rising of a shoal of zooplankton and a cloud of mud in the sea. This is explained by the local geology. Earthquake waves in the steeply dipping Cretaceous and Tertiary strata are propagated mainly in the solid rock and, by total reflection, literally channeled toward the outcrop of these strata on the coast. In the horizontally overlying unconsolidated and saturated Quaternary and Recent layers the shock wave energy is largely dissipated in the material and only locally can a fraction reach the surface of the sea. — D. B. V.

- 186-138. Panasenko, G. D. Zemletryaseniya na Kol'skom poluostrove 2 i 9.2, 1960 [Earthquakes of February 2 and 9, 1960 in the Kola Peninsula]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 4, p. 567-573, 1961.

Earthquakes occurred in the Kola Peninsula on February 2, 1960 at 12^h32^m and on February 9, 1960 at 21^h32^m Greenwich time. Their intensities were

5 and 3-4 points, depths of focuses 30 km, and 5 km, energies $E=10^{19}$ - 10^{20} ergs and 10^{14} ergs, and magnitudes $4.0 < M < 4.5$ and $2.5 < M < 3$, respectively. — A. J. S.

186-139. Tabulevich, V. N. Makhachkalinskoye zemletryaseniye v marte 1960 [Makhachkala earthquake of March 1960]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1612-1613, 1960.

An earthquake near Makhachkala on the western shore of the Caspian Sea on March 21, 1960 is described. The first shock occurred at $00^{\text{h}}02^{\text{m}}$ and the second at $00^{\text{h}}07^{\text{m}}$ Greenwich time. The epicenter was located at lat $42^{\circ}45'$ N. and long $47^{\circ}40'$ E. (24 km from Makhachkala). The magnitude was 4.5 and the greatest intensity was 6.5. The focal depth was approximately 8 km. — A. J. S.

186-140. Gorelikov, S. A. Ochagi zemletryaseniya v Irane [Sources of earthquakes in Iran]: Priroda, no. 12, p. 67-68, 1960.

An account is given of several strong earthquakes that occurred in Iran in the 18th, 19th, and 20th centuries, with reference to the five seismically active zones. — A. J. S.

186-141. Matumoto, Tosimatsu. Tesikaga earthquake of Jan. 31, 1959 (in Japanese with English summary): Tokyo Univ. Earthquake Research Inst. Bull., v. 37, no. 3, p. 531-544, 1959.

An earthquake of magnitude 6.2 occurred near Tesikaga on Hokkaido, Japan, at $5^{\text{h}}39^{\text{m}}$ (G. m. t.) on January 31, 1959. The focus was located at lat $43^{\circ}26'$ N., long $144^{\circ}23'$ E., 20 km depth. A foreshock of magnitude 5.6 had occurred in the same region at $16^{\text{h}}33^{\text{m}}$ on January 22. The Ishimoto-Iida formula $nA^{-m}=k$ held good over the wide amplitude range of these shocks; at Tesikaga the value of m was 1.91. Aftershocks were observed at Tesikaga and Okusy-unbetuby means of electromagnetic seismographs during the period February 14-March 1. The strongest aftershock occurred about 100 min after the main shock and had almost the same magnitude. The epicenters of the aftershocks, determined from the P-S time and an assumed true P-wave velocity, were found to be located only north of the zone of earthquake faults at the eastern foot of Mount Pekeru; the epicenter of the main shock was south of this fault zone. — D. B. V.

186-142. Bune, V. I., Gzovskiy, M. V., Zapol'skiy, K. K., Keylis-Borok, V. I., Krestnikov, V. N., Malinovskaya, L. N., Nersesov, I. L., Pavlova, G. I., Rautian, T. G., Reysner, G. I., Riznichenko, Yu. V., and Khalturin, V. I. Metody detal'nogo izucheniya seysmichnosti [Methods of detailed study of seismicity]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 9 (176), 327 p., 1960.

This is a monograph devoted to detailed study of seismicity. Seismic apparatus, new methods for large-scale determinations of coordinates of seismic focuses, and methods of determination of detailed structure of the earth's crust are described. Determination of seismic energy, analysis of the relationship between the seismic energy source and the prevalent seismic frequencies, and frequency-selective apparatus are described and discussed. Calculation of the magnitudes and of shifts within sources is treated. Methods of investigation of seismic activity and a comparison of the spatial distribution of seismicity with geologic structure of the region investigated are given. The above discussions are illustrated by seismic data of the Garm and Stalinabad regions. A bibliography of 272 titles is given. — A. J. S.

- 186-143. Solov'yev, S. L. Nekotoryye statisticheskiye raspredeleniya zemletryaseniy i tektonicheskoye stroeniye seysmicheskikh zon [Certain statistical distributions of earthquakes and the tectonic structure of seismic zones]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 25-32, 1961.

The statistical distribution of earthquakes in time and space, such as the relation between frequency of occurrence of strong and weak earthquakes and their distribution in the upper part of the mantle, may depend on geologic structure. An attempt is made to construct graphs of earthquake recurrence in the seismic zones of the U. S. S. R. from data of earthquakes of $M \geq 5$ or more during the period 1911-59. — A. J. S.

- 186-144. Kirillova, I. V., Lyustikh, Ye. N., Rastvorova, V. A., Sorskiy, A. A., and Khain, V. Ye. Analiz geotektonicheskogo razvitiya i seysmichnosti Kavkaza [Analysis of the geotectonic development and seismicity of the Caucasus]: Moscow, Akad. Nauk SSSR Inst. Fiziki Zemli, 340 p., 1960.

This book presents the results of geological-geophysical investigations by the Caucasus Geological-Geophysical Expedition since the middle of 1950. A detailed history of the geology of the Caucasus during the Cenozoic and Mesozoic eras is given, problems of tectonic regionalization are discussed, and gravimetric features are compared with geotectonic data. An historical survey of studies of the seismicity of the Caucasus, description of its regional seismicity, and an analysis of its seismic activity are given. A general analysis of seismic-tectonic data includes geologic criteria of seismic activity and a comparison of the latter with structure. The problems of preparing a new map (scale 1:1,000,000) of seismic regionalization are discussed, and the structure and seismicity of the Caucasus and of adjacent countries are compared. The bibliography contains 654 titles. — A. J. S.

- 186-145. Tskhakaya, A. D. Nekotoryye rezul'taty izucheniya zemletryaseniy Kavkaza [Some results of study of earthquakes in the Caucasus]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 1931-1936, 1961

The seismicity of various zones in the Caucasus within the territory of lat 38° - 46° N., and long 38° - 54° E. is described, and the distribution of earthquakes in this region is analyzed according to frequency and magnitude. — A. J. S.

- 186-146. Kirillova, I. V. O poperechnoy differentsiatsii sovremennykh tektonicheskikh dvizheniy v zone yuzhnogo sklona vostochnogo Kavkaza [Transverse differentiation of recent tectonic movements in the zone of the south flank of the eastern Caucasus]: Moskov. Obshch. Ispytateley Prirody Byull. Otdel Geol., v. 36, no. 1, p. 24-39, 1961.

Transverse flexures in the eastern Caucasus are traced by geomorphic means. The seismicity of the region is discussed in connection with explaining these movements, and a seismicity map is presented. — J. W. C.

- 186-147. Bulin, N. K., Bubnova, V. I., and Pronyayeva, Ye. A. O seysmichnosti Turkmenii i Severo-vostochnogo Irana v 1957-1959. [On the seismicity of Turkmenia and northeastern Iran in 1957-1959]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 534-540, 1961.

Instrumental data on 183 earthquakes that occurred in the Turkman S. S. R. and in northeastern Iran during 1957-59 are analyzed and synthesized. By

comparing the seismicity and the subsurface structure it was found that the focuses of earthquakes on the platform are distributed in general along mobile zones, that most of the epicenters are located in areas where the crust is 35-40 km or more thick, and that several platform earthquakes were located in zones of large horizontal gravity gradients. The weak earthquakes in these regions occurred in general during 1957-59 in zones where strong earthquakes have occurred in the past. — A. J. S.

- 186-148. Bune, V. I. Nekotoryye rezul'taty detal'nogo izucheniya seysmicheskogo rezhima stalinabadskogo rayona za 1955-1959 gg [Some results of detailed study of seismicity characteristics of the Stalinabad region for 1955-59]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 369-378, 1961.

The relationship of earthquake sources to the main faults was studied, the parameters of seismic activity rates compared for short-term and long-term observations, and maps of seismic activity compared with maps of isoseists based on microseismic data. — Author's abstract, A. J. S.

- 186-149. Fedotov, S. A., Aver'yanova, V. N., Bagdasarova, A. M., Kuzin, A. P., and Tarakanov, R. Z. Nekotoryye rezul'taty detal'nogo izucheniya seysmichnosti Yuzhnykh Kuril'skikh ostrovov [Certain results of a detail study of seismicity of South Kuril Islands]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 633-642, 1961.

A preliminary report is presented on the results of a geological and geophysical investigation in the region of the Kuriles, Kamchatka, Okhotsk Sea, and the deep Kuril Depression in 1957-59 to explore the transition zone between the continent and the ocean and to determine the seismicity of the southern part of the Kuril-Kamchatka Island Arc. The mean seismic wave velocities in the crust were found to be $\bar{v}_{s-p}=8.4$, $\bar{v}_p=6.1$, and $\bar{v}_s=3.5$ km/s. The mean velocities in the upper zone of the mantle under the islands and under the continental slope of the depression were determined as $\bar{v}_{s-p}=10.6$, $\bar{v}_p=7.8$, and $\bar{v}_s=4.5$ km/s, v_p/v_s diminishes at depths of 50-80 km, and $\bar{v}_p=8$ km/s prevails at the M-discontinuity. This indicates that v_p and v_s decrease with depth in the upper zone of the earth's mantle and leads to the conclusion that the anomalous drop in energy flux from focuses 70-100 km deep, measured at epicentral distances commensurate with depth, is caused by an intense absorption of seismic waves below a depth of 50-60 km. — A. J. S.

- 186-150. Miyamura, Setumi. Local earthquakes in Kii Peninsula, Central Japan. Pt. 2. A brief review of seismicity in Wakayama Prefecture based on intensity investigations [in Japanese with English summary]: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 4, p. 593-608, 1959.

Very small local earthquakes are often felt in the central part of Wakayama Prefecture that are not recorded at the two seismic stations located at the extremities of the Prefecture. These earthquakes, however, are recorded by the 20 intensity substations within the Prefecture. The mean annual number of earthquakes felt at these intensity substations has been calculated. Using these figures together with instrumental data, the details of the seismicity of the region are worked out. In some cases it is shown that the published epicenters should be shifted by as much as several kilometers when the intensity data are taken into account. This demonstrates the importance of the intensity reports in seismicity studies. It is urged that the intensity substations, now not always working efficiently, be strengthened throughout Japan (see also Geophys. Abs. 179-60). — D. B. V.

- 186-151. Miyamura, Setumi. Local earthquakes in Kii Peninsula, Central Japan. Pt. 3. Temporary seismological network in the neighborhood of Wakayama [in Japanese with English summary]: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 4, p. 609-635, 1959.

Instrumental and intensity observations reported in the first two parts of this work (see Geophys. Abs. 179-60 and 186-150) have suggested that seismic activity of the Kii Peninsula is concentrated along the coast between Wakayama and Gobo, and that the earthquakes are very shallow. Temporary seismological networks were established in the neighborhood of Wakayama in order to locate the focuses as accurately as possible and to investigate the geological implications of such supracrustal seismicity.

Special highly sensitive electronic seismographs had to be developed to record these very local earthquakes at more than 4 stations, as required for focal determination by the S-P method. Even then the number so recorded was very limited. The results show that the highest activity is near Wakayama and Kainan, and that shocks there may originate at depths of only a few km. — D. B. V.

- 186-152. Miyamura, Setumi. Local earthquakes in Kii Peninsula, Central Japan. Pt. 4. Location of earthquakes by the temporary network of stations near Wakayama (in Japanese with English summary): Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 1, p. 71-112, 1960.

Data obtained by the temporary seismic network on the Kii Peninsula in 1952-56 were analyzed in order to locate the epicenters of the shallow shocks occurring in that region. The geographic distribution of the epicenters is shown in a sketch map. In the northern three-fourths of the area, no earthquakes originated at depths greater than 10 km and many were extremely shallow. Focal depths seem to be somewhat deeper in the south, but owing to the small number of origins determined in that area, definite conclusions would be premature. No earthquakes were located with focal depths between 10 and 14 km; this suggests the possibility of a plastic asthenosphere in the crust.

Data and results of P- and S-arrival time analysis and S-P interval analysis for the 1956 observations by the least squares and by the simultaneous equations methods, and of S-P interval analysis for the 1952-54 observations by the graphical method are tabulated in full in English. (See also Geophys. Abs. 179-60, 186-150, -151.) — D. B. V

- 186-153. Kogan, S. D., Pasechnik, I. P., and Sultanov, D. D. Seysmicheskiye nablyudeniya v Antarktike [Seismic observations in Antarctica]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 231-237, 1961.

An interpretation of the results of seismic observations at the Russian seismic stations Mirnyy and Oazis in Antarctica from June 1956 to December 1959 are presented. The distribution of earthquake epicenters is compared with the geology of Subantarctica. On the basis of dispersion curves of Rayleigh and Love waves, a continental type crust is established for eastern Antarctica, and an oceanic type for the region situated between Antarctica and the ring of alpine folded structures encircling this continent. — Authors' abstract, A. J. S.

- 186-154. Buffington, P. G. Earthquake insurance in the United States—a reappraisal: Seismol. Soc. America Bull., v. 51, no. 2, p. 315-329, 1961.

For the benefit of seismologists, some of the major problems confronting the earthquake insurance underwriter are discussed and areas in need of further research and study are pointed out. The underwriter would be aided by more detailed information on individual earthquakes including specific information on the type of construction damaged, type of ground on which it was built, total dollar damage, and estimate of property values in high damage areas. Also needed is further evaluation of the relationship between intensity and frequency of occurrence and better analysis of damage caused by earthquakes of various intensities. — D. B. V.

MacDonald, G. J. Seismic activity of the moon. See *Geophys. Abs.* 186-87.

186-155. Ben-Menahem, Ari, and Båth, Markus. A method for determination of epicenters of near earthquakes: *Geofisica Pura e Appl.*, v. 46, p. 37-46, 1960.

A method is described that permits rapid and reliable determination of near epicenters (within 10°), using the differences in arrival times of a phase (usually S_g) common to a network of three stations. The equation for computing epicentral distances is solved numerically by an electronic computer for every triangle of stations and for all possible time differences for each wave used, and the results are arranged in tables which provide an immediate solution of the problem in each individual case.

The method is not intended to replace but to supplement other methods. Its accuracy is discussed, and precautions necessary in its use are emphasized. The method is then applied to some S_g records from Swedish stations by way of illustration. — D. B. V.

186-156. Val'dner, N. G. Godograph voln L_i , L_{g_1} , L_{g_2} , R_g [The traveltime curve of waves L_i , L_{g_1} , L_{g_2} , and R_g]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 6, p. 882-888, 1961.

The records of about 200 earthquakes were analyzed in a study of L_i , L_{g_1} , L_{g_2} , and R_g waves, and the L_g and R_g data were used for determination of epicentral distances. Distinct records of arrivals on the seismograms and a relatively short period of oscillation (2-10 sec) are characteristic for L_g and R_g waves that can propagate through an undisturbed granitic layer only. Sharp arrivals of L_g and R_g waves were found on 140 records, 6 of which are shown in the paper. Epicentral distances of several earthquakes were determined from traveltime curves constructed for L_g and R_g waves and found to be in satisfactory agreement with the epicentral distances determined by other methods. — A. J. S.

186-157. Kuznetsov, V. P. Godograf zemletryaseniy yugo-vostochnogo Kavkaza [Traveltime curve of earthquakes of southeast Caucasus]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 6, p. 889-891, 1961.

Traveltime curves constructed for earthquakes in the southeast Caucasus were found to be inaccurate for epicenter determinations. A correction for these traveltime curves is introduced. — A. J. S.

186-158. Andreyev, S. S. Primeneniye epitzentraly pri neizvestnom skorostnom razreze [Use of epicentrals with an unknown velocity section]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 7, p. 966-976, 1961.

Epicentral lines determined from the true traveltimes of seismic waves, when the velocity section is unknown, pass through the center of a circumference drawn through 3 stations. The coordinates of these epicentral lines with regard to the stations are determined by the value of the ratio K of the differences of the squares of the time. These K -epicentrals are used instead of epicentrals drawn according to the parameter q —the ratio of differences of the arrival times at the three stations. It was found that the K -epicentral method is more practical than the q -epicentral method when the small transformation error (from q to K epicentral lines) can be disregarded. — A. J. S.

186-159. Vvedenskaya, A. V., and Ruprekhtova, L. Osobennosti napryazhenogo sostoyaniya v ochagakh zemletryaseniya u izgiba Karpatskoy dugi [Features of the stress state at the focuses of earthquakes at the bend of the Carpathian Arc]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 953-965, 1961.

Analysis of distribution of stresses based on the theory of deformation forces as a symmetrical second rank tensor applied to the rupture and shear plane of an earthquake hypocenter is carried out for the earthquakes at the bend of the Carpathian Arc. The analysis shows that the compression forces in that region are almost parallel to the horizontal plane and act normally to the bend of the arc, whereas the tensile and intermediate forces are in the plane whose line of intersection with the earth's surface is tangential to the arc and coincides in strike with the axes of mountain folds in the region. The result obtained suggests a homogeneity in the tectonic structure of the region up to a minimum depth of 150 km. This is the depth of the hypocenters of the earthquakes analyzed. A further conclusion is made that the same forces that determine the relief and tectonics act also at the focuses of the earthquakes investigated. — A. J. S.

186-160. Vvedenskaya, A. V. K diskussii po povodu teoreticheskoy modeli ochaga zemletryaseniya [Discussion on a theoretical model of an earthquake focus]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 261-263, 1961.

This is a summary of Vvedenskaya's earlier published hypothesis of focal mechanism (see Geophys. Abs. 166-80, 172-142, 173-76, 183-142). A theoretical model is constructed based on a system of forces at the source that determine a symmetrical tensor of the second order of stresses at every point of the strained plane area at the source. — A. J. S.

186-161. Miyamoto, Sadao. Determination of the depth of earthquake hypocenter by means of Δ -PS curve [in Japanese with English abstract]: Zisin, ser. 2, v. 14, no. 1, p. 39-54, 1961.

The depth of the hypocenter of an earthquake can be determined from the P-S time at the epicenter estimated from its Δ -PS curve. Standard Δ -PS curves to be used for this purpose are presented. Many examples are given to show that this method of depth determination is superior to other methods. — V. S. N.

Hiersemann, L[othar]. Seismotectonics in the domain of young orogens. See Geophys. Abs. 186-363.

186-162. Belotelov, V. L., and Kondorskaya, V. O sootnoshenii mezhdu energiyey zemletryaseniya i maksimal'noy skorost'yu kolebaniy v ob''yemnykh volnakh [On the correlation between the energy of an

earthquake and the maximum rate of oscillations in body waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 38-45, 1961.

The relationship between the energy of an earthquake and the maximum oscillation rate of longitudinal and transverse waves is discussed. The values of the energy obtained earlier (see Geophys. Abs. 182-115) are compared with the values obtained with Gutenberg's formulas (see Geophys. Abs. 111-6710, 166-78, 167-68). It was found that $\log E = 11.8 + 1.5M$, in agreement with Gutenberg's formula. The maximum ratio of amplitude to period $(A/T)_{\max}$ is studied for deep and surface earthquakes; agreement is found with the result obtained in previous investigations, that is, $(A/T)_{\max}$ decreases with distance at a rate less than is expected. An attempt is made to explain this difference by an assumption that the absorption coefficient of body waves decreases with depth. — A. J. S.

186-163. Miyamoto, Sadao. The mean radius of felt area is better than the maximum radius for earthquake classifications [in Japanese with English abstract]: Zisin, ser. 2, v. 14, no. 1, p. 29-32, 1961.

It is shown that because the seismic intensity at stations in a region of abnormal gravity is abnormal also, the mean radius of a felt area is better fitted for the classification of earthquakes than is the maximum radius. — V. S. N.

186-164. Miyamoto, Sadao. Relation between the magnitude and radius of felt area of earthquakes [in Japanese with English abstract]: Zisin, ser. 2, v. 14, no. 1, p. 33-38, 1961.

It is shown that in the case of large earthquakes ($M > 7$), magnitude can be estimated from the mean radius of the felt area. — V. S. N.

186-165. Berg, G. V., and Housner, G[eorge] W. Integrated velocity and displacement of strong earthquake ground motion: Seismol. Soc. America Bull., v. 51, no. 2, p. 175-189, 1961.

Earthquake ground accelerations recorded at El Centro, Calif., on December 30, 1934 and May 18, 1940; at Olympia, Wash., on April 13, 1949; and at Taft, Calif., on July 21, 1952 have been integrated with a digital computer to obtain at each location the three components of ground velocity and ground displacement. Maximum horizontal displacements of 10 and 20 in. and maximum vertical displacements of 5 in. are indicated. — D. B. V.

186-166. Stauder, William, and Adams, W[illiam]M[ansfield]. A comparison of some S-wave studies of earthquake mechanisms: Seismol. Soc. America Bull., v. 51, no. 2, p. 277-292, 1961.

Graphical and analytical techniques for using S-waves in focal mechanism studies are compared. In previous applications the analytical method has shown little or no agreement with the results of fault plane solutions from P-waves, whereas for other groups of earthquakes the graphical methods have shown good agreement between S-waves and P-wave solutions. It is shown that both techniques are identical in principle and when applied to the same three earthquakes yield identical results.

Closer examination of the graphical presentation of the data shows that the disagreement between the S-waves and the fault plane solutions from P is largely apparent. Once it is understood that the discrepancy stems from the peculiar scatter in the S-wave data and the chance occurrence of observations of S at stations located along closely parallel planes of polarization of S, it is

seen that the direction of polarization of S-waves is in substantial agreement with the methods of analysis of focal mechanisms from P-waves, and that the data are consistent with a simple dipole as the point model of the earthquake focus. — D. B. V.

- 186-167. Shirokova, Ye. I. O napryazheniyakh deystvyuyushchikh v ochagakh zemletryaseniy Sredney Azii [On the stresses acting at the focuses of earthquakes in central Asia]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 876-881, 1961.

From the study of seismograms of 12 earthquakes of $M \geq 5$ in central Asia from 1954 to 1958 and from the determination of displacement fields in P- and S-waves caused by these earthquakes, two possible fault planes at the earthquake focuses, their displacements relative to each other, and the orientation of the main stress axes were determined. The compressive stresses were almost perpendicular to the strike of the mountain ridges and had a large horizontal component. The axes of tensile stresses were largely vertical. One of the possible fault planes coincides with the strike of the ridges and other large geologic features. — A. J. S.

- 186-168. Ichikawa, M. On the mechanism of the earthquakes in and near Japan during the period from 1950 to 1957: Geophys. Mag. [Tokyo], v. 30, no. 3, p. 355-403, 1961.

The mechanism of 43 earthquakes that occurred in and near Japan during 1950-57 has been investigated, mainly on the basis of first motions of P-waves. The relations between distribution of focuses, directions of maximum pressure and tension, strikes and dips of fault planes, and directions of fault movement and of the null vector have been analyzed statistically. It is found that the directions of the horizontal component of maximum pressure are nearly perpendicular to the trend of the Japan Trench and the seismic zones. The directions of maximum tension of deep and intermediate earthquakes are nearly parallel to the trench, whereas for shallow earthquakes they are almost perpendicular to the trench in central Honshu and nearly parallel to it in western and north-eastern Honshu. For the vertical component of maximum pressure there are two patterns, the first almost perpendicular to the trend of the vertical distribution of earthquake focuses and the second nearly parallel to it. These patterns agree with Honda's results (see Geophys. Abs. 170-48, -55). — D. B. V.

- 186-169. Bogdanoff, John L., Goldberg, John E., and Bernard, M. C. Response of a simple structure to a random earthquake-type disturbance: Seismol. Soc. America Bull., v. 51, no. 2, p. 293-310, 1961.

A physically plausible second order random function is selected to represent ground acceleration. Several member functions are presented in graphical form. Some of the statistical properties of the response of a simple structure to this acceleration are determined, and possible uses of these properties by designers of aseismic structures are discussed. To render the random function approach, as outlined here, useful to such designers, records of earthquakes at given places must be analyzed statistically and continually corrected as new earthquakes occur; the analysis presented here must be extended to multistoried structures; and simple approximate expressions for the probabilities of failure must be obtained. — D. B. V.

- 186-170. Sato, Yasuo, and Yamaguchi, Rinzo. Coupling effect of shear vibrations of the structure with elastic foundations, and the maxi-

imum response of the rocking motion [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 3, p. 127-140, 1960.

The shear vibration of a continuous circular column excited by ground motions is discussed. The coupling effect of the vibrating body and the elastic foundation is taken into account, and the calculations are based on the theory of Toriumi (1955). Maximum values of the response curves of rocking motion are given taking various values of the ratio (density of structure)/(density of foundation). Empirical formulas are presented that are true for the parameters giving maximum response. — V. S. N.

- 186-171. Yamaguti, Seiti. On the changes of heights of mean sea-levels, before and after the great earthquakes: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 1, p. 145-175, 1960.

The monthly mean sea levels observed at different mareographic stations in Japan over periods ranging from 5 to 60 yr were corrected, smoothed, and plotted against the months on a diagram that also shows the months of great earthquakes ($M \geq 7$) at epicentral distances of >200 , >300 , >400 , and >500 km. The results show that sea level fluctuations began about 6 months before and reached a maximum about 4 months before and a minimum about 1 or 2 months before a great earthquake. In many cases mean sea levels were negative in the month of the earthquake.

Yearly mean sea levels were similarly plotted. There is no apparent increase in sea level height, only a slight 18-yr fluctuation about the secular mean of 40 yr. The apparent increase in the total mass of ocean water noted by oceanographers would probably vanish if their results were corrected for oceanic and meteorologic tides; a small subsidence of the crust relative to mean sea level would probably be observed on some coasts. — D. B. V.

- 186-172. Kanai, Kiyoshi. An empirical formula for the spectrum of strong earthquake motions: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 1, p. 85-95, 1961.

One of the empirical formulas developed in a previous paper (see Geophys. Abs. 176-62) is improved and applied to 1 Japanese and 19 United States earthquakes for which strong-motion observations are available. Three equations are derived (for spectral displacement in cm, for velocity in cm per sec, and for acceleration in cm per sec²), applicable to the determination of ground motion characteristics for purposes of structural design. The magnitudes and epicentral distances of anticipated earthquakes may be estimated from seismicity statistics, and thus an approximate spectrum of seismic waves in bed rock can be obtained. If this spectrum is combined with the vibration characteristics of the ground at the structure, the lateral force coefficient can be determined. — D. B. V.

- 186-173. Kanai, Kiyoshi, and Tanaka, Teiji. On microtremors. VIII: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 1, p. 97-114, 1961.

The results of systematic measurements of microtremors at thousands of places in Japan (see Geophys. Abs. 164-251, 171-297) show that these disturbances, chiefly of artificial origin, have a period distribution curve at any given place that reflects the local nature of the ground and are similar to earthquake motions at that place. Therefore, microtremor measurement is useful not only for anticipating the features of destructive earthquake motions but also for determining the seismic force coefficient to be considered in earthquake-proof construction design. — D. B. V.

- 186-174. Tanabashi, Ryo. On the safety of structures against earthquakes: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 35, 19 p., 1960.

The relation between the grade of damage to engineering structures and the nature of the ground in an area affected by an earthquake is discussed for 9 major Japanese earthquakes that have occurred since January 1924. Results indicate that except for shallow focus local earthquakes, the specific frequency of seismic wave found to predominate in an earthquake area depends upon the property of the ground. To develop criteria on the grade of damage to be expected in various areas, the elastic properties of the ground in areas of known damage have been investigated by seismic surveys and the results applied to other areas. Contour maps of probable future damage have been made for cities such as Kyoto, Osaka, and Nagoya.

A table showing percentage of damage to structures of various types in the Tokyo earthquake of 1923 is presented, and the significant factors in the mechanical properties of building materials necessary to ensure safety against seismic action are discussed. Earthquake-resistant designs should require that a structure be able to store a potential energy greater than $\frac{1}{2}MV^2$ for an assumed velocity of probable ground motion. Various examples are given, and the types of building materials most suitable for Japan are discussed. — V. S. N.

- 186-175. Tanabashi, Ryo. Earthquake resistance of traditional Japanese wooden structures: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 40, 15 p., 1960.

The natural earthquake resistance of the Japanese pagoda and of the traditional and modern Japanese wooden structures is analyzed. It is shown that the safety of a structure in an earthquake depends both upon its strength in a lateral direction and upon its ability to absorb a large amount of deformation. It is important that the period of vibration of the structure be longer than that of the ground acceleration to prevent the possibility of resonance with the ground acceleration waves. — V. S. N.

- 186-176. Goto, Hisao, and Kaneta, Kiyoshi. Analysis with an application to aseismic design of bridge piers: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 41, 17 p., 1960.

The response of a bridge pier on an elasto-plastic foundation subjected to idealized, transient ground motions has been analyzed theoretically by using an electronic analog computer equipped with a nonlinear backlash element to simulate the specific vibration system. The results indicate the great importance of consideration of damping capacity as well as ground-motion duration and acceleration in the aseismic design of bridges; in current aseismic design criteria only the maximum value of earthquake acceleration is taken into account. — V. S. N.

- 186-177. Austin, Charles R. Earthquake fluctuations in wells in New Jersey: New Jersey State Dept. Conserv. and Econ. Devel. Div. of Water Policy and Supply, Water Resources Circ. 5, 13 p., 1960.

About 200 sudden fluctuations of well water levels as observed since 1950 on records of water-stage recorders in 38 wells in New Jersey have been correlated with earthquakes. A table lists the wells with their geographic and geologic location and the number of fluctuations observed for each. These earthquake fluctuations range in amplitude from a trace to 2.66 feet, and the

magnitudes of the earthquakes are generally ≥ 7.0 . Disturbances have been caused by shocks of magnitude < 7 , but in all such cases the epicenters were relatively close to New Jersey. The study of earthquake fluctuations in wells is relatively new, and new methods for determining geologic formations, faults, and density of materials may result if the program is intensified. — V. S. N.

Gougenheim, André. Confirmation by observation of the negligible role of the earth tide in the production of earthquakes. See *Geophys. Abs.* 186-221.

- 186-178. Eaton, J[erry] P., Richter, D. H., and Ault, W[ayne] U. The tsunami of May 23, 1960, on the island of Hawaii: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 135-157, 1961.

The tsunami of May 23, 1960, caused by the Chilean earthquakes, resulted in the greatest natural disaster in Hawaii since the Aleutian-born tsunami of 1946. Study of the T-phases from the earthquakes suggests that the duration of faulting responsible for the largest earthquake and the tsunami was about 7 min. The waves of the tsunami and the destruction caused by them are described.

It is concluded that earthquake waves generated by a crustal disturbance capable of producing a tsunami reach Hawaii minutes after the disturbance and carry vital data permitting calculation of origin time, location, and magnitude of the earthquake, and that the seismogram can also give valuable evidence on depth, proximity to the ocean, and nature of fault movement. Every effort should be made to achieve fullest interpretation of the seismogram in order to establish the likelihood and possible size of a tsunami. Location of the origin seems to be one of the major factors in determining which areas will be most affected by a tsunami and how great the damage might be. Tsunami with about the same geographic origin produce remarkably similar wave-height patterns that differ only in relative amplitude, whereas those from different regions produce contrasting patterns. Empirical ratios between wave heights at critical gaging stations and average measured wave heights for various sections and localities on Hawaii appear to offer the best basis for tsunami wave-height forecasting. — D. B. V.

- 186-179. Gilmour, A. E. Tsunami warning charts: *New Zealand Jour. Geology and Geophysics*, v. 4, no. 2, p. 132-135, 1961.

Two charts have been constructed to assist in predicting the travel times of tsunami waves reaching the New Zealand coast from known origins. If the time and location of the generating earthquake are known, the initial wave arrival times at various points on the coast lying in the direct path of the tsunami can be estimated within a time of approximately one hour. — Author's abstract

- 186-180. Ochapovskiy, B. L. Ob organizatsii na Dal'nem Vostoke spetsializirovannykh stantsii sluzhby tsunami [On the organization of the specialized stations of the tsunami service in the Far Eastern Region]: *Akad. Nauk SSSR Sovet po Seysmologii Byull.*, no. 9, p. 5-6, 1961.

The plans for a tsunami warning system in the Far Eastern Region of the U. S. S. R. are described briefly. — D. B. V.

- 186-181. Popov, G. I. Ob usloviyakh obrazovaniya tsunami [On the conditions of formation of tsunami]: *Akad. Nauk SSSR Sovet po Seysmologii Byull.*, no. 9, p. 7-22, 1961.

The results of investigations in the U. S. S. R., Japan, and elsewhere concerning the conditions that give rise to tsunami are reviewed. — D. B. V.

- 186-182. Solov'yev, S. L., and Ferchev, M. D. Svodka dannyykh o tsunami v SSSR [Summary of data on tsunami in the U. S. S. R.]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 9, p. 23-55, 1961.

This is a catalog of tsunami that have occurred in the U. S. S. R. (Far Eastern Region) since 1737. — D. B. V.

- 186-183. Brune, James N., Benioff, Hugo, and Ewing, Maurice. Long-period surface waves from the Chilean earthquake of May 22, 1960, recorded on linear strain seismographs: Jour. Geophys. Research, v. 66, no. 9, p. 2895-2910, 1961.

Phase and group velocities of mantle Love and Rayleigh waves obtained from strain seismograph records of the Chilean earthquake are presented. The velocities of mantle Rayleigh waves of period from 300 to 550 sec agree with those predicted from periods of free spheroidal oscillation of the earth and do not show a flattening of the group velocity curve for periods greater than 380 sec. Group velocities for mantle Rayleigh waves reach a maximum of 7.8 kmps at a period of about 1,000 sec. Study of initial phases of Rayleigh waves indicates a difference of phase of π between the azimuth to Isabella and the azimuths to Ñaña and Ogdensburg. Determinations of phase and group velocities of Love waves have been extended to periods of 700 sec. The phase velocity data of Sato [see Geophys. Abs. 174-61] have been corrected for the polar phase shift. The correct curve has been identified from the numerous possible curves which result from a 2π ambiguity in the phase correlation made by Sato. Values of phase velocities are presented for periods in the range of 60-700 sec. The group and phase velocities of both Love and Rayleigh waves agree well with those predicted for the Gutenberg-Bullen A model of the earth. It is verified that analysis of seismograms in terms of progressive wave trains is equivalent to analysis in terms of standing waves. In the presence of adsorption, as for the earth, the analysis in terms of progressive wave trains has many advantages. — Authors' abstract

- 186-184. Alsop, Leonard E., Sutton, George H., and Ewing, Maurice. Measurement of Q for very long period free oscillations: Jour. Geophys. Research, v. 66, no. 9, p. 2911-2915, 1961.

The radical amplitude variation with time of long-period spectral peaks corresponding to the periods of free oscillation [see Geophys. Abs. 184-187] is explained. It arises from the rotation of the corresponding standing wave pattern with respect to the earth. The modulation caused by this rotation imposes certain conditions on the length of record and the interval between records used to measure Q by observing the amplitude decrement. Under these conditions the Q for the ${}_0S_2$ mode is measured to be 370, and for the ${}_0T_5$ mode, Q is measured to be about 300. These values are contrasted with other values of Q obtained by various authors for other free periods. Q appears to be constant for modes ${}_0S_2$ through ${}_0S_9$. — Authors' abstract

- 186-185. Takeuchi, H[itoshi], and Kobayashi, N[aota]. Free spheroidal oscillations of the earth: Seismol. Soc. America Bull., v. 51, no. 2, p. 223-225, 1961.

Free periods of the earth's spheroidal oscillations are calculated for the wave numbers n up to 16; the earth's sphericity, self-gravitation, and a liquid

core are taken into account. Period-wave number and period-phase number velocity relations are shown in graphs. — D. B. V.

- 186-186. Backus, George, and Gilbert, Freeman. The rotational splitting of the free oscillations of the earth: [U. S.] Natl. Acad. Sci. Proc., v. 47, no. 3, p. 362-371, 1961.

In the Fourier spectrums of records of the free oscillations of the earth excited by the Chilean earthquakes of May 1960 (see Geophys. Abs. 181-119, 184-183) some of the observed peaks appeared to be double or triple, the components being separated by as much as two minutes and the theoretical line falling approximately at their mean position. This splitting is shown mathematically and quantitatively to be an effect of the diurnal rotation of the earth.

Agreement between the observed and predicted periods of the spheroidal spectral lines is very good. Failure of the records to show splitting of the torsional lines is probably due both to limited resolution and to natural broadening of the lines by dissipation. The observed amplitudes of excitation of the split lines remain to be explained. — D. B. V.

- 186-187. Jobert, Nelly. Calcul approché de la période des oscillations sphéroïdales de la Terre [Approximate calculation of the period of the spheroidal oscillations of the earth]: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 242-258, 1961.

The first part of this paper treats spheroidal oscillations of the earth in the absence of gravity. The effect of the core is considered and the exact solution is obtained for a sphere with a homogeneous liquid core and homogeneous solid mantle having the average properties of the earth's core and mantle, respectively. By application of the Rayleigh principle according to a method of Jeffreys, an approximate value of 66.3 min is obtained for the period of vibration for Bullen's model A.

In the second part gravitation is taken into account in a series of models of increasing complexity. Using the Rayleigh principle, an approximate value of 51.8 min is obtained for the period of vibration of Bullen's models A and B. — D. B. V.

- 186-188. Alterman, Z., Jarosch, H., and Pekeris, C. L. Propagation of Rayleigh waves in the earth: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 219-241, 1961.

This is the same paper as that published in Rehovot, Israel, Weizmann Institute, Department Applied Mathematics, 11 p., 1961 (see Geophys. Abs. 184-184). — D. B. V.

- 186-189. Oliver, Jack [E.]. On the long period character of shear waves: Seismol. Soc. America Bull., v. 51, no. 1, p. 1-12, 1961.

S and multiple S phases at moderate to large epicentral distances are frequently followed by normally-dispersed long-period wave trains for which surface particle motion is elliptical and progressive and in the plane of propagation of the SV wave. The character of such phases can be explained as the result of coupling between the incident shear waves and dispersive PL waves in the near-surface wave guide. A detailed study of shocks in Mexico and in Montana recorded at Resolute, and less detailed studies of other data support this hypothesis. — Author's abstract

- 186-190. Nuttli, Otto [W.], and Whitmore, John D. An observational determination of the variation of the angle of incidence of P waves with

epicentral distance: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 269-276, 1961.

Apparent angles of incidence of the P-wave were obtained from seismograms of the Galitzin-Wilip instruments at Florissant, Colo. The "half-periods" of these waves ranged from $1\frac{1}{2}$ to $3\frac{1}{2}$ sec and the epicentral distributions from 16.5° to 103.2° . The data indicate that the velocity of P-waves at the earth's surface is about 8 km/s, suggesting that these P-waves do not see or are not affected by the crust. P-wave data for the Alaskan earthquake of July 1958 from 5 other stations throughout the world support these conclusions. — D. B. V.

186-191. Båth, Markus. Polarization of transverse seismic waves: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 106-123, 1961.

Changes in polarization of transverse waves during propagation through the earth are investigated. The polarizations have been computed theoretically and numerically for reflection at the core boundary and at the earth's surface, for refraction and reflection at the base of the crust, and for passages through continuously varying mediums. It is shown that great changes of vibration angle and particle orbit may occur in all cases except for continuously varying mediums; in these, transverse waves propagate practically unchanged.

Applied to earthquake mechanism studies using S-waves, these results mean that observations of direct S-waves are most trustworthy, and that in using ScS, sS, SS, or other transverse waves the changes of the vibration angle on reflection at the core boundary or earth's surface must be taken into account. — D. B. V.

186-192. Caloi, Pietro. Seismic waves from the outer and the inner core: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 139-150, 1961.

New formulas for the determination of seismic wave traveltimes in the interior of the earth are derived and applied to the calculation of traveltimes of ScS waves from the shallow Aegean earthquakes of April-June, 1957, which were recorded with exceptional clarity at the Tolmezzo seismic station. The same records also clearly showed PKiKP waves, reflected from the inner core. — D. B. V.

186-193. Hai, Nguyen. Propagation des ondes longitudinales dans le noyau terrestre d'après les séismes profonds des Iles Fidji [Propagation of longitudinal waves in the earth's core after the deep earthquakes of the Fiji Islands (with English and Russian abstracts)]: *Annales Géophysique*, v. 17, no. 1, p. 60-66, 1961.

Results of a study of the traveltime curves for longitudinal waves traveling through the earth's core from three earthquakes originating in the Fiji Islands at focal depths of 600 km are discussed. The most important result is the curve for the PKP1 phase which may be traced from 143° to 158° or 160° ; a table gives the corresponding duration of propagation of the phase. Other important phases are observed between 103° and 143° ; these are illustrated. — V. S. N.

186-194. Matumoto, Tosimatsu. On the spectral structure of earthquake waves. — The relation between magnitude and predominant period: *Tokyo Univ. Earthquake Research Inst. Bull.*, v. 38, pt. 1, p. 13-27, 1960.

Fourier analysis is applied to the P- and S-wave parts of records of 10 shocks that occurred in 1958 in a narrow belt off northeastern Honshu, Japan. The digitalized processing apparatus used for the analysis is described.

In each spectrum there are several maximums, and the periods (T) corresponding to these maximums are related to magnitude (M) as $M = \alpha_i + \beta_i \log T_i$ (where α_i and β_i are determined by the method of least squares). All branches of the P- and S-wave parts are more or less parallel to each other; this suggests that all predominant periods are related to the magnitude of the shock, and that the ratios of the predominant periods belonging to branch O and others are constant regardless of magnitude. These characteristics of predominant period are due clearly to the focal mechanism of the earthquake rather than to the nature of the ray path.

The different groups of predominant period are explained as oscillations of fundamental and higher modes, based on a spherical shell model. — D. B. V.

186-195. Brune, James N., Nafe, John E., and Alsop, Leonard E. The polar phase shift of surface waves on a sphere: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 247-257, 1961.

It has been demonstrated by means of a model experiment that elastic surface waves on a sphere advance in phase by $\pi/2$ on each crossing of the polar or antipodal region. Comparison of the asymptotic forms of solutions of the wave equation for displacements and dilatation before the polar crossing with those that apply afterward also show the $\pi/2$ phase shift. Similarly a $\pi/4$ phase advance occurs for waves leaving a point source.

Because of the occurrence of the polar phase shift, it is necessary to correct previously published Rayleigh and Love wave phase velocities measured by correlation of phases over complete circumferential paths. The corrected Rayleigh wave phase velocity curve is presented here.

The polar phase shift is involved in the determination of periods of free oscillation of the earth from surface wave data. Using data from the great Chilean earthquake of May 22, 1960, it is shown that the ratio of the earth's circumference to the wave length at free oscillation periods gives very nearly half integers in accordance with the formula $2\pi a/\lambda = n + 1/2$. — Authors' abstract

186-196. Kovach, Robert L., and Press, Frank. A note on ocean sediment thickness from surface wave dispersion: *Jour. Geophys. Research*, v. 66, no. 9, p. 3073-3074, 1961.

Objections raised by Evison and others (see *Geophys. Abs.* 185-364) to the use of Rayleigh wave dispersion data for estimating the thickness of unconsolidated sediments on the ocean floor are answered. Crustal thickness is shown to be a negligible factor. A more important source of error is the small but finite rigidity of the sediments. The range of sedimentary thickness found by dispersion analyses is 0.5-1 km, of the same order of magnitude as the typical range found by refraction measurements (0.2-1 km). The effect of irregular topography and contributions from nonbasin portions of the path cannot be determined; until dispersion data and refraction data are available for the same region, the ultimate precision of the method cannot be estimated. Surface wave methods are not meant to be competitive with explosion methods; however, they are the only source of information in remote oceans not covered by refraction surveys. — D. B. V.

186-197. Hochstrasser, Urs, and Stoneley, Robert [S.]. The transmission of Rayleigh waves across an ocean floor with two surface layers, pt. 2: Numerical: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 197-201, 1961.

Continuing the investigation of Rayleigh wave propagation along ocean paths (see also Geophys. Abs. 168-68), values are obtained for the wave velocity and group velocity of Rayleigh-type waves for 8 different models. In these models ocean depths are 4 or 6 km, the sedimentary layer is 1 or 2 km, and basic rocks are 5 or 7 km thick; in all cases these structures are assumed to rest on ultrabasic rocks of great thickness.

The wave velocity was found for a series of values of the wave-number by solving an eleven-row determinantal equation (using an electronic computer), and the corresponding group velocity values were obtained from these by numerical differentiation. The general agreement of these dispersion curves with observed values indicates their usefulness in determining the ray track and time of passage of a train of Rayleigh waves crossing an ocean floor whose structure and depth vary from place to place. — D. B. V.

186-198. Lehmann, I[ngel], and Ewing, M[aurice]. On short-period surface waves as recorded in Copenhagen: [Denmark] Geod. Inst. Skr., ser. 3, v. 34, 19 p. [with diagrams under separate cover, unpagged], 1960.

Records of 300 earthquakes at epicentral distances of 0° - 60° obtained during 1921-53 at Copenhagen were examined carefully for traces of Lg. Because Lg (taken as a purely transverse wave) may be associated with longitudinal and vertical short-period wave groups arriving at the same time, the study was extended to the entire short-period wave train succeeding the forerunners.

Velocities were determined for the wave groups picked out in the record and plotted for each earthquake separately against period in a graph which also showed the Lamont second mode dispersion curve. For most earthquakes a certain number of points were close to the second mode dispersion curve. Most clearly in evidence were waves of rather long but indeterminate period in the first part of the train and groups of waves, sometimes quite strong, arriving with a velocity of 3.5 km/s or less. This is when Lg is supposed to arrive; but if Lg is taken to be purely transverse, this phase is not always very distinct. Most of the period-velocity points of the alleged Lg's are close to the dispersion curve, but they do not gather near its maximum as might be expected. This does not disprove that Lg forms part of the second mode train, but it suggests the possibility that Lg might be connected with the short-period branch of the first mode Love wave dispersion curve.

The vertical and longitudinal wave groups arriving at about the same time are often more conspicuous. Like the transverse Lg, they are indicative of continental structure. In some ways it would be more convenient to let Lg stand for the combined short-period phase rather than just the transverse wave. Several other short-period wave groups arriving earlier and later are not considered in this study. The greater complexity of the Copenhagen records compared to those of Palisades is attributed largely to the more complicated structures on the path.

Diagrams of 31 earthquakes are reproduced under separate cover; remarks on each of these diagrams draw attention to features of interest. — D. B. V.

186-199. Bulin, N. K., and Savarenskiy, Ye. F. O korotkoperiodnykh pov-erkhnostnykh seysmicheskikh volnakh [About short-period surface seismic waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 855-863, 1961.

From study of experimental data on surface waves of 0.2-2.5 sec periods and group velocities of 280-800 m per sec recorded from explosions and earthquakes at distances 1-200 km and 70-250 km, respectively, it was established that such surface waves are connected with the top 10-20 m of the friable sed-

imentary layer. The results of the analysis carried out indicate the feasibility of using low group velocity surface waves in seismic prospecting (see also Geophys. Abs. 175-59). — A. J. S.

186-200. Kobayashi, Naota. Vertical distribution of amplitudes of the Rayleigh type dispersive waves (2d report) [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 4, p. 241-258, 1960.

It is commonly believed that the particle orbit for M_{11} waves at the surface is retrograde to the direction of wave propagation. Kobayashi demonstrates that the particle orbit for waves with wavelengths longer than about $4.6H$ (H = thickness of the superficial layer) changes its rotational direction if the substratum is rigid; the M_{11} waves are classified into 2 groups on this basis. A similar complexity was found to be true also for the M_{21} dispersive-type Rayleigh waves. These complexities for both types of waves occur, however, only at and near the surface; the rotational direction of the particle orbit at a point in depth in the superficial layer is retrograde to the direction of wave propagation. (See also Geophys. Abs. 181-138.) — V. S. N.

186-201. Aki, Keiiti, and Nordquist, John M. Automatic computation of impulse response seismograms of Rayleigh waves for mixed paths: Seismol. Soc. America Bull., v. 51, no. 1, p. 29-34, 1961.

A program has been devised to compute theoretical seismograms of Rayleigh waves for a given epicenter and a given station entirely automatically on an electronic computer. The earth's surface is divided into three regions: continents, Pacific Ocean, and oceans other than the Pacific. Allowance can be made for differences in structure in these regions. This simple division seems satisfactory at present for Rayleigh waves of period longer than 35 sec. — Authors' abstract

186-202. Bolt, Bruce A. Machine processing of seismic travel-time data: Seismol. Soc. America Bull., v. 51, no. 2, p. 259-267, 1961.

A method of constructing empirical traveltimes curves from a sample of observed times has been programmed for an IBM 709 computer. The program processes up to 500 observations of the phase under revision, taken from any number of selected earthquakes. The focus and origin time of each shock are first adjusted by an automatic procedure previously described (see Geophys. Abs. 184-168) and the needed correction applied to the observed times. The corrected times are then weighted relative to a provisional traveltimes table, and the weights are used to fit polynomials up to a specified degree. Sample characteristics are also computed to facilitate statistical treatment.

Preliminary results obtained using the program to process PKIKP times from 9 Aleutian and 1 deep-focus New Zealand shock are presented. These results supply additional evidence that the Jeffreys-Bullen PKIKP times require the addition of about $1\frac{1}{4}$ sec relative to the standard P tables. — D. B. V.

186-203. Adams, W[illiam] M[ansfield], and Allen, D. C. Reading seismograms with digital computers: Seismol. Soc. America Bull., v. 51, no. 1, p. 61-67, 1961.

A device that permits direct input of seismic traces into electronic digital computers is described. Examples of its use and its several merits are presented. The device makes feasible numerical analysis of data recorded in analog form on photographic film or paper. — Authors' abstract

- 186-204. Chakrabarty, S. K., and Tandon, A. N. Calibration of electromagnetic seismographs satisfying Galitzin conditions: *Seismol. Soc. America Bull.*, v. 51, no. 1, p. 111-125, 1961.

Theoretical results are given for the response of electromagnetic seismographs to different tests required in their calibration and to sinusoidal ground motion. The reaction of the seismometer and galvanometer is retained. Final results are given for the special types of seismographs in which the seismometer period and galvanometer period are equal and the galvanometer is critically damped. The variation of the magnification curve as well as that of the response to different tests with changes in the reaction and seismometer damping have been obtained. Methods are indicated for determining the instrumental constants and adjusting the seismographs to any prescribed condition. The results of calibration of a Sprengnether seismograph at Shillong, India, are given. The method suggested can also be used in the precise estimation of the instrumental constants and the magnification of Galitzin-type seismographs even in past operations, if routine test data (particularly the response to tapping test and sudden impulse test) are available. — D. B. V.

- 186-205. Cloud, W[illiam]K., and Hudson, D[onald] E[llis]. A simplified instrument for recording strong motion earthquakes: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 159-174, 1961.

A strong-motion earthquake recorder for the direct measurement of one point on the response spectrum curve is described, and results obtained with the instrument under field conditions are compared with those obtained by a standard spectrum analysis of accelerograph records. The device has the advantage of low initial cost and of low maintenance expense, and can thus be installed in relatively large numbers. A network of such instruments located at points having various local geological conditions is proposed as a supplement to the U. S. Coast and Geodetic Survey strong-motion seismograph system. — Authors' abstract

- 186-206. Willmore, P. L. Some properties of heavily damped electromagnetic seismographs: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 389-404, 1961.

The classical theory of electromagnetic seismographs is discussed with special reference to the properties of combinations of seismometer and galvanometer in which the damping of either or both components is very much greater than critical. The paper includes a graphical method of determining approximate response curves for such seismographs.

The treatment of passive systems is extended to cover cases in which the galvanometer light spot energizes a photoelectric amplifier, and in which the amplifier output is fed back into the mechanical system. Feedback through a seismometer produces new effects, which are discussed. An example is described to illustrate the value of the moving-coil galvanometer as an element in feedback seismographs for use in fixed stations; in conjunction with large damping coefficients, very wide-band response to ground velocity may be obtained. — D. B. V.

- 186-207. Alberta Society of Petroleum Geologists. A new instrument for recording earthquakes: *Alberta Soc. Petroleum Geologists Bull.*, v. 8, no. 8, p. 233, 1960.

A new type of seismometer developed by Carey and Newstead of the University of Tasmania is described briefly. The instrument consists of a pendulum

swinging from a frame well anchored to the earth; unlike the standard seismometer with a stylus attached to the frame and a recording instrument on the heavy pendulum, this instrument has a small pendulum suspended on a hinge. Induction currents are so arranged that as soon as there is a tendency for movement an equal and opposite current is directed to stop the motion; thus, the amount of damping is measured by the feedback. By setting up two instruments at right angles the direction of wave propagation can be observed. The instrument is small and has great sensitivity; when installed in a basement of a house it can pick up all vibrations in the vicinity. With the three instruments now in Hobart set to record all their movements on a single drum, the earthquake waves can be observed both in amplitude and direction. The recordings are continuous and true to the amount of movement at the exact time of movement. With a 12 pen high-speed drum recorder these Tasmanian instruments give records of many earth movements at any certain time—a "spectrum" of every instant. With such a continuous recording device the first small movements of larger earthquakes to come may be detected thus making it possible to issue warnings of impending earthquakes. The instrument may be used also for engineering purposes such as in tunnel construction and mining to warn of impending breakage. — V. S. N.

- 186-208. Weber, Max. P. G. -Seismographen und ihre Eichung [P.G. seismographs and their calibration (with English summary)]: *Geofisica Pura e Appl.*, v. 46, p. 26-32, 1960.

A contribution is made to the theory of pendulum-galvanometer seismographs. The construction and theory of a new calibration device involving horizontal and vertical shaking tables are described, and an example is given of the calibration of a Hiller-Askania seismograph. — D. B. V.

- 186-209. Weber, Max. Ein exakter Seismograph [An exact seismograph]: *Geofisica Pura e Appl.*, v. 48, p. 35-39, 1961.

The theory, construction, and characteristics of an exact seismograph, in which the new element is the rectifier-amplifier, are described. — D. B. V.

- 186-210. Lin'kov, Ye. M., and Tripol'nikov, V. P. Magnito-elektronnyy seysmograph [A magneto-electronic seismograph]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 2, p. 259-260, 1961.

A simple and highly sensitive magneto-electronic seismograph is described. It consists of a horizontal pendulum similar to a Kirnos horizontal seismograph. An annular magnet fastened to its end creates a magnetic field of approximately 200 oersteds along the axis. An electronic tube, fastened rigidly to the base of the seismograph, is situated outside the magnet. Electromagnetic damping is achieved by means of a coil in the field of the magnet. A schematic diagram of the circuit is given. This seismograph has a high sensitivity that is not dependent on amplitude. Such high sensitivity permits the seismic signals to be transmitted by radio. The instrument can be used to record seismic waves as well as to measure tilting of the surface. — J. W. C.

- 186-211. Feofilaktov, V. D. K instrumentalm'nomu opredeleniyu energii seismicheskikh voln [Instrumental determinations of energy of seismic waves]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 3, p. 412-417, 1961.

This paper describes and analyzes a three-component seismic energometer (see *Geophys. Abs.* 179-108) and its performance in recording energies of

earthquakes. The instrument is a velocimeter capable of galvanometric quadratic recording on a cinema film. The energogram appears as a transparent path of variable width which is proportional to the square of the "ground" oscillation, while the area is proportional to the time integral of that value. From earthquakes of 5.5 to 7.5 magnitude and epicentral distances of 20° to 160° recorded during 6 months by the Moscow State University seismograph station it was found that the values of energies given by the energographs are apparently the most accurate, although they are always higher than the energy values calculated from the seismogram of regular seismographs. — A. J. S.

- 186-212. Khristichenko, P. I. K voprosu ob uravnenii dvizheniya mayatnikovykh seysmografov [On the problem of the equation of motion of pendulum seismographs]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 443-444, 1961.

Considering a pendulum seismograph as a bound system of a variable depending explicitly on time coupling, the motion velocity \bar{v}_a under the variable bond consists of two components: the translation velocity \bar{v}_e with the bond and the relative velocity \bar{v}_r within the system; \bar{v}_e is usually known and \bar{v}_r unknown, thus $\bar{v}_a = \bar{v}_e + \bar{v}_r$. Disregarding rotation motions of the reference system and differentiating according to t , the equation of acceleration can be written as $\bar{w}_a = \bar{w}_e + \bar{w}_r$. From this the force equation, $m\bar{w}_r = \bar{F} + (-m\bar{w}) + (-\beta\bar{v}_r) + (-\beta\bar{v}_e)$, can be written according to Newton's second law of motion, considering the resistance of the mediums to be proportional to the first power of velocity and β to be the resistance coefficient. The force $-\beta\bar{v}_e$ affects both the amplitude and phase of the seismic waves; however, it is not taken into account in theories of seismographs. A mathematical analysis of the force $-\beta\bar{v}_e$ is given, and a nonhomogeneous equation of Matieu type is derived for the correction of a seismograph error due to the omission of the force $-\beta\bar{v}_e$ in its equation of motion. — A. J. S.

- 186-213. Vinnik, L. P. O grupirovani nizkochastotnykh seysmografov [On grouping of low frequency seismographs]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 643-648, 1961.

Seismograph grouping and its application to a number of seismological problems that can be solved by the planar arrangement of seismographs are analyzed mathematically. A formula is derived for amplification and frequency characteristics of a seismograph in a group designed for direct galvanometric recording. — A. J. S.

- 186-214. Arkhangel'skiy, V. T., Kirnos, D. P., Popov, I. I., and Solov'yev, V. N. Opyt nablyudeniya dlinnoperiodnykh seysmicheskikh voln na stantsii Simferopol' [A test observation of long period seismic waves at the Simferopol station]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 670-675, 1961.

An experimental model of a vertical seismograph for recording waves of 20-300 sec periods is described, and the results of testing and the data of observed earthquakes are given. Rayleigh seismic waves of 160-480 sec periods from the Chilean earthquake of May 22, 1960 were recorded by this seismograph at the Simferopol station. In contrast to other seismographs which could not record the arrival of P-waves, the new seismograph recorded the diffracted P-wave as an isolated impulse of 35 sec period. At 14,000 km from the epicenter, the extra long seismic waves (about 1,000 km) produced 0.5 cm ground displacement. — A. J. S.

- 186-215. Fremd, V. M. Vspomogatel'naya apparatura seismicheskikh stantsiy severnogo Tyan'-Shanya [Auxiliary equipment of seismic stations of northern Tien Shan]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 744-747, 1961.

Auxiliary equipment for automatic controlling, signaling, and operating seismographs at the central seismic station at Alma-Ata in the northern Tien Shan is described. The equipment consists of a unit for automatic increase in filament heating, oversensitivity reduction, and signaling. Circuit and block diagrams are given, and the operation and maintenance of the apparatus is discussed. — A. J. S.

- 186-216. Kirnos, D. P., and Rykov, A. V. Spetsial'naya bystrodeystvuyushchaya seismicheskaya apparatura dlya opoveshcheniya o tsunami [Special fast-acting seismic apparatus for announcing tsunami]: Akad. Nauk SSSR Sovet po Seismologii Byull., no. 9, p. 56-66, 1961.

Russian devices designed to determine the epicenter and intensity of an earthquake within 3 or 4 min after its beginning are described and illustrated. The UBOPE-1 apparatus was constructed at the Geophysical Institute in 1954-55 and installed at Petropavlovsk-Kamchatka, Klyuchi, and South Sakhalin in 1955. It consists of two sets of devices, an azimuthograph to show the direction of the epicenter and a seismograph (SMR-3) to show the epicentral distance and intensity of an earthquake. This apparatus is intended to give warning of catastrophic tsunami. The UBOPE-2 was developed in 1957 at the Institute of Earth Physics. The principle is similar to that of UBOPE-1 but the seismograph and azimuthograph are of different design, intended to register earthquakes of medium intensity.

Data obtained with the UBOPE-1 in the earthquakes of November 7, 1958 and May 4, 1959 suggest that the magnification of the SMR-3 seismograph should be reduced from $V_0=5$ to about $V_0=1$; the period and damping, and the parameters of the azimuthograph need no change for the present. — D. B. V.

- 186-217. Matumoto, Hideteru. Transistor pre-amplifier for a seismograph [in Japanese with English summary]: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 525-530, 1959.

A transistor preamplifier designed for a highly sensitive electronic seismograph is described; wiring diagrams, graphs of frequency characteristics, and a photograph of the preamplifier and transducer are given (with English captions). Reproductions of seismograms obtained with an Hagiwara electromagnetic short-period seismograph and with an electronic seismograph equipped with the transistor preamplifier show that with the latter, the stability and sensitivity for minor shock observations are greater than previously attained with ordinary electronic seismographs. — D. B. V.

- 186-218. Shima, Etsuzo. Theoretical and experimental approach to the designs and calibrations of electro-magnetic seismograph. Pt. 1. Voltage sensitivity of the moving-coil type seismometer: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, no. 1, p. 29-39, 1960.

Almost all electromagnetic seismometers of recent design are of moving-coil (with fixed magnet) or moving-magnet (with fixed coil) type, both types being the same theoretically. In this paper an equivalent four-terminal network of such instruments is deduced mathematically. It agrees with the one suggested by Sherbatskoy and Neufeld (1937). With this equivalent circuit the

instrumental constants of a seismometer can be determined easily by measuring the motional impedance electrically, when the voltage sensitivity is known. The equivalent circuit can also be used in consideration of a galvanometer by reversing the input and output.

A simple zero-method for measuring voltage sensitivity more precisely than previously possible is described. Motional aspects of the voltage sensitivity are not treated; they will be dealt with in the next paper. — D. B. V.

186-219. Yazaki, K. Earthquake occurrence time recorder [in Japanese with English abstract]: *Quart. Jour. Seismology* [Tokyo], v. 26, no. 1, p. 1-5, 1961.

A new instrument designed to record automatically the time of earthquake occurrence is described and illustrated. It is composed of a signal filter, control gates, second-pulse clock, hour-minute counter, second counter, printing hammer, delivery roller of printed paper, and reset pulse generator. It works in liaison with the observatory clock to show the hour. — V. S. N.

186-220. Willmore, P. L. The new seismograph station at Resolute, Northwest Territories: *Dominion Observatory Ottawa Pubs.*, v. 24, no. 5, p. 101-111, 1960.

In 1957, the Dominion Observatory seismograph station at Resolute, N. W. T., was replaced by a larger station with modern instrumentation. The new station contains three seismographs of short period, three of intermediate period, and three of long period. The construction of the station and the procedure for setting up the instruments are described. Calibration curves for all the instruments are included. — Author's abstract

EARTH TIDES AND RELATED PHENOMENA

186-221. Gougenheim, André. Confirmation, par l'observation, du rôle négligeable de la marée terrestre dans la production des séismes [Confirmation by observation of the negligible role of the earth tide in the production of earthquakes]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 21, p. 3313-3314, 1961.

The time distribution of 19 relatively recent earthquakes widely scattered throughout the globe was compared to earth tide curves. No correlation was found between the amplitude of the earth tide and the occurrence of earthquakes. When premonitory shocks, main shocks, and aftershocks were considered separately, only half or less than half of each type of shock occurred near an extremum of earth tide. It is concluded that the tensions due to earth tides are too slight to trigger earthquakes. — D. B. V.

186-222. Defant, Albert. *Physical oceanography*, v. II: New York and London, Pergamon Press, 598 p., 1961.

The periodic movements of water masses that occur in the form of waves, tides, and related phenomena are discussed in this second volume of the textbook on physical oceanography. The text includes 16 chapters and is divided into two parts: (1) surface and long waves, and (2) tides and tidal currents. Part 2 includes a chapter on tides in relation to geophysical and cosmic problems in which the effect of the ocean tides on the solid earth is discussed. The detection of tides in the solid earth from tidal observations in shallow adjacent seas and the deformations of the solid earth by tidal load are treated. — V. S. N.

- 186-223. Munk, Walter [Henrich], and Hassan, El Sayed Mohamed. Atmospheric excitation of the earth's wobble: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 339-358, 1961.

The excitation of the seasonal and 14-month (Chandler) wobble is discussed on the basis of mean monthly values of the atmosphere's movements and products of inertia for the period 1873-1950. The calculations confirm the conclusion of Jeffreys and others that the seasonal wobble is due largely to atmospheric excitation, but the amplitudes obtained are 25 percent smaller than those given by Jeffreys (see Geophys. Abs. 179-250).

The computed spectral density of the atmospheric variation at the Chandler frequency falls short by one or two orders of magnitude of meeting the requirement of the hypothesis that the Chandler wobble represents a resonance amplification of the irregular (nonseasonal) variation in atmospheric inertia. Excitation by irregular motion in the core is considered; the electromagnetic coupling appears to be far too weak to account for the observed wobble. The case of the Chandler wobble is an unsolved problem. — D. B. V.

- 186-224. Fedorov, E. [Ye.] P. Nutation as derived from latitude observations: Astron. Jour., v. 64, no. 3, p. 81-84, 1959.

This is the same as the paper published in Astron. Zhur., v. 36, no. 5, p. 914-918, 1959 (see Geophys. Abs. 180-78). — D. B. V.

- 186-225. Jeffreys, Harold. Nutation and the variation of latitude: Astron. Jour., v. 64, no. 3, p. 84-86, 1959.

This is the same as the paper published in Astron. Zhur., v. 36, no. 5, p. 918-920, 1959 (see Geophys. Abs. 180-77). — D. B. V.

- 186-226. Munk, Walter H[enrich], and MacDonald, Gordon J. F. The rotation of the earth: Cambridge, University Press, 323 p., 1960.

An account is given of certain irregularities in the rotation of the earth which are not ordinarily included in the gravitational theory; these include irregularities in rate of rotation and in position of the axis that are caused by events on and in the earth. Such events can be effectively studied by means of measured irregularities. It is the purpose of this book to make this method of study readily accessible to the geophysicist. The 12 chapter headings are as follows: preview; precession, nutation, and wobble; dynamics; deformation; Love numbers and associated coefficients; solutions to the approximate Liouville equation; observations of latitude; observations of the length of day; seasonal and other short-period variations; Chandler wobble; historical variations; and geological variations. A bibliography of over 300 entries is included. — V. S. N.

- 186-227. Schatzmann, Evry. Sur la théorie de Holmberg de l'entretien de la rotation terrestre [On Holmberg's theory of the maintenance of the earth's rotation]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 26, p. 4413-4414, 1960.

The relaxation time of the earth's rotation, connected with the semidiurnal wave of the atmosphere, is calculated to be of the order of 3×10^5 yr. Holmberg's mechanism for maintaining the period of the earth's rotation can operate rapidly only if the amplitude ratio is much larger than appears possible. Therefore, the second order terms found by Danjon in the variation of the period of rotation (see Geophys. Abs. 181-375) do not stem from this mechanism. — D. B. V.

- 186-228. Melchior, Paul [J.]. Les relations entre les mouvements du pôle et les fluctuations de la vitesse de rotation de la Terre [The relations between movements of the pole and fluctuations of the velocity of rotation of the earth (with discussion)]: *Astron. Jour.*, v. 64, no. 3, p. 86-95, 1959.

This is the same as the paper published in *Astron. Zhur.*, v. 36, no. 5, p. 920-933, 1959 (see *Geophys. Abs.* 180-74). — D. B. V.

- 186-229. der Waerden, B. L. van. The irregular rotation of the earth: *Astron. Jour.*, v. 64, no. 3, p. 96-97, 1959.

A mechanical explanation of the observed irregular rotations of the surface of the earth is proposed. From this probabilistic model the correlations between the apparent fluctuations of the motion of the moon in successive years are derived and a modified least-squares method is derived for finding the secular variation of sun and moon. — Author's abstract

- 186-230. Brouwer, Dirk. Fluctuations and secular changes in the earth's rotation: *Astron. Jour.*, v. 64, no. 3, p. 97-99, 1959.

This is the same as the paper published in *Astron. Zhur.*, v. 36, no. 5, p. 933-935, 1959 (see *Geophys. Abs.* 180-75). — D. B. V.

- 186-231. Stoyko, Nicolas. Variations périodiques et aléatoires de la rotation de la Terre [Periodic and aleatory variations of the earth's rotation]: *Astron. Jour.*, v. 64, no. 3, p. 99-102, 1959.

This is the same as the paper published in *Astron. Zhur.*, v. 36, no. 5, p. 938-943, 1959 (see *Geophys. Abs.* 181-148). — D. B. V.

- 186-232. Danjon, A[ndré]. Variation progressive et variation saisonnière de la rotation de la Terre [Progressive and seasonal variation of the rotation of the earth]: *Astron. Jour.*, v. 64, no. 3, p. 102-103, 1959.

This is a preliminary report on the results of a comparison of universal time, deduced from astrolabe observations at the Paris observatory, and uniform time furnished by the cesium standard of Essen and others (see *Geophys. Abs.* 173-117). The observed and calculated seasonal variations from 1956.5 to 1958.5 are compared graphically; the differences do not appear to be systematic. — D. B. V.

- 186-233. Nemiro, A. A., and Pavlov, N. N. The influence of systematic errors of star catalogs on the determination of the irregularities of the earth's rotation: *Astron. Jour.*, v. 64, no. 3, p. 103-106, 1959.

In order to lessen the influence of the errors in the right ascensions of stars of fundamental systems on the results of time determinations, it is proposed that the results of time services observing with transit instruments be used for the determination of an independent system of right ascensions of stars. The participation in this work by a maximum number of observatories in different countries is desirable. — D. B. V.

- 186-234. Markowitz, W[illiam]. Variations in rotation of the earth, results obtained with the dual-rate moon camera and with photographic zenith tubes: *Astron. Jour.*, v. 64, no. 3, p. 106-113, 1959.

This is the same as the paper published in *Astron. Zhur.*, v. 36, no. 5, p. 949-958, 1959 (see *Geophys. Abs.* 181-149). — D. B. V.

- 186-235. Woolard, Edgar W. Inequalities in mean solar time from tidal variations in the rotation of the earth: *Astron. Jour.*, v. 64, no. 4, p. 140-142, 1959.

The deformation of the earth by the luni-solar tide-generating forces alters the moments of inertia of the earth and thereby causes periodic variations in the rate of rotation, which introduces inequalities in the measure of time determined by the rotation. The cumulative effects of the larger long-period components with period up to one year have been detected by observations with the aid of accurate clocks. In this paper, all long-period inequalities with amplitudes as great as 0.10 millisecond are computed and are listed in a table. — Author's abstract

ELASTICITY

- 186-236. Latter, A[ibert] L., Martinelli, E. A., Mathews, J., and McMillan, W. G. The effect of plasticity on decoupling of underground explosions: *Jour. Geophys. Research*, v. 66, no. 9, p. 2929-2936, 1961.

The effect of plasticity, including work hardening, on seismic decoupling of underground explosions has been studied for large spherical cavities designed to give maximum decoupling and for small (overdriven) cavities designed to give partial decoupling. An important result is that plasticity plays no role in explosions in large cavities, even those at great depth for which some plastic flow occurs during construction of the cavity. For small cavities at great depth plasticity affects the decoupling factor by an amount depending upon the degree of overdriving, the depth, and the detailed stress-strain relation of the medium. A further result is that for cavities at a depth of about 1 km in a medium like salt, which exhibits work hardening, the decoupling factor is at least as great as that obtained in the overdriven Cowboy experiments and could be appreciably greater. It is also concluded that the depth of the cavities in the Cowboy experiments was not sufficient for plastic flow to occur in the salt medium before other inelastic behavior, e. g., cracking, set in. A simplified model of the Cowboy inelasticity is discussed. [See also *Geophys. Abs.* 184-259, -260, -261]. — Authors' abstract

- 186-237. Haskell, Norman A. A static theory of the seismic coupling of a contained underground explosion: *Jour. Geophys. Research*, v. 66, no. 9, p. 2937-2944, 1961.

According to the theory of Latter, Martinelli, and Teller [see *Geophys. Abs.* 178-369] the amplitude of the distant seismic signal from a completely contained underground explosion is determined by the permanent displacement produced in the neighborhood of the source. A static-equilibrium theory of this displacement is developed. A Coulomb-Mohr type of yield condition is used to determine the stresses in the near zone where the stresses are beyond the elastic limit. If the internal friction parameter that occurs in the Coulomb-Mohr yield condition is treated as a phenomenological constant, to be determined by the seismic data, it is possible to obtain reasonably good agreement with the relative amplitudes of the seismic signals observed in the Project Cowboy series of chemical explosions in cavities of various sizes in salt. The indicated value of the friction parameter is, however, appreciably

less than the values usually observed in compression tests on unconsolidated materials. The theory is also consistent with the observed size of the cavity produced in tuff by the underground nuclear explosion Rainier, but an even smaller value of the friction parameter must be assumed in this case. — Author's abstract

- 186-238. Adams, W. S., and Carder, D[ean] S. Seismic decoupling for explosions in spherical cavities: *Geofisica Pura e Appl.*, v. 47, p. 17-29, 1960.

A series of paired explosions in a salt mine near Winnfield, Louisiana, has been conducted to test the theory of Latter and others (see *Geophys. Abs.* 184-259) concerning seismic decoupling by underground cavities. The theory predicted decoupling of about 100. Free field and surface measurements from an explosion in either a 6-ft- or a 15-ft-radius spherical cavity were compared with similar measurements from a completely tamped explosion. Shot sizes were from 20 lb up to a few tons. Surface measurements were made out to 100 km and covered the frequency range 0.5-100 cycles per sec. The results are in sufficiently good agreement with the theory to suggest its general validity. There would appear to be no reason why corresponding results would not be obtained for nuclear explosions in the frequency range of interest for detecting clandestine nuclear tests. — D. B. V.

- 186-239. Dix, C. H[ewitt]. The seismic head pulse, reflection and pseudo-reflection pulses: *Jour. Geophys. Research*, v. 66, no. 9, p. 2945-2951, 1961.

The shapes of the seismic head pulse, the ordinary reflection and pseudo-reflection pulses are compared with the direct pulse shape. The direct pulse in the step in the radial displacement potential. The method used is a variation of Cagniard's work together with suitable approximations. The results are contained in Cagniard's original work. The present treatment is simpler than Cagniard's and better adapted to direct numerical calculations for many important cases. A numerical example is given. — Author's abstract

- 186-240. Anderson, Don L. Elastic wave propagation in layered anisotropic media: *Jour. Geophys. Research*, v. 66, no. 9, p. 2953-2963, 1961.

This is an analysis of the dispersive properties of transversely isotropic media. This kind of anisotropy is exhibited by hexagonal crystals, sediments, planar igneous bodies, ice sheets, and rolled metal sheets where the unique axis is perpendicular to the direction of surface wave propagation and the other axes are distributed randomly in the plane of the layers. Period equations are derived for waves of Rayleigh, Stoneley, and Love types, and comparisons are made, in certain cases, with ray theoretical and plane stress solutions. Anisotropy can have a pronounced effect on both the range of existence and the shape of the dispersion curves and can lead to an apparent discrepancy between Love and Rayleigh wave data. Attention is focused in this initial paper on a single solid layer in vacuo (i. e., a free plate) and a solid layer in contact with a fluid halfspace. The single layer solutions are generalized to n-layer media by the use of Haskell matrices. — Author's abstract

- 186-241. Knopoff, Leon, and Gilbert, Freeman. Diffraction of elastic waves by the core of the earth: *Seismol. Soc. America Bull.*, v. 51, no. 1, p. 35-49, 1961.

The problem of the diffraction of a seismic pulse by the core of the earth is investigated theoretically. The result is compared to that of diffraction by a half-plane. The differences are striking. Laboratory model experiments have been performed to verify the theoretical approximations in their regions of validity, and to complement the theory elsewhere. The curves, thus obtained, of the theoretical amplitude distribution in the shadow of the earth's core agree very well with the observations of Gutenberg. It is therefore concluded that diffraction is a completely adequate explanation for the amplitude distribution in the shadow zone. — Authors' abstract

- 186-242. Nuttli, Otto [W.]. The effect of the earth's surface on the S wave particle motion: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 237-246, 1961.

Expressions are derived for the motion of a plane free surface of the earth due to the incidence of plane harmonic S-waves of arbitrary polarization and incidence angles. For angles of incidence less than $\sin^{-1}(b_0/a_0)$, where a_0 and b_0 are the P- and S-wave velocities at the surface, all three components of ground motion will be in phase and the resultant motion is linear. For angles of incidence greater than $\sin^{-1}(b_0/a_0)$ all three components will in general be out of phase, and the resultant motion describes some three-dimensional figure. The epicentral distance at which the motion changes from linear to nonlinear depends on the wave length of the S-wave and the slope of the traveltime curve at that distance. — D. B. V.

- 186-243. Brekhovskikh, Leonid M. *Waves in layered media*: New York, Academic Press, 561 p., 1960.

A systematic presentation of the theory of the propagation of elastic and electromagnetic waves in layered media is given. The text has been translated from Russian, and although it is not restricted to Russian work in the field, it does present a complete picture of Russian researches on wave propagation through layered media. The following chapters are included: plane waves in layers, some applications of the theory of plane wave propagation in layered media, plane waves in layered-inhomogeneous media, reflection and refraction of spherical waves, wave propagation in layers, and the field of a concentrated source in a layered-inhomogeneous medium. — V. S. N.

- 186-244. Pekeris, C. L. Propagation of seismic pulses in layered liquids and solids, in *International symposium on stress wave propagation in materials*: New York and London, Interscience Publishers, Inc., p. 45-57, 1960.

The application of computer techniques to shallow-water propagation is discussed with reference to the existing types of computers, as well as to the supercomputers to be available in the next decade. The problem of sound propagation from a periodic point source and that of explosive sound propagation in a two-layered liquid are considered solved on existing computers. However, when the three-layered case is considered or when rigidity of the bottom is included in the two-layered case a super computer is required to reduce the time of computation to a few hours. Illustrations are given of the solution on WEIZAC of explosive wave propagation problems in two-layered liquids, and a comparison is made with a previous solution obtained by normal mode theory. The nature of the problems in the field of propagation to be solved in the future is discussed. — V. S. N.

- 186-245. Bullen, K. E. *Seismic ray theory*: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 93-105, 1961.

Seismic ray theory is developed initially with special emphasis on the variables ξ and α , (where $\xi = d \log v / d \log r$ and $\alpha = 2/(1-\xi)$). Traveltime-distance relations are examined for a variety of types of velocity distribution, including the case where α and v change discontinuously, or rapidly but continuously, with increasing depth. This analysis should provide an improved basis for working out in qualitative detail the effect on traveltimes of types of velocity variation relevant to the earth. In particular it is hoped that the analysis will lead to more effective use of ray theory in the current difficult problems of outer mantle structure.

Some previous results involving ξ and α are presented in revised form as part of a wider logical development. Previous work on deriving seismic velocity distributions from traveltime data is generalized.

Nonnumerical applications are given, but references are given to papers containing such applications. — D. B. V.

186-246. Baumgarte, J., and Krey, T[heodor]. Reflexion und Brechung beim schrägen Durchgang ebener seismischer Wellen durch N planparallele Medien [Reflection and refraction of plane seismic waves on oblique propagation through N plane-parallel mediums (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 2, p. 242-260, 1961.

The problem of propagation of an obliquely incident periodic longitudinal plane wave through $(n+2)$ homogeneous, isotropic, plane parallel layers with both longitudinal and transverse waves occurring in each medium is investigated mathematically. It is shown that a general solution can be given explicitly, using only 4-row and 4-column matrices. The two-layer problem must be solved in its very general form, and from this the solution of any multilayer problem can be derived. The method is clear and concise, and also yields correct solutions in the case where the critical angle of total reflection for longitudinal or transverse waves is exceeded in one or more mediums.

Two special cases important in refraction seismology are given special attention: the case where the longitudinal waves of medium l assumed the critical angle, and the case where the transverse waves of medium t assume the critical angle.

The treatment begins by calculating the considerably simpler reflection and refraction in optics, then investigates the relatively simple seismic case of an incident transverse wave polarized at right angles to the common plane of refraction, and finally calculates the principal case of longitudinal seismic waves occurring in common with transverse waves polarized in the plane of refraction. — D. B. V.

186-247. Schulz, Gerhard. Über ein Refraktionsproblem [On a refraction problem (with English abstract)]: *Zeitschr. Geophysik*, v. 26, no. 5, p. 236-245, 1960.

The amplitudes of plane elastic waves generated by grazing incidence at an interface are calculated and set in relation to the amplitude of the primary wave that is refracted to produce the grazing incidence. — Author's abstract

186-248. Chakraborty, Sakti Kanta. Disturbances in a viscoelastic medium due to impulsive forces on a spherical cavity: *Geofisica Pura e Appl.*, v. 48, p. 23-26, 1961.

The disturbances produced in a viscoelastic medium by impulsive forces on the surface of a spherical cavity within the medium are treated mathematically. — D. B. V.

- 186-249. Riznichenko, Yu. V., and Shamina, O. G. O mnogokratnykh otrazhennykh i prokhodyashchikh volnakh [Multiple reflected and transmitted waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1689-1706, 1960.

The intensities of diffuse reflected and impulse transmitted seismic waves in a multilayered medium are calculated on the basis of the theory proposed by Riznichenko (see Geophys. Abs. 180-372). Model experiments, conducted with the aid of an impulse ultrasonic apparatus in a tank containing a liquid medium and solid models of layers (see Geophys. Abs. 152-14284), essentially confirm the theory and provide additional information on the forms and periods of the waves and on their changes after multiple reflection and passage through a multilayered medium. — A. J. S.

- 186-250. Ogurtsov, K. I. Outochenii asimptoticheskikh otsenok intensivnosti volny, rasprostranyayushcheyasya v parallelnosloistoy uprugoy srede [Accuracy improvement of asymptotic evaluations of wave intensity traveling in an elastic medium of parallel layers]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 224-230, 1961.

The problem of finding an approximate optimum evaluation of the intensity of waves propagating through an elastic medium composed of parallel layers is treated mathematically. The asymptotic solution is given with two first terms, and conditions that permit the second term to be disregarded without loss of accuracy are discussed. Formulas derived are simplified for the case where one of the links of a seismic ray makes a small angle with an interface; then the second term of the formula becomes important. — A. J. S.

- 186-251. Riznichenko, Yu. V., Shamina, O. G., and Khanutina, R. V. Up-rugiye volny s oboshchennoy skorost'yu v dvumernykh bimorfnykh modelyakh [Elastic waves of generalized velocity in two-dimensional bimorphic models]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 497-519, 1961.

Formulas are derived for the velocities of long longitudinal and transverse waves in thin bimorphic and polymorphic plates in two-dimensional modeling of seismic waves. Experiments with bimorphic models confirm the accuracy of the long-wave theory and establish its limitations. If the thickness of a bimorphic plate is considerably smaller than the wavelength, generalized P-, S-, and R-waves can propagate within them. Attenuation of longitudinal and transverse waves in bimorphic plates conforms to the same laws as in monomorphic plates. Experiments with a gradient medium demonstrate that even with such an insignificant variation in velocity with depth that it cannot be detected by traveltime curves, the amplitude characteristics of longitudinal waves are very sensitive to changes. — J. W. C.

- 186-252. Pod'yapol'skiy, G. S. Koeffitsiyent prelomleniya i otrazheniya uprugikh voln na sloye [Indices of refraction and reflection of elastic waves at a layer]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 520-533, 1961.

The indices of refraction and reflection are taken to be the so-called displacement coefficients, which can be defined as the ratios of the length of the vector displacements in the reflected or refracted waves to the lengths of the vector displacements in the incident waves, where the length of a vector is taken to be positive or negative depending on the sign of its projection on the X-axis. Formulas are derived for calculating the refraction and reflection

indices of elastic waves at a layer of constant thickness. These formulas are given in particular in terms of the refraction and reflection coefficients at the boundaries of a layer. The coefficients are treated as operators that transform the waveforms and their frequency patterns. — J. W. C.

- 186-253. Osipov, I. O. Otrazheniye i prelomleniye ploskikh uprugikh voln na granitse dvukh anizotropykh sred [Reflection and refraction of plane elastic waves at the boundary of two anisotropic mediums]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 649-665, 1961.

The problem of reflection and refraction of plane elastic waves at the interface of 2 anisotropic mediums of 3 elastic constants is discussed. After a mathematical analysis of a planar dynamic problem of propagation of elastic waves in anisotropic mediums, the waves are divided into two types. Changes of elastic velocity in halite, sylvite, pyrite, and fluorite for both types of waves are analyzed. The analysis is also applied to Rayleigh boundary waves. — A. J. S.

- 186-254. Usami, Tatsuo. Some remarks on the solutions of the equation of motion in an isotropic and homogeneous elastic body—Especially on the uniqueness of the solutions for boundary value problems in an infinite elastic medium [in Japanese with English abstract]: Zisin, ser. 2, v. 14, no. 1, p. 18-28, 1961.

The equation of motion of an elastic medium expressed in vector form makes it clear that there are several different solutions which satisfy the condition $\Delta=0$; eight different expressions are derived in this paper. By using one of these solutions two independent solutions are given for a problem of motion in an infinite elastic medium when displacements (or stresses) are given for the wall of a cavity in that medium. — V. S. N.

- 186-255. Bolt, Bruce A., and Dorman, James. Phase and group velocities of Rayleigh waves in a spherical, gravitating earth: Jour. Geophys. Research, v. 66, no. 9, p. 2965-2981, 1961.

Periods of spheroidal eigenvibrations, with order of spherical harmonic $n \geq 20$, have been computed for self-gravitating inhomogeneous spheres corresponding to a variety of earth models, and then used to deduce phase and group velocities for the fundamental and first higher modes of Rayleigh waves of periods < 320 sec. The mathematical methods, program checks, and estimations of accuracy are presented in some detail. A comparison is made between phase and group velocities for different spherical models and with corresponding flat earth velocities calculated for the same physical parameters. The comparison shows that the inclusion of gravity and sphericity increases the phase velocity by about 5 percent near $T=300$ sec and by about 2.5 percent near $T=150$ sec. The group velocities for the spherical case remain within 1 percent of the corresponding velocities of the horizontally layered case for $100 < T < 250$ sec.

The variation with depth of the relative amplitudes of the radial and horizontal displacements and the perturbed gravitational potential is shown graphically for one earth model in the cases $n=30, 80,$ and 110 . Comparison with these theoretical results shows that recent observations are consistent with a mantle having a density distribution similar to that of Bullen's model A, and P- and S-velocity distributions similar to those calculated by Gutenberg.

A group velocity dispersion curve corresponding to the first higher mode (or first shear mode) of Rayleigh waves has also been computed for $20 < T < 150$ sec ($500 > n > 40$) for a continental model. The minimum and maximum of this

curve occur at a velocity of 4.30 km/s and period of 60 sec and at a velocity of 4.54 km/s and period 25 sec, respectively; the period and velocity of the latter agree well with those of the Sa phase described by Caloi (see Geophys. Abs. 161-100) and Gutenberg (see Geophys. Abs. 161-99) and of the Sn phase of Press and Ewing (see Geophys. Abs. 160-97). — D. B. V.

186-256. Lapwood, E. R. The transmission of a Rayleigh pulse round a corner: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 174-196, 1961.

The form of a Rayleigh pulse after it passes around a corner is investigated mathematically. The problem is treated as two-dimensional, the pulse traveling on one face of an elastic quarter-space and the crest-line being parallel to and traveling toward the edge. It is found that the form of the pulse is changed greatly, depending on the P-, S-, and R-wave velocity values. Whereas the displacements u and v on $y=0$ have the shape of $\phi(t)$ and its allied function $\phi'(t)$, respectively, each of u and v on $x=0$ is given by a linear combination of ϕ and ϕ' . Since ϕ' may differ greatly from ϕ in form, the change in shape of each component of displacement when it turns the corner may be very marked. — D. B. V.

186-257. Nag, K. R. On the propagation of Rayleigh waves in three dimensions in alluvial soils: Geofisica Pura e Appl., v. 48, p. 16-22, 1961.

The propagation of Rayleigh waves in three dimensions in alluvial soils that do not behave as ordinary isotropic elastic solids is treated mathematically. The frequency equation is solved for different soil constants. — D. B. V.

186-258. Takeuchi, Hitoshi, and Saito, Masanori. Surface waves propagating along the free surface of a semi-infinite elastic medium of variable density and elasticity (pt. 4). A computer program for the computation of Rayleigh-dispersion on the homogeneous multilayered media [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 4, p. 227-231, 1960.

Phase and group velocities of Rayleigh waves are obtained on the Bendix G-15D computer for a specified wave length for up to 20 homogeneous solid layers. A liquid layer lying on the solid layers may be taken into account. (See also Geophys. Abs. 181-134, 184-225, 186-262). — V. S. N.

186-259. Deresiewicz, H. The effect of boundaries on wave propagation in a liquid-filled porous solid: 2. Love waves in a porous layer: Seismol. Soc. America Bull., v. 51, no. 1, p. 51-59, 1961.

The transcendental equation is derived relating frequency and phase velocity of propagation of Love waves in a porous layer containing a viscous liquid. This equation, being complex, can be satisfied only if the wave number of the motion is complex, indicating that the disturbance is dissipative. The general expression being intractable analytically, an approximate scheme is employed to determine the phase velocity and measure of dissipation valid for porous materials in which the mass (per unit volume of aggregate) of the interstitial liquid is smaller than that of the solid. — Author's abstract

186-260. De Noyer, John. The effect of variations in layer thickness on Love waves: Seismol. Soc. America Bull., v. 51, no. 2, p. 227-235, 1961.

A model is considered in which Love waves propagate perpendicular to the trend of a structure that varies in thickness as a sine function of distance. The period equation for this model is obtained and average values for phase and group velocities are found for several distance ranges. A method is proposed for finding relative amplitudes as a function of position along the structure for any specified period. This approach can also be applied to arbitrary crustal structures other than sinusoidal, as long as the thickness of the upper layer and the slope of the interface are continuous single-value functions and the thickness of the upper medium remains positive; the first and second derivatives of the wave number k with respect to horizontal distance x must also be small.

A solution for dispersion of Rayleigh waves propagating across a similar type of structure may permit more reliable interpretation of crustal structures than has been possible with the "average" thickness concept. As more long-period seismographs are put into service, it may become practical to use surface wave amplitude data along with group and phase velocities for the determination of crustal structure. — D. B. V.

186-261. Knopoff, Leon. Green's function for eigenvalue problems and the inversion of Love wave dispersion data: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 161-173, 1961.

The change in the nature of the dispersion curve for Love waves has been determined for the case of a delta function inhomogeneity introduced at depth. The unperturbed medium is arbitrarily inhomogeneous in the depth dimension. It is shown that the perturbations in the dispersion curves due to a density inhomogeneity are decoupled from those due to a modulus inhomogeneity. Hence it is proved that any dispersion curve can correspond to an infinity of possible distributions of density and modulus; the relation between the possible solutions is given by a linear integral equation. The inversion of the integral equations is carried out for the case when the starting values are those of the usual homogeneous layer overlying a homogeneous half-space. Hence from a given dispersion curve, the infinity of solutions are obtained as perturbations upon the assumed starting structure. The limitations of the inversion are discussed. — Author's summary

186-262. Takeuchi, Hitoshi, and Saito, Masanori. Surface waves propagating along the free surface of a semi-infinite elastic medium of variable density and elasticity (pt. 3). A computer program for the computation of Love wave dispersion on the homogeneous multi-layered media [in Japanese With English abstract]: Zisin, ser. 2, v. 13, no. 4, p. 219-226, 1960.

A program for the Bendix G-15D computer prepared by Press and Takeuchi to calculate Love wave dispersion using Haskell's matrix iteration method (see Geophys. Abs. 152-14273) is discussed. The phase and group velocities obtained correspond to a specified wave length of Love wave for up to 39 homogeneous solid layers lying on a homogeneous solid half-space. [See also Geophys. Abs. 181-134, 184-225.]— V. S. N.

186-263. Kobayashi, Naota, and Takeuchi, Hitoshi. Surface waves propagating along the free surface of a semi-infinite elastic medium of variable density and elasticity (pt. 5). Mantle Love waves [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 4, p. 232-240, 1960.

Using the variational calculus method developed in previous papers (see Geophys. Abs. 175-254, 181-134, 184-225, 186-258, and 186-262), the man-

the Love-wave problem is studied for the model earths of Jeffreys and Gutenberg. Contrary to the corresponding mantle Rayleigh wave problem, the Jeffreys' model gives better agreement with observations of mantle Love waves than does the Gutenberg model. — V. S. N.

- 186-264. Sato, Yasuo. Analysis of dispersed surface waves, in *International symposium on stress wave propagation in materials*: New York and London, Interscience Publishers, Inc., p. 303-327, 1960; Japanese version in *Zisin*, ser. 2, v. 13, no. 3, p. 163-192, 1960.

The study and analysis of dispersed surface waves is aimed at a knowledge of (1) the structure of the medium through which the waves are being propagated, and (2) the mechanism of the source which radiates the disturbance into this medium. A general survey of the different methods of analysis starting from observed data is first presented, with special emphasis on direct methods for obtaining the structure of the medium. These are the use of the WKB-approximation, and a high-speed iterative computation procedure. The use of Fourier analysis is also discussed, and examples shown based on data from natural and from artificial disturbances. — Author's abstract

- 186-265. Kumar, Sudhir. Edge waves in plates, in *International symposium on stress wave propagation in materials*: New York and London, Interscience Publishers, Inc., p. 119-131, 1960.

The waves recorded at the edge of a plate when a certain stress is propagating in the plate are termed here "edge waves." In the present paper, the boundary value problem of propagation of edge waves in a flat plate of specified width and infinite length has been solved. The plate with free edges is assumed to be thin, and the external forces are taken as acting in the plane of the plate in order to make the problem one of plane stress. The frequency equation of propagation is obtained, and some limiting cases of the frequency equation are then discussed. Finally, the similarity of one of the two frequency equations for edge waves in a plate with the frequency equation for flexural waves in a plate is pointed out. — Author's abstract

- Brune, James N., Nafe, John E., and Alsop, Leonard E. The polar phase shift of surface waves on a sphere. See *Geophys. Abs.* 186-195.

- 186-266. Keylis-Borok, V. I. *Interferentsionnyye poverkhnostnyye volny* [Interference surface waves]: Moskva, Akad. Nauk SSSR Inst. Fiziki Zemli, 195 p., 1960.

This is a monograph on the specific oscillations of elastic mediums known variously as surface waves, natural oscillations of layers, normal waves, guided waves, interference waves, and the like. The generalized physical-mathematical treatment of the subject permits investigations for an arbitrary number of layers of an arbitrary nonsymmetrical, nonstationary, and arbitrarily situated oscillation source. Only flat-parallel, homogeneous, isotropic, and ideally elastic layers are discussed. Applications of the theories to problems of the constitution of the earth, engineering seismology, seismic exploration, seismic regionalization, oceanography, meteorology, and recognition of nuclear explosions are discussed. A bibliography of 106 titles is given. — A. J. S.

- 186-267. Birch, Francis. The velocity of compressional waves in rocks to 10 kilobars, pt. 2: *Jour. Geophys. Research*, v. 66, no. 7, p. 2199-2224, 1961.

The measurements of the velocity of compressional waves up to 10 kilobars for some 250 specimens of rock, reported in part 1 [see *Geophys. Abs.* 184-227], are discussed with respect to the effects of porosity, alteration, anisotropy, and composition. The relations of isotropic elasticity are shown to be approximately valid for a number of examples. Reasonable agreement with theoretical values for quasi-isotropic aggregates is demonstrated where comparison is possible. At pressures above a few kilobars, the principal factors determining velocity are density and mean atomic weight; oxides and silicates conform to the same general relations, with a few exceptions. Details of symmetry or crystal structure appear to be of secondary importance. Velocity is an approximately linear function of density for materials having a common mean atomic weight, but is in general not a single-valued function of density alone. — Author's abstract

- 186-268. Roever, W. L., Vining, T. F., and Strick, E. Propagation of elastic wave motion from an impulsive source along a fluid solid interface. Pt. 1. Experimental pressure response; Pt. 2. Theoretical pressure response; Pt. 3. The pseudo-Rayleigh wave: *Royal Soc. London Philos. Trans.*, v. 251, no. 1000, p. 455-523, 1959.

The pressure response for the impulse-excited fluid-solid interface problem was investigated experimentally by means of a pressure wave generated in the system by a spark and detected with a small barium titanate probe, the output of which was displayed on an oscilloscope and photographed. Two cases were investigated: one where the transverse wave velocity is lower than the longitudinal wave velocity in the fluid, and the other where it is higher. Both observed responses agree even as to details of wave-form with exact theoretical calculations made for a delta-excited line source. In the case of low transverse wave velocity one finds a Stoneley type of interface wave in addition to critically refracted P, direct, and reflected waves; a Stoneley wave thus may be the largest contributor to a response curve. In the case of high transverse wave velocity the critically refracted P-wave is smaller and the Stoneley wave becomes compressed in time and arrives very soon after the reflection. Between the critically refracted P-wave and the direct arrivals there is a pressure build-up preceding the arrival time that might be expected for a critically refracted transverse wave.

The pressure build-up is investigated and found to consist of the superposition of three arrivals. Most prominent of these is the pseudo-Rayleigh wave; the others are the critically refracted transverse wave and the build-up to the later arriving Stoneley wave. The pseudo-Rayleigh wave has the velocity of a true Rayleigh wave and the same retrograde particle motion, but mathematically it originates from a pole lying in a lower Riemann sheet in the complex plane rather than from a pole on the real axis of the plane of the variable of integration. The migration of this complex pole explains why such a pseudo-Rayleigh wave was not observed in the low transverse velocity case.

Finally, a method is suggested for obtaining the solid rigidity of bottom sediments in watercovered areas from measurements in place of the pseudo-Rayleigh and (or) Stoneley wave velocities and arrival times. — D. B. V.

- 186-269. Müller, Gerhard. Geschwindigkeitsbestimmungen elastischer Wellen in gefrorenen Gesteinen und die Anwendung akustischer Messungen auf Untersuchungen des Frostmantels an Gefrierschächten [Velocity determinations of elastic waves in frozen rocks and the application of acoustic measurements to investigations of the frozen belt at frozen shafts (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 2, p. 276-295, 1961.

Acoustic velocity measurements were made on synthetic frozen cores in order to determine the applicability of such measurements to the method of sinking mine shafts through unfavorable ground by freezing during sinking. The validity of the laws of sound propagation through unfrozen porous mediums is extended to temperatures below the freezing point of water. Measurements in place demonstrate that the elastic wave velocity of solid rocks increases considerably on freezing.

It is concluded that such measurements in shafts can supply important information concerning the structure and thickness of the frozen belt, changes in stability of the rock due to freezing, and the planning of temporary and final shaft lining. A four-page bibliography is given. — D. B. V.

- 186-270. Balakrishna, S. Ultrasonic velocities in some metamorphic rocks: *Geol. Soc. India Jour.*, v. 1, p. 136-143, 1959.

Sound velocities, both longitudinal and torsional, are measured in some metamorphic rocks by the ultrasonic pulse method. Results show that changes in physical structure of the rock, too slight to make a measurable difference in density, are capable of changing the modulus of extension by a large factor. Velocity varies linearly with change in grain size; it decreases as grain size increases. Moreover, the ultrasonic velocities in metamorphic rocks decrease rapidly with increasing temperature, and the temperature gradient for longitudinal velocities is greater than for torsional ones. The temperature gradient in metamorphic rocks is controlled mostly by the degree of metamorphism and consequent compaction and, therefore, by their petrogenetic history. [See also *Geophys. Abs.* 175-96, 179-130, 182-170, 185-160.]— V. S. N.

- 186-271. Pros, Zdeněk, and Vaněk, Jiří. Experimental study of a pulse method for measuring elastic parameters of rocks in samples: *Československá Akad. Věd Studia Geophys. et Geod.*, v. 4, no. 4, p. 338-349, 1960.

The pulse method variant using two electroacoustic transducers is particularly suitable for measuring elastic parameters of rocks. Two principal arrangements of this variant are the transmission method, in which the transmitter and receiver are placed on opposite faces of the sample, and the profiling method, in which the transmitter is on one face or on the surface and the receiver is moved over the surface of the sample. The transmission method is more reliable in the case of longitudinal wave velocity and permits the determination of both P- and S-wave velocities in a single measurement. As a relatively complicated wave pattern consisting of several wave groups is observed in this method, a thorough knowledge of the wave pattern and changes in its geometry in the sample is necessary for interpretation of the results. Also, the plane wave approximation usually used in computing velocities cannot be realized in many cases.

This paper investigates these questions in detail. The wave patterns generated by a plane wave in a cylindrical sample, by a point source in a cylindrical sample, and by a source of infinite dimensions in a cylindrical sample are examined theoretically; methods of determining the wave velocities from the wave patterns are discussed; and then the results are generalized for samples of shapes other than cylindrical. With the aid of the detailed classification of observable wave groups and with the use of smaller transducers and the generalized results given here, the applicability and reliability of the transmission method are greatly enhanced. — D. B. V.

- 186-272. Rykunov, L. N., Khorosheva, V. V., and Sedov, V. V. Dvukhmer-naya model' seysmicheskogo volnovoda s nerezкими granitsami

[Two-dimensional model of a seismic wave guide with diffuse boundaries]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1601-1603, 1960.

An experiment for investigation of seismic wave propagation in a low velocity wave guide is described and its results discussed. The changes in velocity and absorption of elastic waves and the wave processes in the wave guide were studied with a wave guide model in the form of a sheet 740X520X5 mm made of paraffin-polyethylene alloy (97:3), which changes its elastic properties with change of temperature. A wire that could be heated by electric current was embedded in the plate. The radiant heat from the wire affected the elasticity of the plate, forming a low velocity channel with diffuse boundaries. The velocity and amplitude curves in terms of changing temperature, the curves of the energy capture, and the form of the wave guide layer were obtained. — A. J. S.

186-273. Bayuk, Ye. I. Izucheniyе uprugikh svoystv obraztsov gornyx porod iz glubokoy skvazhiny pri vysokikh davleniyakh [Study of elastic properties of rock samples from a deep borehole under high pressures]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1756-1761, 1960.

Cores of sedimentary rocks were tested for elastic parameters. The first tests were made under atmospheric pressure and showed that in general the density and the values of elastic properties of the rocks increase and porosity decreases with depth. The three deepest samples deviate from this regularity, however. Subsequent tests were conducted under confining pressure increased in steps of 200-300, 500, and 1,000 kg per cm². The elastic parameters of the rocks increase with increased pressure. The rate of the increase is especially pronounced up to a pressure of 1,000 kg per cm², depending also on the depth from which the samples tested were taken. The values of V_p , V_s , σ , G , and E are given in terms of the composition of the core and the pressure applied. — A. J. S.

186-274. Rapoport, M. B. Ob otrazhenii seismicheskikh voln ot nezeral'nykh granits [On reflection of seismic waves from nonspecular boundaries]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 185-196, 1961.

The structure of the wave field of a nonstationary (quasi-sinusoidal) wave emitted by a point source and reflected from a nonspecular boundary is discussed. Secondary diffracted waves that are generated under certain conditions and travel with a dispersion of the phase velocity along the profile possess specific properties which explain many phenomena observed in prospecting by the method of controlled oriented reception of seismic waves (RNP method). Experiments on models of periodically rough boundaries and the secondary diffracted waves isolated in the laboratory by the RNP method are found to agree with the theoretical findings. — A. J. S.

186-275. Rykunov, L. N., and Feofilaktov, V. D. P'yezoelektricheskiy izluchatel' ul'trazvukovykh impul'sov tipa odinochnogo vybrosa dlya modelirovaniya seismicheskikh voln [Piezoelectric emitter of ultrasonic impulses of single ejection type for modeling of seismic waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 205-214, 1961.

Free vibrations excited in a pack of 45° Z-cut ammonium dihydrogen phosphate plates by electric pulses are made up of two superimposed modes on

different frequencies that cause different kinds of deformation of the plates. The characteristics of these deformations make it possible to eliminate one of the modes so as to produce an oscillator characterized by one natural frequency. The vibrations excited in this oscillator by square electric pulses of varying duration were examined, and on this basis an emitter was designed to radiate elastic ultrasonic pulses of various forms and, in particular, a single-ejection type. — Authors' abstract, J. W. C.

- 186-276. Ulomov, V. I. O modelirovaniy ochagov tektonicheskikh zemletryaseniy pri pomoshchi ul'trazvukovykh izluchateley [On modeling of focuses of tectonic earthquakes with the aid of ultrasonic emitters]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 255-248, 1961.

A piezoelectric emitter of elastic waves having a distribution of forces equivalent to the distribution of forces at a real focus of an earthquake is described. The stresses arising in a fault earthquake are compared with the stresses in a paraffin model subjected to narrow rectangular electric impulses transformed into mechanical impulses of a desired width. Diagrams of sign and intensity distribution of the first arrival around the emitter are given for a vertical fault and for a vertical rupture in the model. — A. J. S.

- 186-277. Rykunov, L. N., and Selyuminov, S. D. Generator impul'sov dlya vzbuzhdeniya p'yezoelektricheskikh izluchateley [An impulse generator for excitation of piezoelectric emitters]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 730-731, 1961.

Construction and operation of a piezoelectrical electronic generator of trapezoidal impulses having a minimum of residual oscillation is discussed. The generator consists of a blocking generator, a cathode repeater, and an output amplifier. The residual oscillations emitted by a 2-cm cube of ammonium dihydrophosphate excited by the generator described were found to be 7 percent or less. A circuit diagram and oscillograms of the device are given. — A. J. S.

- 186-278. Frolov, A. D. Rasprostraneniye ul'trazvuka v merzlykh peschanoglinistykh porodakh [Propagation of ultrasound in frozen sandy-clayey rocks]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 732-736, 1961.

An experimental study was made of ultrasonic velocities in 116 specimens of clay, 56 specimens of interbedded clay and sand, 45 specimens of sand, and 14 specimens of sandstone at temperatures of -20° , -10° , -5° , -2° , -0° , $+2^{\circ}$, and $+20^{\circ}\text{C}$. The results are tabulated and also presented in graphs. — J. W. C.

- 186-279. Adachi, Ryuzo. On the magnification of the record of a vibration by an electromagnetic-type transducer and a galvanometer [in Japanese with English abstract]: Butsuri-Tanko, v. 13, no. 2, p. 96-101, 1960.

The mathematical expressions for the magnification of the displacement, velocity, and acceleration of a vibration by an electromagnetic-type transducer and a galvanometer are given. The method of determining the values of the damping coefficients is discussed, and the results are illustrated. — V. S. N.

- 186-280. Kutschale, Henry. Long-range sound transmission in the Arctic Ocean: Jour. Geophys. Research, v. 66, no. 7, p. 2189-2198, 1961.

Strong hydroacoustic signals from underwater explosions as small as 2 lb of TNT have been detected in the Arctic Ocean at distances up to 1,150 km by hydrophones at depth and geophones on the ice surface. The signals propagate in the Sofar channel, but the character of the signals differs markedly from that typical of the nonpolar regions largely because of the predominance of low-frequency waves in the Arctic. The character of these signals is best explained by normal-mode wave propagation in a channel bounded by the surface and by the zone of increasing velocity in the upper several hundred meters of water. Irregularities in the ice boundaries apparently strongly attenuate the high-frequency waves but have a negligible effect on the amplitudes of the low-frequency waves. At least 2 normal modes were observed; in each, the waves have a nearly sinusoidal appearance with periods decreasing from about 120 to 30 msec in the first mode and from 70 to 40 msec in the second mode. A good quantitative fit between experimental data and theoretical dispersion curves has been obtained. The signals were detected in both deep and shallow water. — D. B. V.

186-281. Hudson, D[onald] E[llis], Alford, J. L., and Iwan, W. D. Ground accelerations caused by large quarry blasts: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 191-202, 1961.

Ground acceleration-time measurements have been made within 2,000 feet of 2 quarry blasts of total charge weight 185 and 673 tons. The character and magnitude of the ground accelerations were similar to those associated with damaging earthquakes. Complete response spectrum curves calculated from the acceleration records are presented. Direct comparisons are made between these results and previous similar measurements and calculations of strong-motion earthquakes, high explosive blasts, and the Rainier nuclear blast. — D. B. V.

186-282. Leet, L[ewis] Don. *Vibrations from blasting rock*: Cambridge, Harvard Univ. Press, 134 p., 1960.

This book, designed primarily for readers with some technical training who have not been active in engineering or research in recent years, brings together all available information on vibrations caused by the detonation of explosives. Such factors are discussed as the characteristics of rock, the preparation of blasts, events during and after detonation, and the nature of explosives. Methods of recording the elastic waves generated in the earth and their significant features, and the criteria for estimating their ability to damage structures are described. The unique features of motion within the potential crater zone and the use of impedance ratios to achieve maximum blasting efficiency are also discussed. — V. S. N.

Hoffman, John P., Berg, Joseph W., Jr., and Cook, Kenneth L. Discontinuities in the earth's upper mantle as indicated by reflected seismic energy. See *Geophys. Abs.* 186-442.

Steinhart, J. S., and Meyer, R. P. (with contributions by Woollard, G. P., Bonini, W. E., and Smith, T. J.). *Explosion studies of continental structure*. See *Geophys. Abs.* 186-431.

186-283. Pasechnik, I. P. K opredeleniyu parametrov zatukhaniya voln P_n i S^* [On determination of damping parameters of P_n and S^* waves]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 12, p. 1740-1743, 1960.

An evaluation of the power of the divergence function "n" and the amplitude absorption "α" is made by two independent methods from single amplitude

curves of P_n and S^* waves obtained along a profile from underground nuclear explosions of 5 and 19 kilotons equivalent and also from the Arys'trotyl explosion. Mean values of $n \approx 2$, $\alpha = 0.0022$ per km were found for waves P_n of 0.6-0.8 sec oscillation period, and $n \approx 1.7$, $\alpha = 0.0023$ per km for S^* waves of 1.0-1.2 period. — Author's abstract, A. J. S.

- 186-284. Pasechnik, I. P. Seismicheskiy metod obnaruzheniya i identifikatsii yadernykh vzryvov [Seismic method of detection and identification of nuclear explosions]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 835-846, 1961.

Quantitative characteristics of seismic noise level at quiet, medium, and noisy seismic stations for various period ranges are given. The seismic method of detection of elastic waves caused by nuclear and chemical explosions is discussed. The correlation between seismic wave amplitudes and epicentral distances of the explosion points are analyzed. Groups of up to 100 vertical seismographs connected to the same galvanometer, seismographs in deep (up to 2 km) boreholes, and seismographs on the ocean floor are recommended to avoid seismic noises causing more than 20μ elastic displacement in the rock. — A. J. S.

- 186-285. Kubotera, Akira, and Okano, Kennosuke. Observations of seismic and microbarometric waves produced by nuclear explosions [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 4, p. 210-218, 1960.

A new type of wave group has been found on the records of long-period seismographs from the nuclear explosions in the central Pacific (Bikini Atoll) in June and July 1958. The wave has a period of 9 to 1 min and a propagation velocity of about 300 m per sec; its arrival time is about 3 hr later than that of the seismic P-wave. The waves are attributed to the effect of atmospheric pressure fluctuations upon the inert mass of the seismograph. — V. S. N.

- 186-286. Iida, Kumizi, and Aoki, Harumi. Attenuation of seismic waves in the vicinity of explosive seismic origin: Nagoya Univ. Jour. Earth Sci., v. 8, no. 2, p. 109-119, 1960.

Seismic wave attenuation characteristics in a viscoelastic medium in the vicinity of an explosive origin are investigated by comparison of Fourier components of body waves at various distances from the seismic origin. Results from field experiments show that the attenuation law can be explained approximately by the viscoelasticity of a Voigt type medium. The decrease in amplitude with distance r is found theoretically to be intermediate between $\frac{1}{r}e^{-\alpha r}$ and r^{-n} ; the index of attenuation of the seismic waves in the area of field experiment was found to be 2.22, a value considerably different from that of a perfectly elastic body. The solid viscosity coefficient of the medium in which the seismic waves are propagated is of the order of 10^7 cgs units, and the ratio of the solid viscosity coefficient to the square of the wave velocity is of the order of 10^{-3} . — V. S. N.

- 186-287. Aoki, Harumi. Seismic waves in the region near explosive origin: Nagoya Univ. Jour. Earth Sci., v. 8, no. 2, p. 120-173, 1960.

Experimental and theoretical investigations of the shape of seismic waves radiated from an explosive seismic origin and the mechanisms of wave generation are described. It is shown that near the ground surface the nearly spherical waves generated at the point of origin are somewhat affected by the inho-

mogeneity of superficial structures of the medium resulting in a deviation of wave form from spherical symmetry, and the smaller the amount of charge the more is the fluctuation of amplitude. The form and propagation of the elastic waves that proceed ahead of the plastic wave front are discussed also, and it is concluded that the ratio λ/μ and the expansion of the plastic region are important factors in determining the shape of an elastic wave. The observed elastic waves are composed chiefly of free oscillations of the crushed region produced by the detonation of the explosive, although in the solution of the wave equation, the first half-cycle of the disturbance may be represented by forced oscillation terms. However, the experimental results, such as change in amplitude with change in charge size and shape during progression of the disturbance, do not agree with the theoretical results unless the viscoelastic behavior of the medium is taken into account. — V. S. N.

ELECTRICAL EXPLORATION

- 186-288. Wait, James R. A phenomenological theory of induced electrical polarization: *Canadian Jour. Physics*, v. 36, no. 12, p. 1634-1644, 1958.

A brief theoretical derivation is presented for the effective conductivity and dielectric constant of a homogeneous medium loaded with a uniform distribution of spherical conducting particles. To account for the effect of induced polarization the particles are taken to have a concentric membrane or film which has a blocking action to the current flow into the particle. The characteristics of this phenomenological model are very similar to the experimentally observed features of induced polarization in a block of compacted andesite particles which contains a dissemination of small metal particles and is partially saturated with a weak electrolyte. The theory is then extended to a two-layer medium where the lower region is polarizable. The results explain, at least in a qualitative way, the observed features of induced electrical polarization in rocks, soils, and clay. — Author's abstract

- 186-289. Ward, Stanley H. The electromagnetic response of a magnetic iron ore deposit: *Geophys. Prosp.*, v. 9, no. 2, p. 191-202, 1961.

Field experiments in the vicinity of a tabular body of nearly massive magnetite have demonstrated that the body may respond in either of two ways; it may react as a permeable mass, or it may react as an eddy current indicator, depending upon the frequency employed. If several frequencies, spanning a broad range, are employed, both types of response will be experienced. The transition from one type of response to the other would appear to have considerable significance. Based upon theoretical and empirical work to date, it seems possible to establish a relationship between transition frequency and percentage magnetite at any given section of a deposit. — Author's abstract

- 186-290. Bosschart, R. A. On the occurrence of low resistivity geological conductors: *Geophys. Prosp.*, v. 9, no. 2, p. 203-212, 1961.

On the basis of past field results the possibility has been denied that natural massive sulfide orebodies could have as low resistivities as those measured on laboratory specimens (of the order of 0-10 ohm-cm). This paper discusses anomalies obtained with the loop-frame method on massive sulfide bodies in different parts of Canada. Model experiments show that the conductors all have very low resistivities which, where effective thickness can be determined, appear to correspond to the order of magnitude of the laboratory specimen resistivity. It is demonstrated that confusion of the total width with effective thickness of a conductor may lead to erroneous resistivity data. — D. B. V.

- 186-291. Alfano, L[ui]gi]. The influence of surface formations on the apparent resistivity values in electrical prospecting. Pt. 2: Geophys. Prosp., v. 9, no. 2, p. 213-241, 1961.

In part 1 (see Geophys. Abs. 184-279) the theory developed in a previous paper (see Geophys. Abs. 179-133) was applied to the problem of surface inhomogeneities with cylindrical structure; this part treats those with noncylindrical structure, taking into account effects due to potential electrodes and to current electrodes. Almost all the conclusions drawn in part 1 are found to be generally valid. Details of the calculation procedure are given to show the suitability of the method used for study of this problem. — D. B. V.

- 186-292. Crea, Antonio. Perturbazione indotta nel campo di un elettrodo rettilineo indefinito da un piano perfettamente conduttore parallelo all'elettrodo [Perturbations induced in the field of a rectilinear indefinite electrode by a perfectly conducting plane parallel to the electrode (with English and German summaries)]: Geofisica Pura e Appl., v. 46, p. 83-94, 1960.

This paper calculates the electrical field and potential generated by a filiform, rectilinear, indefinite electrode on the surface of a homogeneous ground containing, at a given depth, a perfectly conducting plane. In practice, such a plane could be a metalliferous vein having a thickness that is negligible compared to its other dimensions. The contrast between this and the shape of the potential in the case of the same electrode on homogeneous ground is striking. — D. B. V.

- 186-293. Seshadri, S. R. Diffraction of a plane wave by a unidirectionally conducting half-plane: India Natl. Inst. Sci. Proc., v. 27, pt. A, no. 1, p. 1-10, 1961.

The problem of the diffraction of a plane wave by a unidirectionally conducting half-plane is formulated in terms of an integral equation whose solution is obtained by the standard Wiener-Hopf procedure. Expressions for the fields and the current induced on the screen are given. — V. S. N.

- 186-294. Shaub, Yu. B. O primenenií metoda vrashchayushchegosya magnitnogo polya dlya elektrokartirovaniya [On application of the method of the rotating magnetic field for electrical mapping]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1485-1489, 1960.

The correlation between the active and reactive components of a disbalanced signal and the electrical resistivity of a homogeneous half-space (homogeneous earth) is analyzed, with a view toward application to airborne geologic mapping by the method of rotating magnetic field (see Geophys. Abs. 162-67, 165-112, 174-117). It was found that by measuring the two orthogonal components of the disbalanced signal the method can be applied advantageously not only to prospecting for highly conducting ore bodies but also to mapping of the country rock. — A. J. S.

- 186-295. Shakhshvarov, D. N., and Rybakova, Ye. V. O primenimosti predstavleniy dal'ney zony pri chastotnykh elektromagnitnykh zondirovaniyakh [On applicability of the distant zone concept in frequency electromagnetic sounding]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1604-1607, 1960.

This is a development of Van'yan's (see Geophys. Abs. 180-108) and Tikhonov and Shakhshvarov's (see Geophys. Abs. 179-147) papers on the theory of di-

pole electromagnetic field of a distant zone. For the case of a layer of apparent resistivity ρ_1 underlain with a layer of $\rho_2=0$, this method leads to a satisfactory interpretation of the profile investigated by permitting construction of simple master charts. The amplitude and phase characteristics of the electric and magnetic components of the field cannot be determined uniquely when the underlying basement rock is an insulator. Serious errors in the profile determination may occur if the concept of distant zone is applied when ρ_2 differs considerably from zero. — A. J. S.

186-296. Glyuzman, A. M. Pole tochechnogo istochnika toka, raspolozhenogo na granitse poluprostranstva v prisutstvii paraboloidal'noy poverkhnosti razdela [Field of a point source of a current located on the boundary of a half-space which includes a paraboloid interface]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1791-1795, 1960.

A mathematical analysis is presented for the field that results from an electric current point source situated inside and outside of a paraboloid of revolution, which forms an interface in the lower half-space. Formulas for the potential functions are derived for both cases. — A. J. S.

186-297. Dmitriyev, V. I. Ekraniruyushcheye vliyaniye nanosov na anomal'noye pole [The screening effect of alluvium on an anomalistic field]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 46-53, 1961.

A rigorous solution of the diffraction problem of electromagnetic field on a perfectly conducting half-plane immersed in a homogeneous conducting half-space covered with a conducting layer of different resistivity is given. The solution is presented in the form of an absolutely convergent monotonic series, one or two terms of which are sufficient for practically accurate results. — A. J. S.

186-298. Tikhonov, A. N., and Shakhsuvarov, D. N. O neravnomernosti asimptotiki elektromagnitnykh poley, vzbuzhdayemykh dipolem peremennogo toka v sloistoy srede [On nonuniformity of the asymptotics of electromagnetic fields induced by an a-c dipole in a layered medium]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 107-110, 1961.

This is a further development of the study of electromagnetic fields induced by an a-c dipole in a layered medium (see Geophys. Abs. 179-147) showing that

$$\lim B_z^* \neq \lim B_z^*, \quad \text{where } \tilde{B}_z^* = r^2 \tilde{B}_z / \Lambda_1^2$$

$$r = \infty \quad \mu_2 = \infty$$

$$\mu_2 \rightarrow \infty \quad r \rightarrow \infty$$

where \tilde{B}_z is a nondimensional complex amplitude which depends on the structure of the medium, the distance r from the dipole to the observation point, and current frequency f ; Λ_1 is the wavelength in the upper layer, and μ_2 is the magnetic permeability of the second layer. — A. J. S.

186-299. Shaub, Yu. B. O kolichestvennoy mere informatsii dostavlyaemyoy metodamy aeroelektrozazvedki [On a quantitative standard for information furnished by airborne electric prospecting methods]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 160-168, 1961.

It is feasible to establish a unique quantitative measuring unit for evaluation of the information obtained by various methods of airborne electrical prospecting. A comparison was made for a conducting spherical body using the methods of induction, infinitely long cable, totaling magnetic field, and measuring the angle of inclination of the polarization plane of the natural alternating magnetic field of the earth. The last method is found to be the most effective in prospecting for good-conducting ore bodies. The method of totaling magnetic field and of infinitely long cable are approximately equal in effectiveness, whereas the induction method is the least effective of the four. — A. J. S.

- 186-300. Glyuzman, A. M. Resheniye krayevoy zadachi dlya giperboloida vrashcheniya v elektrorazvedke [Solution of the boundary problem for a hyperboloid of revolution in electrical prospecting]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 717-724, 1961.

The problem of the distribution of potential from a point source at the boundary of a half space when hyperboloidal interfaces are present is treated analytically. Solutions of the problem are obtained in the form of real integrals which combine the Legendre function with imaginary sign, and its derivative. The coefficients are found with the Mehler-Fok integral theorem of expansion. The integration of the Laplace equation was carried out in the system of de-generated ellipsoidal coordinates. — A. J. S.

- 186-301. Glyuzman, A. M. Resheniye krayevoy zadachi dlya konicheskoy oblasti v elektrorazvedke [Solution of a boundary problem for a conical region in electrical prospecting]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 1009-1015, 1961.

The solution is worked out for the potential distribution problem in electrical prospecting when the distribution in a nonhomogeneous medium bounded by the surface of an infinite circular cone is sought. Formulas are derived for potential distribution along the cone axis lying on the surface plane of the earth, and in a profile that coincides with the cone axis near a hole in the form of a circular cone. — A. J. S.

- 186-302. Tarkhov, A. G. Geofizicheskiye poiski rudnykh mestorozhdeniy [Geophysical prospecting of ore deposits]: Sovetskaya Geologiya, no. 2, p. 108-124, 1961.

Geophysics has not met the growing needs of ore exploration although much progress has been achieved. The depth of exploration can be increased by suppressing the heterogeneities of a field that obscures the geophysical anomaly produced by an ore deposit. This requires certain alterations of present practices. In using the isoline method it would be expedient to eliminate those observations taken in the zone of the electrodes, to increase the unit areas from 1X1 to 2X2 km or even 4X4 km, and to plot changes of the absolute values of potential together with the purely qualitative tracing of the isonomalies. Great attention should be given to electrical surveying using alternating current; this includes the method of the ungrounded loop using low frequencies and the induction and radiomethods using high frequencies. The radio-wave method is particularly promising for underground exploration. This method has already yielded good results in study of veinlet-disseminated ores, which are practically inaccessible to direct current surveys. — J. W. C.

- Kolmakov, M. V., and Vladimirov, N. P. On the problem of equivalence of magnetotelluric sounding curves. See Geophys. Abs. 186-121.

- 186-303. Yoshizumi, Eizaburo, and Irie, Tsuneji. A new interpretation method of resistivity method—input resistance method [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 2, p. 81-88, 1960.

Resistance network analogs, based on recognition of the formal similarity between Kirchhoff's law equations and the results of finite difference expansion of Laplace's equation, are applied to the solution of data from electrical prospecting. The equivalent resistance network of the two-electrode resistivity method is explained according to potential bowl theory, and a new interpretation method called the input resistance method is proposed. — V. S. N.

- 186-304. Fukuzawa, Hiroshi, and Arima, Sumiteru. Model experiments on the artificial electric potential methods utilizing drill holes and adits [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 3, p. 172-179, 1960.

Model experiments on the electric potential method of prospecting for ore bodies are discussed. The devices used in the experiments, the arrangement of electrodes and model ore body, and the results of the experiments are well illustrated in pictures and graphs. — V. S. N.

- 186-305. Corbett, J. D. An empirical demonstration of geophysical methods across the Caribou deposit, Bathurst, N. B.: *Canadian Mining Metall. Bull.*, v. 54, no. 587, p. 227-229, 1961; *Canadian Inst. Mining Metallurgy Trans.*, v. 64, p. 160-162, 1961.

Profiles are presented of the anomalies over the Caribou massive sulfide deposit, Bathurst, N. B., obtained with six electrical and electromagnetic geophysical techniques. A generalized geologic section is included for correlation purposes. The data are compared empirically, but no attempt is made to compare directly the relative advantages of one method over another. When related to the initial phase of an exploration program, the magnitudes and ratios obtained from any of the methods described would be sufficient to warrant further investigation. — V. S. N.

- 186-306. Fleming, H. W. The Murray deposit, Restigouche County, N. B. — A geochemical-geophysical discovery: *Canadian Mining Metall. Bull.*, v. 54, no. 587, p. 230-235, 1961; *Canadian Inst. Mining Metallurgy Trans.*, v. 64, p. 163-168, 1961.

Eighteen months of coordinated geophysical and geochemical exploration were needed to locate the Murray massive-sulfide deposit in northern New Brunswick. Extensive leaching had produced a fossil gossan that made the deposit an elusive target for exploration techniques of limited penetration. Initial selection of the area was based on anomalies from an airborne electromagnetic survey. The actual target area was localized by geochemical means, but geophysical surveys were necessary to determine the nature of the deposit and to indicate the most favorable drilling sites. Electromagnetic and magnetic data were interpreted to indicate a good nonmagnetic conductor, and it was correctly predicted that massive pyrite would be encountered in drilling. All electrical methods—the horizontal-loop, Turam electromagnetic, and self-potential surveys—indicated the deposits strongly and accurately. — V. S. N.

- 186-307. Artamonov, L. V., and Shuval-Sergeyev, N. M. O primeneni aeroelektrozavedki v tselyakh geologicheskogo kartirovaniya [Use of aroelectrical exploration for geologic mapping]: *Sovetskaya Geologiya*, no. 2, p. 125-132, 1961.

The results are presented of experimental use of aeroelectrical surveying during 1959 in the Dzhezkazgan are region of Kazakh S. S. R. These tests were part of a large program to evaluate the method of dipole magnetic profiling under a variety of geologic conditions. In the Dzhezkazgan area this method was used successfully to trace contacts of Paleozoic and Cenozoic deposits. On the basis of this survey, areas were selected for immediate prospecting for copper mineralization. — J. W. C.

- 186-308. Shansi Provincial Department of Agricultural Construction. Applications of electro-prospecting in hydrogeology and engineering geology work [translation from Chinese]: Shui-wen Ti-chih Kung-ch'eng Ti-chih [Hydrogeology and Engineering Geology], no. 4, p. 3-6, 1960; translated by U. S. Joint Publications Research Service, JPRS no. 9356, 1961.

The application of electrical prospecting methods to the determination of underground structures and to prospecting for water supply is discussed. Examples are given of the use of the resistivity method in five different localities to locate aquifers, fault planes for engineering construction purposes, and other structures. The electric-charge method for tracing the speed and direction of flow of ground water is also discussed. In this method salt is placed in a borehole or well to decrease the resistivity of the ground water and thus form a highly conductive zone which moves as the ground water moves. — V. S. N.

- 186-309. Hattori, Yasuzo; Mashiko, Yasushi; Sato, Koji, Kanroji, Yasuo; and Hosaya, Noboru. Geochemical studies on mineral springs, Pt. 9. On the hot springs in Kamigano-Village, Izu [in Japanese with English abstract]: Balneol. Soc. Japan Jour., v. 12, no. 1, p. 21-22, 1961.

The results of chemical studies of the waters and electrical prospecting in the vicinity of the hot springs in Kamigano, Izu, Japan, are reported. The hot spring water produces a negative anomaly zone near Tsukigase and Sagasawa. In the Nishibira district a positive anomaly occurs over silicified tuff breccia and a negative anomaly over argillized tuff breccia. It is concluded that the natural electric potential anomalies are the result of difficulties in the flow of the hot water. — V. S. N.

- 186-310. Kunori, Shoichi, and Ishii, Fujio. Studies on the relation between spontaneous polarization potential and mineralization on the adit in the Kaimei mine, Aomori Prefecture [in Japanese with English abstract]: Butsuri-Tanko, v. 13, no. 2, p. 118-121, 1960.

The Kaimei mine is an epithermal fissure-filling copper deposit. Twenty-five samples were collected in an interval of 10 m from the propylite host rock and the base exchange capacity was determined to aid in evaluation of results from a spontaneous potential survey. Results of spontaneous potential measurements are discussed in relation to the iron-magnesium chlorite mineralization and a statistical analysis is made. It is concluded that the spontaneous potential values are closely related to the bonanza and also to the increase of exchangeable magnesium ion in the propylites formed before ore deposition. — V. S. N.

- 186-311. Atkins, E. R., Jr. Techniques of electric log interpretation: Jour. Petroleum Technology, v. 13, no. 2, p. 118-124, 1961.

The following techniques of electrical logging are reviewed and discussed: formation water resistivity from SP curves, true resistivity values from log data, water saturation from electric logs, and formation porosity from resistivity data. Particular emphasis is placed on 12 assumptions made in log interpretation. — J. W. C.

- 186-312. Street, Norman. Electrokinetics, III.—Surface conductance and the conductive solid effect: Illinois State Geol. Survey Circ. 315, 16 p., 1961.

Interpretation of electric logs is made difficult by the presence of conductive solids in a formation; therefore, it is desirable that the mechanism of the conduction be fully understood. This discussion concerns the theory and measurement of surface conductance, the condition that is mainly responsible for the conductive solids effect. The application of the theory to logging problems in the petroleum industry is indicated. — V. S. N.

- 186-313. Lum, Daniel. The resistivity method applied to ground water studies of glacial outwash deposits in eastern South Dakota: South Dakota State Geol. Survey Rept. Inv., no. 89, 44 p., 1961.

The results of electrical resistivity surveys of water-bearing glacial outwash deposits of sand and gravel in eastern South Dakota during the summers of 1957 and 1958 are reported. The principles, field procedures, and methods of interpretation are discussed, particularly for the Wenner configuration. The deposits are too inhomogeneous and variable in lithology to permit correlation and interpretation of the resistivity data except for very local and detailed investigations. The horizontal traverse method was found to be more useful than the depth-profile method in locating sites for test wells. Apparent resistivity field curves plotted with theoretical curve-matching interpretations and drill-hole control data from glacial deposits are presented for reference. — V. S. N.

- 186-314. Plewa, Stanisław. Zagadnienie identyfikacji i korelacji pokładów węglowych metodami geofizyki kopalnianej [Problems of identification and correlation of coal seams by means of mining geophysics methods (with English and Russian summaries)]: Przegląd Geol., v. 8, no. 12, p. 640-645, 1960.

The principles of geophysical logging of boreholes in coal seams are discussed. Coal seams can often be distinguished on the resistivity log and on the natural gamma radiation log. The Ruda beds are an example of this; they contain a geophysical marker horizon. In general, geophysical correlation and identification of coal seams is more accurate than geological. Several examples of geophysical correlation are given. — J. W. C.

- 186-315. Sarkisov, I. K., and Makhmudova, V. M. K voprosy teorii elektricheskogo karotazha neftyanykh i gazovykh skvazhin [Problem of the theory of electrical logging of oil and gas wells]: Vyssh. Ucheb. Zavedeniy Izv., Neft' i Gaz, no. 8, p. 17-26, 1960.

Study of the field of linear electrodes is increasingly important in connection with logging boreholes during drilling using the drill pipe as an electrical connector. With linear electrodes of small length, the resistivity of the electrode is negligible; however, where the casing of the cable or the drill pipe is

used as a second electrode, and particularly where the latter is used as an electrical connector, the effect of the resistivity becomes determinable. Diagrams are presented of the configuration of the equipotential lines of the field of electrodes with various lengths and resistivities. These lines change from ellipsoidal to more circular with increasing values of kL , where L =length of the electrode and $k=\sqrt{r_0 g_0}$ (r_0 is resistivity of a unit length of electrode and g_0 is conductivity of a unit length of electrode). — J. W. C.

- 186-316. Klyucharev, V. S., Shevkunov, Ye. N., and Lazarev, V. N. Izu-cheniye karbonatnykh porod po geofizicheskim dannym [Study of carbonate rocks according to geophysical data]: Vyssh. Ucheb. Zavedeniye Izv., Neft' i Gaz, no. 12, p. 15-19, 1960.

Results are presented of experiments in locating marker horizons as well as porous and permeable zones in carbonate rocks of Carboniferous age in the Or'yebash oil field in northwestern Bashkir A.S.S.R. Electrical logs are presented that show how several marker horizons are correlated. Using gamma and neutron gamma logs, empirical relationships were established for determining porous zones. Correlation of the porous zones and shale beds is shown in a profile. — J. W. C.

- 186-317. Zaporozhets, V. M. K voprosu ob oboznachaniyakh velichin ispol'-zuyemykh v promyslovyoy geofizike [On the problem of symbols of quantities used in logging geophysics]: Prikladnaya Geofizika, no. 27, p. 236-244, 1960.

An attempt is made to establish more regular terminology and symbols than are presently used in logging geophysics of the U.S.S.R. A comparison is made between terms and symbols used in the U.S.S.R. and in the United States. — A. J. S.

- 186-318. Grechukhin, V. V. Korrelyatsiya razrezov uglenosnykh otlozheniy po karotazhnym diagramam [Correlation of sections of coal-bearing deposits by logging diagrams]: Razvedka i Okhrana Nedr, no. 11, p. 28-33, 1960.

Electrical exploration by the method of apparent resistivity for coal deposits in the Pechora basin in the northern Urals is discussed. A standard electric gradient sonde A3, 5MO, 1N was used in borehole logging for a unique determination of coal layers at three separate locations in the Vorkuta region, and the geologic structure of the region was determined by correlation of the layers. A subsurface fault with a displacement of 144 m was discovered by the correlation of electric logging diagrams. — A. J. S.

- 186-319. Ushakov, A. P., and Itenberg, S. S. Opyt ispol'zovaniya geologicheskikh i geofizicheskikh dannykh dlya izucheniya geologii Apsheron-skogo poluostrova, vostochnogo i tsentral'nogo Predkavkaz'ya [Experiments in the use of geological and geophysical data for study of the geology of the Apsheron Peninsula, eastern and central Ciscaucasus]: Moskva, Gosudarstvennyy Nauchno - Tekhnicheskii Komitet, 131 p., 1960.

The second half of this work deals with stratigraphic correlation using geophysical logging data. The topics discussed are the geological-geophysical characteristics of the section of a borehole, construction of detailed correlation charts for local structures, type and standard geological-geophysical

sections, and construction of regional correlation charts. An example is presented of how such correlation was accomplished in the east and central Ciscaucasus. — J. W. C.

186-320. Ito, Junji. On the prospecting and handy electric-logging at the Makimine mine [in Japanese with English abstract]: *Mining Geology [Japan]*, v. 11, no. 45/46, p. 369-372, 1961.

A highly effective micrologging device developed for use in prospecting the bedded cupriferous iron sulfide ores of the Makimine Mine, Miyazaki Prefecture, Japan, is described. With the use of the micrologger the lenticular ore bodies can be prospected from drill holes. — V. S. N.

ELECTRICAL PROPERTIES

186-321. Logan, John. Estimation of electrical conductivity from chemical analyses of natural waters: *Jour. Geophys. Research*, v. 66, no. 8, p. 2479-2483, 1961.

Several methods of estimating the electrical conductivity of natural waters from their chemical analyses are tested statistically with a previously undscribed empirical method. Standard errors of estimate resulting from the latter are less than 7 percent for each of two tests; this value is in the range of sampling and analytical error in many cases. — Author's abstract

186-322. Howell, B[enjamin] F., Jr., and Licastro, P. H. Dielectric behavior of rocks and minerals: *Am. Mineralogist*, v. 46, no. 3-4, p. 269-288, 1961.

A reconnaissance study of the dielectric constants of 23 common mineral and 71 rock samples was made at 13 frequencies in the range 50c to 30 Mc. Dispersion was observed for all rock samples tested and for a few minerals at the lower end of the frequency spectrum. Moisture in a rock can increase the dielectric constant by an amount greater than is predicted by simple mixing rules. Water appears to be the principal constituent of the rock controlling the dispersion. The observed dispersion was similar in form to the Maxwell-Wagner type polarization, but was quantitatively much greater. Some form of electrode or membrane polarization appears to be the most likely explanation. The dispersion is probably the result of the same mineral properties on which induced-polarization methods of geophysical prospecting are based. — Authors' abstract

186-323. Stacey, F. D. Dielectric anisotropy and fabric of rocks: *Geofisica Pura e Appl.*, v. 48, p. 40-48, 1961.

Measurements were made of the dielectric anisotropies of a number of rocks for which magnetic anisotropy data were available in order to examine the possible usefulness of dielectric anisotropy as a physical property indicative of rock fabrics. The advantage over the magnetic method is that dielectric anisotropy reflects the average alinement of crystals of dominant minerals, whereas magnetic anisotropy is due only to the ferromagnetic grains. Disadvantages are extreme sensitivity to specimen shape and difficulty in distinguishing the several types of alinement that can give rise to dielectric anisotropy.

The results indicate that dielectric anisotropy actually is a measurable property of rocks and can be used in petrofabric work. It should be very

suitable for detailed examination of the problem of crystal settling. Suggestions are made concerning improvements over the method used here. — D. B. V.

- 186-324. Migaux, Léon, Astier, Jean-Louis, and Revol, Philippe. Essai de détermination expérimentale de la résistivité électrique des couches profondes de l'écorce terrestre [Attempt at experimental determination of the electrical resistivity of the deep layers of the earth's crust]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 4, p. 567-569, 1960.

D-c electrical resistivity soundings, using a conventional four-electrode setup, were carried out in the homogeneous Mortagne granitic massif in the Vendée, France. The experimental results, presented in a curve compared to a theoretical curve, indicate that average apparent resistivity is 200 ohm-m to 10 m depth, 250 ohm-m to 580 m, and 1,400 ohm-m to 7,000 m. At about 7,000 m it begins to increase sharply; eventually true resistivity (ρ) must reach at least 15,000 ohm-m before decreasing due to the presence of a good conducting medium below.

The thickness (e) of the resistant layer is such that $e\rho > 250$ megohms per m^2 (probably about 400 and not more than 1,000 megohms per m^2); the mean resistivity value would correspond, for instance, to a 25 km layer averaging 16,000 ohm-m or an 8-km layer averaging 50,000 ohm-m. These high resistivities at depth are explained by the fact that any increase in conductivity due to increase in temperature is largely compensated by a diminution in the amount of electrolyte in the rocks. — D. B. V.

- 186-325. Volarovich, M. P., Tarasov, O. A., and Bondarenko, A. T. Issledovaniye dielektricheskoy pronitsayemosti obraztsov gornyykh porod pri atmosfernom odnostoronnem u vsestonnem (do 5,000 kg/cm^2) davleniyakh [Investigation of dielectric permeability of rock samples under unilateral atmospheric pressure, and confining (up to 5,000 kg/cm^2) pressure]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 1004-1008, 1961.

The methods of determination of electric permeability (dielectric constant) ϵ of rock samples under varying pressure at a frequency of 500 kc are discussed. Dielectric constants of sandstone, limestone, syenite, granite, and diabase were determined under unilateral pressure; the greatest change in the value of ϵ was found to be in the pressure range up to 600 kg/cm^2 . Under confining pressures up to 5,000 kg/cm^2 , ϵ of the rocks increased by 10-30 percent. The increase in ϵ of rocks under pressure was found to be due mainly to a decrease in the volume of pores, an increase in the contact area of the structural elements of the minerals, and the subsequent increase in the number of polarized particles per unit volume. — A. J. S.

- 186-326. Berlin, T. S., and Khabakov, A. V. O razlichnykh elektrokineticheskikh potentsialov karbonatnykh osadochnyykh gornyykh porod razlichnogo genezisa i sostava [On differences in the electrokinetic potentials of carbonate sediments of different origin and composition (with English summary)]: Geokhimiya, no. 3, p. 195-208, 1961.

Investigation of 115 samples of different sedimentary carbonate rocks shows that those that originated by chemical precipitation have a positive and those of organic origin a negative electrokinetic potential (ζ). The effect of various impurities on the sign and magnitude of the ζ -potential is discussed. — D. B. V.

- 186-327. Newfarmer, L. R. Geophysics' share of the exploration dollar in the U. S. A. and Canada: Oil in Canada, v. 13, no. 32, p. 33-35, 1961.

In 1952, a high point in geophysical field work, 40,456 party weeks of reflection seismograph work were completed on the North American continent; by 1959 this number had fallen to 24,321 party weeks. However, as nearly two-thirds of the continent's six million cubic miles of sediments remain to be explored in detail, a leveling-off in this downward trend is to be expected. — V. S. N.

- 186-328. Oilweek. Crisis in geophysics: Oilweek, v. 12, no. 26, p. 20-24, 1960.

An eight-year decline in geophysical exploration activity in Canada is leveling off. Most observers predict a two to five year level period before activity gains appreciably. One of the great difficulties in Canada is the highly seasonal nature of the operations resulting from the trend to northern areas in the past five years. It is probable that contracting companies will have to pay a premium for work in the winter when crews are scarce, or else spread the work more evenly throughout the year. — V. S. N.

- 186-329. Garlick, W. G., and Gane, P. G. Geophysics, in The geology of the Northern Rhodesian Copperbelt: London, Macdonald and Co., Ltd., p. 178-187, 1961.

An appraisal is given of the prospecting value of various geophysical methods in the Copperbelt, Northern Rhodesia. The deep residual soils with a laterite zone of variable thickness grading down into weathered formations and the generally complete oxidation of sulfides to a depth of 200 feet constitute a severe handicap to most geophysical methods. Electrical, magnetic, and gravimetric methods have been used, and most have been unsuccessful as direct indicators of sulfide bodies; the self-potential method has been of use in direct indication of oxidizing sulfides—more commonly pyrite than copper sulfides. All of the geophysical methods that are not too expensive to operate have considerable value in recognition of the various characteristics of hidden rock formations and thus are used indirectly to locate mineralization. Geochemical methods have been highly effective in direct exploration for mineralization. However, those orebodies which fail to reach into the zone of weathering are unlikely to show any appreciable surface geochemical anomaly and must be discovered by drillholes located on the basis of thorough knowledge of the geology and on data provided by geophysical methods capable of indicating the deep sulfide bodies directly. Continued refinement of instruments and methods may make geophysical methods as useful as geochemical in the Copperbelt. A brief history of the use of geophysical methods is given, and the individual methods tested are discussed. Seismic methods have not been used because of the high cost in this area. — V. S. N.

- 186-330. Vol'fson, N. B., Gar'kovets, V. G., and Khvalovskiy, A. G. Opyt primeneniya geofizicheskikh metodov pri reshenii nekotorykh voprosov glubinnogo geologicheskogo kartirovaniya v Almalykskom rudnom rayone [Experience in the use of geophysical methods for solving several problems of subsurface geological mapping in the Almalyk ore region]: Sovetskaya Geologiya, no. 1, p. 109-120, 1961.

As a result of combined magnetic and geological surveys in the Almalyk ore region of the Uzbek S. S. R., areas of altered and unaltered syenite were

distinguished, and the position of a deep-seated granodiorite porphyry and its stockwork of apophyses was determined. A spatial association of copper and lead mineralization with the granodiorite porphyry was established, and a horizontal zonality in the distribution of the ore was revealed. The thickness of an effusive cover was determined by vertical electrical sounding. — J. W. C.

- 186-331. Sato, Konosuke. Recent development in geophysical exploration [in Japanese with English abstract]: *Mining Geology [Japan]*, v. 11, no. 45/46, p. 365-369, 1961.

Newly developed Japanese techniques in geophysical surveying methods for oil; coal; radioactive, metallic, and nonmetallic minerals; ground water; natural steam; and in civil engineering problems are described. Future problems in geophysical exploration in Japan are discussed. — V. S. N.

- 186-332. Lister, H. Is Antarctica a continent?, in *Science Survey 1: New York*, MacMillan Co., p. 257-266, 1960.

A popular account is given of the scientific evidence on the nature of the continent underlying the Antarctic icecap. Recent studies, started during the International Geophysical Year, have contributed the greater part of the information. Results so far achieved, although meagre, all point to Antarctica being a continent. — V. S. N.

- 186-333. Hoinkes, H. Die Antarktis und die geophysikalische Erforschung der Erde [The Antarctic and the geophysical investigation of the earth]: *Naturwissenschaften*, v. 48, no. 9, p. 354-374, 1961.

This is a review of geophysical research in the Antarctic, mainly during the International Geophysical Year. The present ice cap and subglacial topography, the present mass budget of the ice, and sea level fluctuations related to the Antarctic ice budget are discussed. A 110-item bibliography is given. — D. B. V.

- 186-334. Hatherton, T. New Zealand IGY Antarctic expeditions, Scott Base and Hallett Station: *New Zealand Dept. Sci. Indus. Research Bull.*, no. 140, 132 p., 1961.

The work contributed by New Zealand's Antarctic expeditions at Scott Base and Hallett Station to the International Geophysical Year in 1957 and 1958 is reviewed briefly. The location, design, and construction of the bases are described, and a summary of the results of the scientific investigations in meteorology, geomagnetism, auroras, vertical ionospheric soundings, glaciology, oceanography, seismology, gravity, and whistlers is given. — V. S. N.

GENERAL

- 186-335. Fultz, Dave. Developments in controlled experiments on larger scale geophysical problems, in *Advances in Geophysics*, v. 7: New York and London, Academic Press, p. 1-103, 1961.

A review is presented of experimental developments mainly in meteorology and oceanography but also including work in geology and certain other fields. Emphasis is placed on experiments that have begun to be quantitatively successful in the realm of medium- and large-scale phenomena. The topics touched upon are approached from the point of view of macroscopic continuum mechanics; the tacit hypothesis being that some form of the equations of hy-

drodynamics, thermodynamics, or elasticity governs the phenomena in question. Under large-scale natural phenomena are discussed experimental meteorological and oceanographic work involving properties of homogeneous fluids, density differences, and convection; geological work on the elastic and plastic behavior of the earth; and work connected with cosmic electromagnetic phenomena such as the aurora. Under medium-scale phenomena three groups of investigations are surveyed. The first two involve almost purely hydrodynamic effects of density fields under the influence of gravity for primarily vertically stable density distributions and for essentially unstable arrangements; the third concerns the problems of elastic wave propagation relevant to seismic waves either artificial or natural. — V. S. N.

186-336. Krauskopf, Konrad, and Beiser, Arthur. *The physical Universe*: New York, McGraw-Hill Book Co., Inc., 536 p., 1960.

The aim of this textbook is to present the essential elements of physical science to the reader who has a minimum of formal preparation. Basic concepts and their role in understanding the natural world are emphasized, and an effort is made to convey something of the historical and philosophical development of physical science. Topics that currently lie on the frontier of knowledge—elementary particles, cosmic rays, thermonuclear power, DNA and RNA, and the origin of the universe—are specifically mentioned. The following chapters are included: the sun and its family; force and motion; gravitation; energy; solids, liquids, and gases; basic chemistry; the periodic table; electricity; currents and magnetic fields; light; the atomic nucleus; atomic structure; subatomic chemistry; fundamentals of chemistry; organic chemistry; rocks and minerals; the changing crust; the atmosphere; within the earth; the history of the earth; the sun; structure of the universe and evolution of the universe. Two types of exercises for each chapter are provided in the appendix. One or more references for further reading are given at the end of each chapter. — V. S. N.

186-337. True, Webster P., ed. *Smithsonian Treasury of science*, v. 1: New York, Simon and Schuster, Inc. 377 p., 1960.

The 17 papers included in this volume are reprinted from various Annual Reports of the Smithsonian Institution; in some cases the papers were originally published in scientific journals. For the more recent articles, the authors have made such minor revisions as seemed desirable to indicate current changes in thought. Most of the articles, however, have been chosen for their more or less timeless character. The following papers of particular interest to geophysics are included in this first volume: Claude W. Heaps—The structure of the universe; E. J. Öpik—The time scale of our universe; Thornton Page—The origin of the earth; John W. Evans—Solar influence on the earth; Fred L. Whipple—Meteors; Paul C. Aebersold—Radioisotopes; and Hans E. Suess—The abundance of the chemical elements. — V. S. N.

186-338. Fairbridge, Rhodes W. *Eustatic changes in sea level*, in *Physics and chemistry of the earth*, v. 4: New York, Pergamon Press, p. 99-185, 1961.

A study of basic data associated with eustatic changes in sea level is presented. Historical and contemporary observations are reviewed; theories of shoreline displacements and the development of an integrated theory are discussed; and Quaternary changes in sea level are analyzed. Pleistocene eustatic curves given in this paper show that there are overriding controls of eustasy that supersede both climatic and local tectonic influences. Eustatic

changes are now recognized universally, and a basic assumption of possible eustatic events should be made for every geologic period regardless of climatic events. During the Quaternary, two major and several minor effects are noticeable: (1) a climatically controlled glacio-eustasy involving vertical oscillations of a few meters up to 100 or 125 m in periods from 550 to 90,000 yr; (2) a geodetic effect, associated with the shape of the geoid in respect to the spheroid, and perhaps associated with a polar shift—this is probably tectono-eustatic in part; and (3) the minor roles of glacial loading and unbalancing effects on the globe that have not yet been analyzed. A close correlation is observable over the last 15,000 yr between minor oscillations of sea level and climatic events; geomorphic and stratigraphic effects can be recognized also. In general, the study results in implications that impinge on the fields of meteorology, geodesy, tectonophysics, and stratigraphy, and that urgently call for intensive quantitative investigation. A bibliography of approximately 350 references is included. — V. S. N.

186-339. Fairbridge, Rhodes W. The changing level of the sea: *Sci. American*, v. 202, no. 5, p. 70-79, 1960.

Glacial cycles and the slow sinking of the ocean floor or rise of continents have caused sea level to fluctuate from epoch to epoch. The slow changes caused by crustal movements are either reinforced or obscured by the more rapid changes caused by the melting of glaciers. The history of the Quaternary ice age leads to one dominant conclusion: Sea level is a most variable plane and a sensitive indicator of even minor world climatic change. Since the geoid corresponds to sea level at any given time, it must vary with the cycle of world climate. Thus the geoid fluctuates around three norms: a stage of minimum dimension when vast ice sheets cover much of the earth in the brief glacial stages; a stage of maximum dimension when the earth is relatively free of ice; and a stage of oscillation between these extremes in interglacial periods such as the present when a large portion of the earth's water is held in the Greenland and Antarctic icecaps. — V. S. N.

186-340. Bascom, Willard. A hole in the bottom of the sea: Garden City, New York, Doubleday and Company, Inc., 352 p., 1961.

The history of geologic thought about the earth is reviewed, and modern methods of making indirect investigations of the earth's interior are described. A discussion is included of the bearing of geology, oceanography, engineering, modern drilling technology, and various other fields on these investigations and of their application to the specific plan for drilling a hole to the M-discontinuity. The following topics are discussed: origin of the Mohole idea, science fiction and pseudoscience inside the earth, evidence in the rocks, exploring the crust with gravity, probing with earthquakes and explosions, the examination of the oceans, magnetism, heat and pressure, evidence in the skies, objectives and sites, modern oil-well drilling, the oil rig goes to sea, experimental holes in deep water, on to the Moho, and the future. An appendix lists unit equivalents, a bibliography, and the membership of the American Miscellaneous Society committee for the Mohole. — V. S. N.

186-341. Montandon, Frédéric. Les grandes catastrophes naturelles survenues pendant les années 1948-1957 [The great natural catastrophes happening during the years 1948-1957]: *Rev. Étude Climatés*, no. 36, p. 58-60, 1959.

The great natural disasters (continental inundations, marine invasions, oceanic cyclones and tornadoes, earthquakes, volcanic eruptions, and others)

of the world during the 10 year period 1948-57 are tabulated according to the total number of each type of disaster per year and the total number of each type by country for the entire period. Continental inundations accounted for the largest number of disasters; cyclones and tornadoes were next, followed by earthquakes. — V. S. N.

186-342. Chapman, Sydney. From Polar Year to Geophysical Year: Československá Akad. Věd Studia Geophys. et Geod., v. 4, no. 4, p. 313-324, 1960.

This is the text of a paper presented at a conference held near Prague on March 28-30, 1960, on the contribution of Czechoslovakia to the International Geophysical Year and Cooperation. It is a review of international cooperative efforts in geophysics, the First and Second International Polar Years, and the International Geophysical Year. — D. B. V.

186-343. Alger, R. P. Modern logging programs and interpretation methods: Canadian Oil and Gas Industries, v. 14, no. 6, p. 41-58, 1961.

The responses of recently developed logging methods—induction log, laterolog, proximity log, sonic log, and gamma-gamma density log—to varied borehole and formation conditions are now sufficiently understood to permit the proper selection of logs for most efficient interpretation. The new logs are discussed with a brief indication of where each fits into the several families of logging devices and with an outline of the essential logging combinations or programs by mud and formation type. A summary table recapitulates the appropriate usage of tools. Numerous diagrams and tables are included. — V. S. N.

186-344. Aswathanarayana, U. Nuclear geology—a review: Indian Minerals, v. 14, no. 4, p. 342-346, 1960.

The four principal facets of nuclear geology—measurement of geological time, radioactive heat generation in the crustal rocks, isotopic abundances and their geological significance, and radiometric surveys—are reviewed briefly. — V. S. N.

186-345. Tarkhov, A. G., and Sidorov, A. A. O matematicheskoy obrabotke geofizicheskikh dannykh [On the mathematical treatment of geophysical data]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1450-1457, 1960.

The problem of statistical treatment of geophysical data on the basis of information theory (see Geophys. Abs. 177-165) for the purpose of separating true anomaly data from superposed natural and man-produced interferences is discussed. The arithmetical and geometrical averages and the method of the inverse probability are capable of substantially increasing the anomaly to interference ratio. Methods of statistical filtration of the signal (anomaly) from the noise (interference) background may decrease the absolute value of the signal, but the signal to noise ratio may be increased considerably by statistical suppression of the noise. Klushin (see Geophys. Abs. 178-192) was able to measure a 0.5 mgal gravity anomaly on a background of interference ranging up to 1.0 mgal by increasing the anomaly to error ratio by 4.1 times. — A. J. S.

GEODESY

- 186-346. Marussi, Antonio. Intrinsic coordinates in practical geodesy: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 83-89, 1961.

The basic concepts of intrinsic geodesy—the local description of the gravity field of the earth using only coordinates and quantities that are physically real and therefore observable—are reviewed. It is shown how the integrability conditions necessary for the existence of the coordinate surfaces and the fundamental operators may be expressed in terms of the curvature of the field and of gravity. The theory is applied to a classic geodetic problem, the generalized Legendre expansion for the displacement of the potential (dynamic height) along an optical path. — D. B. V.

- 186-347. Bhattacharji, J. C. Comments and some suggestions on Hunter's formula of reduction of observed values of gravity to the earth model for use in Stokes's integral: Royal Astron. Soc. Geophys. Jour., v. 5, no. 2, p. 162-170, 1961.

The reduction formula as evolved by Hunter [see Geophys. Abs. 178-202], for reducing the observed values of gravity to the surface of the earth model is discussed and proved to be not quite accurate. The main defect involved appears to be due to his ignoring altogether the gravity effect on account of the sphericity of the earth while dealing with the difference of attraction between actual and model earths.

The corrected reduction formula posing again a delicate problem for geodesists, a suggestion is here made for a more convenient method of reduction based on a suitable isostatic hypothesis for use in the Stokes's integral without any real difficulty. — Author's summary

- 186-348. Kaula, W[illiam] M. Analysis of gravitational and geometric aspects of geodetic utilization of satellites: Royal Astron. Soc. Geophys. Jour., v. 5, no. 2, p. 104-133, 1961.

Expressions are derived for the first-order effects of any period of any term, U_1^n , of the gravitational potential on the orbital elements, plus the second-order effects arising from the interaction of U_1^n with U_2^0 , the oblateness. The order of magnitude of some daily and semidaily variations is estimated to be ± 100 m from statistical data on the gravitational harmonics.

A general geometric and statistical treatment of all types of observations is developed, with the purposes of obtaining rigorous evaluations of orbital and observational schemes, and optimum solutions for geodetic positions, gravitational harmonic coefficients, and orbital elements. — Author's summary

- Tengström, Erik. Calculation of the external gravity anomalies and deflections of the vertical at higher elevations by means of Taylor expansions from the geoid. See Geophys. Abs. 186-388.

Ledersteger, K[arl]. The flattening function of one-parameter spheroidal equilibrium figures. See Geophys. Abs. 186-451.

- 186-349. Mueller, Ivan I. The determination of the regional part of the vertical gradient anomaly by a geodetic method: Geofisica Pura e Appl., v. 48, p. 1-6, 1961.

For practical purposes, regional vertical gradients are the best values to use in reduction of observed gravity to sea level. This paper presents a method of determining regional vertical gradients in large areas from geodetic observations, which, added to the normal part, will give the regional vertical gradients. The regional vertical gradient anomalies for central Europe, computed from astrogeodetic deflections of the vertical, are shown on a map. Similar computation is under way for the United States. — D. B. V.

186-350. Burša, Milan. Bestimmung der Dimensionen des bestanschliessenden Ellipsoids für Europa auf Grund der astronomisch-geodätischen Daten des Katalogs IAG [Determination of the dimensions of the best-fitting ellipsoid for Europe on the basis of the astronomical-geodetic data of the IGY catalog (with Russian summary)]: Československá Akad. Věd Studia Geophys. et Geod., v. 4, no. 4, p. 404-409, 1960.

The parameters of the best-fitting ellipsoid for Europe are calculated from astronomic-geodetic data given in the International Geophysical Year catalog, using both the translative and projective variants of the surface method. The results show that the catalog data provide an adequate basis for such calculations, and that the two variants are equally accurate. The mean of the values obtained for the ellipsoid parameters are $a=6,378,112$ m, $\alpha=1:298.4$, $\xi_0=+5''$, and $\eta_0=+2''$ (a =major semiaxis, α =polar flattening, ξ_0 and η_0 =deflections of the vertical). These values are closest to those of the Krassovskiy ellipsoid. Comparison with the best-fitting ellipsoids determined for the U. S. S. R. and North America suggests that the geoid surfaces on the continental areas of the northern hemisphere can be replaced by a common ellipsoid, preferably the Krassovskiy. (See also Geophys. Abs. 182-252.)— D. B. V.

186-351. Bonchkovskiy, V. F., and Skur'yat, A. N. Urovenny variometr UV [The leveling variometer UV]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 79-90, 1961.

The paper describes, analyses mathematically, and discusses a tiltmeter for continuous recording or visual observation of small variations in altitude between two or several points on the earth surface from tens to hundreds of meters from each other. The instrument is based on the principle of "connected vessels," in which the temperature gradient in the ambient air, variation in atmospheric pressure, air humidity, and the evaporation of liquid in the vessels have been taken into account. — A. J. S.

GEOTECTONICS

186-352. Dietz, Robert S. Continent and ocean basin evolution by spreading of the sea floor: Nature, v. 190, no. 4779, p. 854-857, 1961.

A "spreading sea floor" concept is proposed to explain sea-floor bathymetry. This concept requires the acceptance of a specific crustal model that is slightly at variance with the present consensus of opinion. The model is described. The oceanic "crust" (the gabbroic layer) is almost wholly coupled with convective overturn of the mantle creeping at a rate of a few cm per yr. The sea floor is essentially the outcropping of the mantle; it thus marks the tops of convection cells and slowly spreads from zones of divergence to those of convergence. The gross structures of the sea floor are direct expressions of this convection, and much of the minor sea floor topography may be too. Conditions deep within the mantle control the convective pattern without regard for continent positions. By viscous drag, the continents initially are moved

along with the sima until they attain a position of dynamic balance overlying a convergence; there they come to rest, but the sima continues to shear downward beneath them. If new upwells happen to rise under a continent it tends to be rifted; thus, North and South America were separated from Europe and Africa. In their normal position over convergences the continents are under compression from both sides and tend to buckle; in contrast, the ocean basins are domains of tension. If a continental block is drifted along with the sima the margin is tectonically stable, but if the sima slips under it, marginal mountains tend to be formed.

This hypothesis conserves the volumetric capacity of the oceans, unlike contraction or expanding earth theories. It provides a more plausible mechanism of continental drift, and explains the fact that the continents have stood high throughout geologic time despite erosion. It also fits well with the marine geologic evidence that the sea floor is young though the ocean basins are old, and with the stress pattern indicated by magnetic anomalies off the west coast of North America. — D. B. V.

- 186-353. Gilvarry, J[ohn] J. The origin of ocean basins and continents: *Nature*, v. 190, no. 4781, p. 1048-1053, 1961.

In a recent paper (see *Geophys. Abs.* 186-88) Gilvarry suggested that the circular lunar maria are large meteorite craters with sedimentary floors excavated by explosive impact of meteorites on the lunar surface in the presence of a hydrosphere. Here he proposes an exactly analogous mode of formation of the ocean basins as the result of explosive impact of meteorites at a pristine time when the hydrosphere covered the earth to a roughly uniform depth. The conclusions presented here are identical in principle with Harrison's suggestions (see *Geophys. Abs.* 185-266), but the basis of the argument is entirely independent and the mechanism of crater formation is essentially different. — D. B. V.

- 186-354. Trümpy, Rudolf. Der Werdegang der Geosynklinale [The development of a geosyncline (with English summary, p. 700)]: *Geol. Rundschau*, v. 50, p. 4-7, 1960.

In the geosynclinal prehistory of many mountain chains there are two phases having different paleogeographic configurations, one characterized by tension tectonics, the other by compression tectonics. The climax of preorogenic magmatic activity coincides with an intermediate phase of gentle submarine topography. — D. B. V.

- 186-355. Geis, Hans-Peter. Frühorogene Sulfidlagerstätten [Early-orogenic sulfide ore deposits (with English summary, p. 694)]: *Geol. Rundschau*, v. 50, p. 46-52, 1960.

The Caledonian, Variscan, and Alpine orogenies were preceded by the formation of syngenetic lead-zinc-pyrite and chalcopyrite-pyrite deposits more or less parallel to the bedding. These were formed in subsiding basins and are arranged en echelon toward the higher parts of the sedimentary sequence, following definite laws. These laws can be used to interpret the mechanism of subsidence of parts of geosynclines. — D. B. V.

- 186-356. Cadisch, Joos. Der Oberbau der Orogene [The upper structure of orogens (with English summary, p. 691)]: *Geol. Rundschau*, v. 50, p. 53-63, 1960.

The arcuate form of mountain ranges is largely an expression of deep-seated tectonics. Apparently uniform arcs are often composed of different

segments, as in the case of the Rif and the Carpathians. Smaller marginal arcs are flow-forms, thrust over the surface. Aside from shear- and glide-planes parallel to the regional trend, which are part of the fold and nappe structure, fracturing plays a secondary role in the formation of alpine mountain ranges; misjudgment of the scale of ruptural processes has often led to overestimation of their tectonic role.

So far, the upper and lower levels of an orogen can be separated only on theoretical grounds. It is possible that the deep extension of orogens is limited mainly to their central zones. Where it has been possible to check, it has been found that the original width of depositional areas has not been overestimated. Too much importance is attached to gravity sliding. Later orogenic phases involve considerable tilting; this can be considered to be epeirogenic. — D. B. V.

- 186-357. Michot, Paul. Le problème des intrusions marginales [The problem of marginal intrusions (with English summary, p. 696)]: Geol. Rundschau, v. 50, p. 94-104, 1960.

The characteristic features of mafic eruptive manifestations in deep orogens are reviewed briefly, and their significance in catazonal orogens is examined in the light of the deep-seated catazonal monocyclic areas of southwest Norway. It is impossible for the mafic intrusions to have come from under the anorthosite masses that form the subbasement of the tectonic structure; they can only have been intruded laterally along the large recumbent folds that form the deeper parts of the orogen. These lateral intrusions are related to a "fundamental orogen," formed on the oceanic crust at the margin of a continental area, that develops into an orogen of deep catazonal type ("Grundgebirge" in the strict sense). The particular conditions engendered during the paroxysmal phase of orogenesis determine the formation of magmas at the oceanic margin of the orogen; these rise to form "marginal intrusions." In the deep part of the orogen these magmas are plagioclastic and give rise to the anorthositic foundation. — D. B. V.

- 186-358. Eskola, Pentti. Granitentstehung bei Orogenese und Epirogenese [Granite formation during orogenesis and epeirogenesis (with English summary, p. 693)]: Geol. Rundschau, v. 50, p. 105-123, 1960.

The formation of granites is illustrated by examples from the Archean basement of Finland, where deep erosion has exposed horizontal sections through at least two orogens of different age. Four percent of the granitic rocks (including migmatites) that underlie 78.3 percent of Finland are epeirogenic granites, such as rapakivi. According to radioactive age determinations the basement rocks represent half of geologic time; therefore, it is uncertain whether granites were formed in the same way then as now, either qualitatively or quantitatively. In fact, many more granites were regenerated during the Archean Karelian orogeny than in any subsequent orogeny. — D. B. V.

- 186-359. Borchert, Hermann. Zusammenhänge zwischen Lagerstättenbildung, Magmatismus und Geotektonik [Relations between ore deposition, magmatism, and geotectonics (with English summary, p. 691)]: Geol. Rundschau, v. 50, p. 131-165, 1960.

Stille's concept that the sialic orogen and subsequent magmatism are of paligenetic origin is developed on the basis of petrologic and geophysical information on the nature of the crust. In the magmatic cycle the initial and final stages of simatic magmatism, drawing their basalts from 60 km or deeper in the crust, are interrupted only briefly by a "sialic intermezzo." The relations of the most important types of ore deposits to either the juve-

nile-basaltic magmatism or to the sialic-paligenetic melting are discussed. The geotectonic consequences of the occurrence of the two types of magmatism are discussed in detail. Deep fractures permit the rise of basaltic magmas. Subsidence of sial to 20-25 km leads to the mobilization of paligenetic magmas, which rise "backwards." The lubrication afforded by their rise makes paroxysmal folding possible in the geosynclinal crust. Sialic mountain roots cannot exist, but the silicic residues of basaltic magmas constitute a considerable introduction of sial into the upper crust during every orogeny. A 14-page bibliography is given. — D. B. V.

186-360. Amstutz, G. C. Some basic concepts and thoughts on the space-time-analysis of rocks and mineral deposits in orogenic belts: *Geol. Rundschau*, v. 50, p. 165-189, 1960.

The basic patterns underlying time and space analyses of ore deposits in orogenic and geosynclinal belts are reviewed. It is concluded that the present crisis in genetic concepts of rock and ore genesis will not be overcome without a fairly radical departure from conventional methods of analysis. An "integrated" appraisal, constantly including contemporary knowledge of other fields of science, philosophy, and psychology in addition to detailed observations and experiments, is required. — D. B. V.

186-361. de Sitter, L. U. Compression and tension in the earth's crust: *Geol. Rundschau*, v. 50, p. 219-225, 1960.

Variations in density in the basaltic layer and upper mantle are postulated as being due to phase transformations resulting from high temperature and pressure variations. This theory is developed to explain the elevation of mountain systems, median ocean rises, and deep sea trenches in terms of compressional and tensional stress fields. In this theory, orogenesis consists of three phases: (1) compression, conversion of basalt to eclogite, formation of deep basins by isostatic sinking and tectonic thrusting, deposition of flysch; (2) strong compression, shortening of cross-section, considerable thickening of sialic crust upwards and downwards accompanied by tectonic uplift; and (3) tension, faulting, conversion of eclogite to basalt, isostatic uplift.

Magmatic phases develop along with these and influence the average density of the mountain chain or parts of it. The initial magmatic phase with basic intrusions and pillow lavas occurs during the geosynclinal stage; regional metamorphic changes occur during the phase of strong compression; and intrusive phases coincide with the phase of tension. — D. B. V.

186-326. Egyed, L[ászló]. On the mechanism of mountain building and folding: *Geol. Rundschau*, v. 50, p. 225-234, 1960.

Mountain building and associated phenomena are explained in terms of the expanding earth theory. The geosynclinal phase is connected with deep fractures, accompanied by deep sea troughs, isostatic anomalies, and andesitic volcanism. The phase of emergence is accompanied by the formation of rift zones, which in turn are connected with shallow earthquakes and basaltic volcanism. Folding occurs during and immediately after the geosynclinal phase, due to the lateral pressure of intruding magmas and later by gravity sliding of accumulated sediments. — D. B. V.

186-363. Hiersemann, L[other]. Seismotektonik in Bereich junger Orogene [Seismotectonics in the domain of young orogens (with English summary, p. 694)]: *Geol. Rundschau*, v. 50, p. 235-250, 1960.

Earthquakes are the clearest expression of recent tectonics. According to the uniformitarianism principle, the study of focal mechanisms should offer real clues to the development of orogens. The mechanics and dynamics of earthquakes are reviewed briefly, and the theoretical possibilities of the dynamic interpretation of the kinematic parameters are indicated. The north-west Pacific margin of Asia is discussed as an example of a seismotectonically active young orogen. The dynamic interpretation by the Japanese agrees well with the geology of the area, but the fault-plane solutions are ambiguous and cannot yet be accepted as final. — D. B. V.

186-364. Pannekoek, A. J. Post-orogenic history of mountain ranges: *Geol. Rundschau*, v. 50, p. 259-273, 1960.

Late folding, fracturing, and differential vertical movements constitute the morphogenetic phase of an orogeny; these differential movements and erosion together determine the morphology of mountains during their later history. Morphogenetic movements are independent of the earlier orogenic history. Any theory of orogenesis must also explain the morphogenetic phases; isostatic uplift as a result of erosion is considered inadequate. The connection of morphogenetic movements with post-orogenic volcanism suggests the possible importance of magmatic processes.

The collapse of large basins with positive gravity anomalies, such as the Mediterranean, may be related to the uplift of neighboring mountain chains; it seems to be independent of orogenic structures. — D. B. V.

186-365. Kraus, Ernst C. Über Definition und Wesen des Orogens [On the definition and nature of the orogen (with English summary, p. 695)]: *Geol. Rundschau*, v. 50, p. 292-298, 1960.

The history of the changing usage of the term "orogen" is traced, together with consideration of the nature of geosynclines and orogens. The geosynclinal orogen is defined as a bilaterally outward-diverging structure of the young earth's crust, developed from a longitudinal marine zone some 1,000-2,000 km long that tended mainly to sink throughout millions of years. Under orokinetic-magmatic, facies, and seismic-morphologic attendant circumstances conducive to high mobility, the sialic crust thickens downward to as much as 40 km. In the last stage the orogen rises isostatically to form mountains; as erosion progresses toward peneplanation, the uplift becomes relatively stable. — D. B. V.

186-366. Sonder, R[ichard] A. Kritische Gedanken zur orogenen Problematik [Critical opinions on the orogen problem (with English summary, p. 700)]: *Geol. Rundschau*, v. 50, p. 298-315, 1960.

The essential elements required for constructing a general theory of orogenesis are reviewed. Individual geologic arguments, which are based on unprovable assumptions, are evaluated in terms of their mechanical feasibility. Without mechanism studies, only the most superficial and questionable insight into geotectonics can be obtained.

The contraction hypothesis is considered to have the best chance of fulfilling all the major requirements of a general theory of orogenesis, but it is inadequate in the elaboration of details; other theories meet the basic requirements only in part. — D. B. V.

186-367. Belousov [Belousov], V. V. Tectonic map of the earth: *Geol. Rundschau*, v. 50, p. 316-324, 1960.

The tectonic map of the world compiled by Belousov shows regions of continental and oceanic crust; within the former it shows Alpine geosynclines and Alpine platforms, the latter subdivided according to the age of the basement. Anteclines, synclines, and tectonically active regions on platforms are marked.

The map is based on the concept that in the course of earth history the oceanic type of crust is secondary with respect to the continental type. During the geosynclinal-platform, or granite stage the granitic continental crust was formed. During the basalt stage, superheated basalts rose from deep in the mantle; surface manifestations of this stage are tectonic activity, extrusion of plateau basalts, and "oceanization"—secondary transformation of the granite-basalt continental crust into the water-basalt oceanic crust. Theories of mobilism of any kind are categorically rejected; the continuously stable geographic location of many regions of uplift and subsidence of the crust of the continents shows that these regions stay over the same part of the mantle wherein lie the causes of these vertical movements. — D. B. V.

- 186-368. Bemmelen, R. W. van. Zur Mechanik der ostalpinen Deckenbildung [On the mechanics of nappe formation in the East Alps (with English summary p. 690)]: Geol. Rundschau, v. 50, p. 474-499, 1960.

Three genetic profiles through Salzburg and the Hohe Tauern show that the East Alpine orogeny can be explained better by gravitational tectonics than by tangential pressure. Nappes of Helvetic type are formed where the skin of Alpine sediments glides off, and nappes of East Alpine type where the basement is also involved in the lateral movement; nappes of Penninic character are formed by flow in deeper, rheomorphic parts of the crust. The gravitational explanation does not require crustal shortening; this agrees with seismic and gravimetric data. — D. B. V.

- 186-369. Goodman, A. J. Review of some hypotheses on mountain building: Alberta Soc. Petroleum Geologists Jour., v. 8, no. 8, p. 215-227, 1960.

This paper reviews recent concepts of mountain building. Bucher's ideas and experiments, representing the contraction viewpoint with emphasis on horizontal stress, are considered. Belousov's contention that vertical stress is the prime factor in mountain building is also mentioned together with the views of others who challenge the overall décollement idea as exemplified in Buxtorf's Jura interpretation. Carey's revolutionary concepts, which include an expanding earth, continental drift, and the interlocking on a global scale of all major tectonics, are given consideration and related to earlier concepts by others. — Author's abstract

- 186-370. Deutsch, E. R. First-order tectonics of North America—A review: Alberta Soc. Petroleum Geologists Jour., v. 8, no. 8, p. 228-232, 1960.

Deutsch reviews the comments made by Warren S. Carey in an introduction to a symposium in Calgary, Canada, on the structure of western North America. The chief structural features of western North America can be understood if the action of a dextral shear couple along the Pacific coast is invoked. To account for the couple, Carey's concept of the orocline (see Geophys. Abs. 163-201; 176-165) must be considered. By unbending the kink in the Alaskan orocline both the Arctic Basin and the North Atlantic Ocean are closed off; a certain continental motion—chiefly rotational—is implied, and this would account for the shear movement of western North America relative to the Pacific Ocean. Two lines of corroborative evidence are cited: (1) present knowledge of seismicity in relevant regions; and (2) measurements of remanent magnet-

ism of rocks. Deutsch also notes that seismic evidence is not confined to distribution of earthquake focuses along the continental fracture systems but includes recent information from fault-plane analysis showing that much of the faulting is transcurrent in type. The features of the bold tectonic pattern of western North America (see Geophys. Abs. 178-217) are discussed, and it is concluded that the tectonics of the whole great region are dominated by structures manifesting dilation at one end, compression at the other, and shear in the center. Continental drift can be inferred only if polar traces deduced from paleomagnetic results on two or more continents fail to coincide. Confirmation of a dextral shear couple along the west coast of North America by paleomagnetism must await examination of suitable rocks from the adjacent deep ocean. — V. S. N.

- 186-371. Alberta Society of Petroleum Geologists. Discussion—Perspectivities in the solar system: Alberta Soc. Petroleum Geologists Jour. v. 9, no. 5, p. 162-173, 1961.

Haites' recent paper "Perspectivities in the solar system" (see Geophys. Abs. 185-265) is discussed by Gretener (p. 162-164), Holland (p. 164-165), and Hall (p. 165-167). Haites' answer (p. 168-173) includes a wire-diagram which, with figures 2 and 4 of the original paper, he feels demonstrates better than words or formulas what the perspectivities try to accomplish. — V. S. N.

- 186-372. Egyed, L[ászló]. The expanding earth: New York Acad. Sci. Trans., ser. 2, v. 23, no. 5, p. 424-432, 1961.

This is an English version of Egyed's expansion theory to explain the internal constitution and structure of the earth. For previous publications of this theory see Geophys. Abs. 167-165, 171-203, 173-236, 177-178, 178-215, 182-58, and 183-325. — V. S. N.

- 186-373. Jordan, P. Zum Problem der Erdexpansion [On the problem of the earth's expansion]: Naturwissenschaften, v. 48, no. 11, p. 417-425, 1961.

The concept of an expanding earth is reviewed. The ideas of Ewing and others (see Geophys. Abs. 181-490) concerning a globe-girdling system of oceanic rifts; Binge's early analysis of volcanism and intrusion as supporting the strong expansion hypothesis; strong expansion as advocated independently by Fisher, Egyed, and Heezen, and expansion based on Dirac's cosmology (see Geophys. Abs. 182-58, -281) are discussed. The theory of strong expansion can well explain continents and oceans; its application to the earth's interior is more difficult but possible. — D. B. V

- 186-374. Belousov [Belousov], V. V. The origin of folding in the earth's crust: Jour. Geophys. Research, v. 66, no. 7, p. 2241-2254, 1961.

Folding represents the reaction of layered beds to differential vertical movements of separate blocks of the crust. Block folding is the most direct reaction to these movements, and characteristically produces box-like folds; they may occur either in platforms or geosynclines. Injection folding is due to horizontal flow of the more plastic rocks, which are squeezed out from some areas and accumulate in others; such flow results from uneven loading by overlying layers and, particularly, from fracturing of these layers, and occurs mainly in foredeeps and tectonic basins. Metamorphic or deep folding is connected with granitization and metamorphism; when rock density be-

comes lower due to impregnation by volatile substances, upward flow is induced and deep diapir-like structures are formed. General crumpling is the result of gravitational sliding of layers down the slopes or the spreading of the upper parts of uplifted blocks; horizontal compressive forces are created which crumple adjacent layers. General crumpling can also be formed by mechanical pushing apart due to the formation of injection cores or deep diapirs. Deep folding and general crumpling occur in geosynclinal belts.

Folding phenomena do not indicate the existence of general compressional forces in the crust; horizontal compression is a purely local phenomenon limited to narrow belts within geosynclines. The primary cause of folding is vertical movements. — D. B. V.

- 186-375. Sheynmann, Yu. M. Znacheniyе okeanov atlanticheskogo tipа dlya razvitiya struktur Zemli [Significance of oceans of the Atlantic type for the development of the structure of the earth]: Moskov. Obshch. Ispytateley Prirody Byull. Otdel Geol., v. 36, no. 2, p. 29-38, 1961.

Oceans of the Atlantic type are younger than the structures that surround them; they form by the destruction of these structures. The same type of destruction of older structures by younger is observed at the junction of the ancient structures of old platforms with the folded belts that frame them. The Atlantic and Indian Oceans are in the very first pregeosynclinal stage and further development will lead to the appearance of broad primary geosynclines. Ocean development does not encompass the entire earth. The formation of new folded belts is distinctive of part of the earth, but elsewhere older folded structures continue to develop. — J. W. C.

- 186-376. Subbotin, S. I. Prychyny tektonichnykh rukhiv ta mekhanizm formuvannya osnovnykh heostrukturykh elementiv zemnoy kory [Causes of tectonic movements and mechanism of formation of the fundamental geostructures of the earth's crust (in Ukrainian with Russian summary)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 22, no. 5, p. 3-17, and no. 6, p. 3-16, 1960.

Analysis of gravity and other data suggests that volume changes in sub-crustal matter are the most likely cause of vertical movements in the crust. The changes occur intermittently at depths of 60 or 80 to 800 or 900 km and may be due to polymorphism, phase transformations, electron migration, or chemical reactions. Each of these factors is discussed in some detail in the first part of the paper. The second part treats the formation of depressions in platform areas, deep fractures, geosynclines (and their folding), and the deep basins of intracontinental seas (such as the Black, Caspian, and Aegean Seas) as a result of vertical movements. Numerous diagrams and a 54-entry bibliography are given. — D. B. V.

- 186-377. Quiring, Heinrich. Der Rand der Mondnarbe im Pazifik [The rim of the moon scar in the Pacific]: Neues Jahrb. Geologie u. Paläontologie Monatsh., no. 3, p. 140-150, 1961.

The lack of sial crust and the ascent of ultramafic magmas suggest that in the north Pacific the sial crust, with an average thickness of 16 km, was probably torn away catastrophically to form the moon, allowing sima magma to rise to the level of isostatic equilibrium and fesima magma to about 75 km below this level. The magmas rose only to within 5 km of the geoid surface, leaving the Pacific basin. The catastrophe rocked the whole earth; this was the Laurentian revolution. The earth's radius was shortened by some 42 km

and the primitive crust, settling in over the magmas that flowed toward the scar, was compressed, heated, and permeated by gases.

The Laurentian revolution was the strongest of all crustal movements; the primitive crust is nowhere preserved, whereas all later movements have been limited to more or less extensive zones of weakness between stable cratons. The rim of the moon scar is clearly discernible in the form of circum-pacific Archean fault systems. Other evidence of the moon's ejection consists of the ring of deep sea troughs, volcanoes, and earthquake zones surrounding the north Pacific. — D. B. V.

186-378. Hodgson, R. L. Drift or shift: Univ. Sheffield Geol. Soc. Jour., v. 4, no. 2, p. 18-22, 1961.

Five current hypotheses to explain the shift in position of the geomagnetic pole from Precambrian to Recent times and to explain the discrepancy in longitude and latitude of the pole positions from continent to continent are discussed as follows: (1) the direction of magnetization of the rock today does not represent the direction of the local earth's field at the time of magnetization; (2) the earth's crust as a whole has shifted relative to the axis resulting in wandering of the geographic pole; (3) the crust has remained fixed but the geomagnetic field in the past corresponded to a dipole not directed along the rotational axis, resulting in wandering of the magnetic pole; (4) the earth's field had strong nondipole components in remote geological times; and (5) continental drift has occurred. Scientific opinion in general seems to conclude that both continental drift and polar wandering have occurred and are the important factors although Blackett and others (see Geophys. Abs. 184-491) believe polar wandering is unimportant. — V. S. N.

186-379. Joplin, Germaine A. On the tectonic environment of basic magma: Geol. Mag., v. 97, no. 5, p. 363-368, 1960.

It is shown that basic magma is associated with vertical and not with folding movements, that basic intrusions take on forms characteristic of unfolded regions and of relatively high levels, and that differentiation in place is common. Basic magma is emplaced in the orogenic belts as flows and typically nonorogenic intrusions during the geosynclinal or sinking phase of the orogenic cycle. The terms "Nonorogenic Association" and "Orogenic Association" are suggested to replace "Volcanic Association" and "Plutonic Association" to indicate the relation of basic and silicic magmas to their tectonic environment. — V. S. N.

186-380. Richter, C[harles] F. Comparison of block and arc tectonics in Japan with those of some other regions: Jour. Physics of Earth [Tokyo], v. 8, no. 1, p. 1-10, 1960.

Most of the seismicity of the world is related to the two principal environments—block and arc tectonics; the latter is found chiefly in the circum-pacific and Alpidic belts. Distinction between block and arc structures is usually not one of essential character but one of the present stage of development. Block tectonics may be considered as a later stage which follows the folding and thrusting of a typical orogeny. It represents a lower degree of activity than the arc stage; large shallow earthquakes are common, intermediate are rare, and deep are absent; volcanoes are in a late stage of activity or extinct; and foredeeps and gravity anomalies are less pronounced than in an active arc.

In Japan, block and arc structures occur in a geometrical and mechanical relationship that promises to shed light on the nature of both. The five subdivisions in Japan are discussed as follows: (1) west Japan (the main islands

west and southwest of the Fossa Magna) a major area of block tectonics with only traces of arc features; (2) northeast Japan, (Honshu east of the Fossa Magna and southwest Hokkaido) a part of a major Pacific arc with block faulting in the interior in a belt adjacent to the Japan Sea; (3) northeast Hokkaido, terminus of the active Kuril Arc; (4) the Ryukyu Islands Arc, which extends into Kyushu to intersect and modify the block structure; and (5) the Shichito Arc extending south to the Ogasawara (Bonin) Islands. The tectonic characteristics of these subdivisions are compared with those of New Zealand, California and the Great Basin area, the East Indies, the West Indies, the Himalayan Arc, the Italian Arc, and the tectonics of the U. S. S. R.

A statistical study of the proportion of large to smaller earthquakes is recommended as a valuable means of distinguishing between areas of different tectonic type. Statistical results in the Pamir-Baikal seismic belt show a higher proportion of large to small earthquakes than in the Pacific arcs and suggest an area of block tectonics. — V. S. N.

- 186-381. Inoue, Eiji. Land deformation in Japan: Japan Geog. Survey Inst. Bull., v. 6, pt. 2-3, p. 73-134, 1960.

Recent land deformations in the Japanese Islands based on data from local geodetic surveys compared with data from the original geodetic network are discussed and illustrated for major earthquakes from 1891 to 1952. A recent and almost completed revision of the primary geodetic network of the Japanese Islands substantiates the belief derived from earthquake displacements that there are regional crustal movements in Japan that are continuous over a period of several decades. The horizontal and vertical displacements deduced from a comparison of the results of the present and previous geodetic surveys (60 yr interval) are shown in figures. These comparisons indicate that deformation is systematic in each region and seems to be closely related to the present topography of the Japanese Islands. The types of displacements directly related to earthquakes and the horizontal and vertical movements of secular crustal displacements are discussed in detail and illustrated for various areas of Japan. Major gravity anomalies are located, and their relation to secular crustal deformation is discussed.

It is concluded that present crustal movements in the Japanese Islands are caused by lateral pressure of the Asian Continent on the Pacific Ocean basin or by a contraction pressure between the continent and ocean basin acting continuously at least since early Cenozoic and resulting in land deformations characterized by the interaction of arc structures. — V. S. N.

- 186-382. Blake, Weston, Jr. Russian settlement and land rise in Nordaustlandet, Spitsbergen: Arctic, v. 14, no. 2, p. 101-111, 1961.

The evidence from a Russian hut on Nordre Russøya, an island in Murchisonfjord, Nordaustlandet, Spitsbergen, that is at least 100 years old and is now only 1.2 m above highest tide indicates that land uplift in this area is very slight if it is occurring at all; a rise of 1 m or more per century would put this hut under water when it was built. No long term observations on land rise are available from this area, but it appears that such a rise is measurable at most in terms of a few centimeters per century; if slow isostatic uplift of the land is occurring, it is balanced by the present eustatic rise of sea level. Present stability is further indicated by the well-developed shingle beachbars that are generally lacking at higher levels on the raised beaches. — V. S. N.

- 186-383. Christiansson, Hans. The Russian settlement at Russekeila and land rise in Vestspitsbergen: Arctic, v. 14, no. 2, p. 112-118, 1961.

Evidence from the ruins of a Russian settlement at Russekeila, Isfjorden, Vestspitsbergen, indicates that there has been no appreciable land rise in at least 100 years. This is in accord with evidence from Murchisonfjord (see Geophys. Abs. 186-382) and elsewhere in northwestern Vestspitsbergen. At Amsterdamøya, an island off northwest Vestspitsbergen, no significant change in the relation between land and sea has occurred for more than three centuries. — V. S. N.

GLACIERS

186-384. Sharp, Robert P. *Glaciers*: Eugene, Univ. Oregon Press, Condon Lectures, 78 p., 1960.

Some basic facts are presented as background for an understanding of certain facets of modern glaciological research. The Blue, Saskatchewan, and Malaspina-Seward glaciers are used as examples to illustrate the various phenomena under discussion. The seven chapters, originally given as lectures, are: the constituent parts of a glacier, the glacier budget, glaciers and climate, the conversion of snow to glacier ice, the flow of glaciers, structures in glaciers, and oxygen-isotope ratios. — V. S. N.

186-385. Wilson, Charles R., and Crary, A. P. Ice movement studies on the Skelton Glacier: *Jour. Glaciology*, v. 3, no. 29, p. 873-878, 1961.

During the 1958-59 Victoria Land Traverse operations, 12 major geophysical stations were occupied on Skelton Glacier on the west side of the Ross Ice Shelf, and seismic, gravity, magnetic, and glaciological studies were made; other sites were occupied for intermediate gravity and elevation observations. Included in the studies were detailed measurements of ice thicknesses, water depths, absolute and relative movements along a 16 km line across the floating mouth of the glacier near Teall Island, and 2 movement studies on the northeast branch of the upper grounded glacier at an elevation of 372 m. The floating part of Skelton Glacier seems to be moving as a solid block with nearly constant velocity; the amount of movement was calculated as 88.7 m per yr or an annual volume of flow of $791 \times 10^6 \text{ m}^3$. At the observation points on the upper glacier the yearly absolute value of movement at the surface was determined to be 75 m or an annual volume of flow of $245 \times 10^6 \text{ m}^3$.

Estimates of the local ice regime are reported from two sites on the glacier where ice thickness and strain rates are known. It is inferred that thinning of the ice must take place in the direction of motion. The thinning necessary for an absolute movement of 75 m per yr would be 20 m per km. — V. S. N.

186-386. Sil'nitskaya, V. I., and Cheremnykh, G. D. O metodike izmereniya skorostey dvizheniya l'da poverkhnostnykh chastey nekotorykh lednikov v Antarktiki po materialam dvukratnoy aerofotos'emki [On the method of measurement of the surface flow rates of some glaciers in Antarctica according to data of two aerophoto surveys]: *Akad. Nauk SSSR Izv. Ser. Geog.*, no. 5, p. 90-95, 1959.

Two aerophoto surveys over the same glacier in Antarctica in the years 1956 and 1957 showed displacements of markers on the glacier. The flow rate was determined to be about 40 m per month. — A. J. S.

GRAVITY

- 186-387. Gamow, George. Gravity: *Sci. American*, v. 204, no. 3, p. 94-100, 102-104, 106, 1961.

A popular and well-illustrated account is given of the history of gravitational theory. Major emphasis is given to a discussion of Einstein's theory that gravitation can be interpreted as a geometrical property of space-time. Einstein's efforts to relate gravity and electromagnetism through his "unified field" theory, which has been largely rejected by modern scientists, are also discussed along with the more recent approach, as expressed by Gamow, that the true relation between gravitational and electromagnetic forces is to be found through an understanding of the nature of elementary particles and of the relation between the masses and the electric and magnetic properties of the particles. Dirac's proposal that the value of the constant ratio that is found by comparison of the actual strength of the electrostatic and gravitational forces between a pair of particles is a factor of the age of the universe is examined. It is further shown that if, in the future, it should be demonstrated that antiparticles have a negative gravitational mass, Einstein's principle of equivalence and thus the entire relativistic theory of gravity will have been disproved. — V. S. N.

- 186-388. Tengström, Erik. Calculation of the external gravity anomalies and deflections of the vertical at higher elevations by means of Taylor expansions from the geoid: *Ohio State Univ. Inst. Geodesy, Photogrammetry, and Cartography Repts.*, no. 5, 15 p., 1959.

This paper is a continuation of Tengström's paper (1959) on the boundary value problem of physical geodesy. The gravity anomalies Δg and geoid undulation values N at sea level are used; the disturbing potential T , the gravity anomaly Δg , and the components ξ and η of the deflection of the vertical are expanded in Taylor series of altitude h . These formulas give the quantities T_h , Δg_h , ξ_h , and η_h at elevations up to 150 km. — D. B. V.

- 186-389. O'Keefe, John A., Eckels, Ann, and Squires, R. Kenneth. The gravitational field of the earth: *Astron. Jour.*, v. 64, no. 7, p. 245-253, 1959.

It is shown that all of the 222 elements of the orbit of the Vanguard I satellite (1958 β 2) for the 37 epochs since its launching can be derived from the zonal harmonics of the earth's gravitational field of degrees 0, 2, 3, and 4, together with 6 initial elements and the values of the mean anomaly. (See also *Geophys. Abs.* 180-183.) — D. B. V.

- 186-390. King-Hele, D. G. The earth's gravitational potential, deduced from the orbits of artificial satellites: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 3-16, 1961.

This is a more detailed version of the paper published in *Nature*, v. 187, no. 4736, p. 490-491, 1960 (see *Geophys. Abs.* 183-314). — D. B. V.

- 186-391. Merson, R. H. The motion of a satellite in an axi-symmetric gravitational field: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 17-52, 1961.

The equations for the variation of the osculating elements of a satellite are integrated to yield the complete perturbations of the first order due to the sec-

ond harmonic, together with the secular perturbations of the second order due to the second harmonic and of the first order due to the third to sixth harmonics. A set of smoothed elements is then derived, in which the perturbations of the even harmonics have no singularities, the semimajor axis and eccentricity have no variation due to the second harmonic and the other elements have the smallest possible amplitudes of oscillation. The formulas presented will be extremely useful in the reduction of earth-satellite observations and geopotential studies based on these. — Author's summary

186-392. Cook, A[lan] H[ugh]. Resonant orbits of artificial satellites and longitude terms in the earth's external gravitational field (with appendix by H. J. Norton): Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 53-72, 1961.

As there is little prospect at present of finding the longitude-dependent parts of the earth's external gravitational potential from the motion of an arbitrary satellite, it is of interest to see if in special circumstances long-period or secular perturbations could arise in these parts. A preliminary study of satellite orbits with periods bearing some specific relation to the period of the earth's rotation shows that secular and long-period perturbations can arise. In the appendix it is shown that many resonant orbits are possible besides those given in the main body of the paper. — D. B. V.

186-393. Tsuboi, Chuji. Numerical tables useful for studying the gravitational field at higher elevations of the earth: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 73-82, 1961.

Expressions for the gravitational potential and force at a point (not necessarily on the earth's axis) at any higher elevation of the earth have been obtained in a simple summation series form in terms of zonal averages of surface gravity anomalies taken around the axis passing through the point. Numerical values to be multiplied to zonal averages of gravity anomalies in order to obtain the potential and force are given in tables. If the elevation is zero, our values for the potential naturally agree with those of Lambert's Q function. — Author's summary

Kaula, W[illiam] M. Analysis of gravitational and geometric aspects of geodetic utilization of satellites. See Geophys. Abs. 186-348.

186-394. Gladkiy, K. V. Otsenka razreshayushchey sposobnosti metodov raspredeleniya gravitatsionnykh poley [Evaluation of the resolving power of the methods of separation of gravity fields]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 685-693, 1961.

This is a mathematical analysis (information theory) of the problem of separating a necessary signal obtained with a geophysical apparatus from the interfering signals. Gravity anomalies observed and observation errors are treated as probability functions, and the resolving power of the methods of separation of gravity fields are investigated. The evaluation of the resolving power and the selection of optimum parameters in determination of higher derivatives in the upper half-space are discussed. — A. J. S.

186-395. Afanas'yev, N. L. Sglazhivaniye gravitatsionnykh anomalii [Smoothing of gravity anomalies]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 994-1003, 1961.

A method for smoothing gravity anomaly curves on the basis of the theory of probability, proposed in 1935 by Whittaker, is discussed. The method secures

the actual value of the mass and correct coordinates of the center of gravity of the anomalous body. Graphical examples of smoothed anomaly curves, and auxiliary tables are given. — A. J. S.

- 186-396. Tsuboi, Chuji. Upward and downward continuation of gravity values based on the cylindrical co-ordinate system: *Japan Acad. Proc.*, v. 37, no. 1, p. 37-41, 1961.

A method of gravity continuation by which the distribution of an underground mass may be determined from the surface anomaly is presented. The method is based on a cylindrical coordinate system that is superior to the rectangular system because the circular form of its relevant domain permits uniform extension in different azimuths. An example is illustrated in a figure and the mathematical solution given. The method is readily modified to solve for an upward continuation of gravity values. — V. S. N.

Troshkov, G. A. On the problem of interpretation of magnetic and gravity anomalies of three-dimensional bodies. See *Geophys. Abs.* 186-515.

Marussi, Antonio. Intrinsic coordinates in practical geodesy. See *Geophys. Abs.* 186-346.

- 186-397. Jackson, J. E. The Cambridge pendulum apparatus: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 375-388, 1961.

The three-pendulum method, developed and used by Lenox-Conyngham, was superseded in 1930 on the arrival of a new vacuum box for swinging two pendulums. With three invar pendulums taken over from the earlier apparatus and three new ones acquired in 1931, this box is the centerpiece of the apparatus which has been in use up to the present day for geophysical investigations and for establishing gravity reference stations in many parts of the world. This article describes briefly the apparatus and the various modifications of procedure and changes of auxiliary gear that have taken place in the past 30 years. A list of the work done with the apparatus is given. — Author's summary

- 186-398. Bancroft, A. M. The establishment of gravity bases at airports across Canada: *Dominion Observatory Ottawa Pubs.*, v. 24, no. 2, p. 45-66, 1960.

Gravity base stations were established at 48 airports across Canada using the method of forward looping. The three gravimeters used were transported by aircraft. A complete tabulation of the observations and adjustments is given together with detailed station descriptions. Six closed circuits were formed within the network in order to make subsequent adjustments. Observations for each instrument were adjusted separately by a tabular iteration method which is described in detail, and instruments were calibrated by comparison with Cambridge pendulum data. All values are listed relative to that adopted for the National Reference Pier in Ottawa. The standard deviations of the observations are estimated to range from 0.2 mgal for stations near Ottawa to 0.5 mgal for stations in western Canada. — V. S. N.

- 186-399. Hamilton, Angus C. Gravity measurements in Canada—January 1, 1957 to December 31, 1959: *Dominion Observatory Ottawa Pubs.*, v. 24, no. 3, p. 71-82, 1960.

A brief review is given of gravity measurements made in Canada from January 1, 1957 to December 31, 1959 by the Dominion Observatory, the National

Research Council, and other public institutions, universities, and industrial groups. The following are discussed: absolute measurements and connections to first order world stations, the national primary network, regional mapping, reconnaissance surveys and detailed studies of particular interest, isostatic and geodetic studies, and instrumental development. — V. S. N.

186-400. Dooley, J. C., and Williams, L. W. Absolute gravity value at Adelaide: *Australian Jour. Sci.*, v. 23, no. 1, p. 17-18, 1960.

In his assessment of the absolute gravity value at Adelaide, South Australia, Mumme (see *Geophys. Abs.* 182-209) was apparently unaware of several recent developments in establishing a gravity datum for Australian stations generally. The currently adopted value for the New Observatory Base at Adelaide is 979.7228 gal, based on the Melbourne value which in turn is based on Cambridge. International gravimeter connections suggest that this is a little too low.

The suggestion for establishing a permanent gravity station is admirable, but the value should not be recorded permanently on a brass plug as it is liable to readjustment in the near future. The Potsdam reference system is being revised; the first order international network, which includes Melbourne, will probably be adjusted within the next two years; and values of gravity stations within Australia will then be adjusted internally. — D. B. V.

186-401. Stott, P. M. Gravity observations in Tasmania: *Australian Jour. Sci.*, v. 23, no. 9, p. 300-301, 1961.

Gravity readings between the old base station at Cambridge Airport and the new station at Llanherne Airport in Tasmania were made with a Worden No. 61 gravimeter. Observations were also made at 6 other points in Tasmania for use as base stations for future measurements. Results, referred to the Footscray (Melbourne) value which is based on the Cambridge (England) value, are tabulated. — D. B. V.

186-402. Harada, Yoshimichi; Suzuki, Hiromiti; Ohashi, Shin-ichi; and Kakinuma, Seiichi. Determination of the differences in gravity between Chiba, Singapore, Cape Town and Syowa Station in Antarctica: *Japan Geog. Survey Inst. Bull.*, v. 6, pt. 2-3, p. 135-156, 1960.

The results of gravity measurements carried out during the 2d, 3d, and 4th Japanese Antarctic Research Expeditions at Singapore, Capetown, and Syowa Station in Antarctica are summarized (see also *Geophys. Abs.* 177-219, 184-409). The difference in values determined in 1957-58 using a GSI pendulum apparatus are as follows:

$$\text{§Singapore} - \text{§Chiba} = -1709.3 \pm 0.45 \text{ (mean error) mgal}$$

$$\text{§Capetown} - \text{§Chiba} = -142.8 \pm 0.45 \text{ (mean error) mgal}$$

Using a gravity value for Chiba of 979.7898 relative to the national fundamental station at Kyoto, Japan, of 979.7215, the following values are obtained: $\text{§Singapore} = 978.0805 \text{ cm per sec}^2$, and $\text{§Capetown} = 979.7215 \text{ cm per sec}^2$. The gravity value at Syowa station determined in 1958-59 by a Worden gravimeter is 982.540 cm per sec² relative to the Capetown value. The Syowa results were further checked in 1959-60, and gravity values were determined for 5 stations in the Ongul Islands. Observations on pack-ice in Lützw-Holm Bay show a gravity anomaly of more than +50 mgal, whereas those in the Ongul Islands are about -10 mgal. It is concluded that a large gravity gradient exists along the coast of Lützw-Holm Bay. — V. S. N.

- 186-403. Suzuki, Hiromiti; Ohashi, Shin-ichi; and Kakinuma, Seiichi. Report of the gravity measurement by the Japanese Antarctic Research Expedition, 1959-60 [in Japanese with English abstract]: Antarctic Rec., no. 12, p. 37-44, 1961.

During the fourth Japanese Antarctic Research Expedition, 1959-60, a re-measurement was made of the gravity value at Astronomical Point, Syowa Station, Antarctica, previously determined in 1958-59. The mean value, 982.5427, was only 2.6 mgal higher than the 1958-59 value and, therefore, the 1958-59 value is considered accurate enough to be used as a reference value in gravity measurements in this district.

On the way to and from Antarctica 10 gravity stations were reoccupied and 10 new stations were established on Singapore Island; observations were also carried out in Naha, Ryūkyū. Results are given in tables. — V. S. N.

- 186-404. Garland, G. D., Kanasewich, E. R., and Thompson, Thomas L. Gravity measurements over the southern Rocky Mountain Trench area of British Columbia: Jour. Geophys. Research, v. 66, no. 8, p. 2495-2505, 1961.

A series of negative gravity anomalies found along the southern part of the Rocky Mountain Trench in Canada is interpreted to be the effect of relatively deep basins in the trench floor. These are apparently filled with light material and are separated from each other by regions of only thin cover over bedrock of normal density. The pattern obtained is very suggestive of a system of longitudinal and transverse faults, and the gravity field is therefore consistent with the theory that the trench, in this vicinity, was produced chiefly by downfaulting. — Authors' abstract

- 186-405. Murphy, Thomas. Gravity anomaly map of Ireland, Sheet 5—South West: Dublin Inst. Adv. Studies Geophys. Bull., no. 18, 2 p., 1960.

The gravity (Bouguer) anomaly map presented here is one of a series designed to give a complete gravity coverage of Ireland. In the area of this sheet, the value of the gravitational field has been determined at about 2,300 stations approximately 3 km apart. Measurements were made with a Worden gravimeter, and the base stations used are those of the Irish network with a few interpolated ones. The map, on a scale of 1:250,000, covers the area of southwest Ireland between lat 51°18'—52°40' N. and long 07°43'—10°30' W. A brief description is given of the anomaly field which, in general, is positive with an average value of 8 mgals. Few gravity features can be correlated with the surface rocks; one of the better defined features is a low trough running east-west that coincides with a syncline of Carboniferous limestone in Devonian rocks. The most striking feature of the sheet is the large negative anomaly south of Killarney and connecting to the east with one north of Cork. A strong positive anomaly to the north of Killarney on the Dingle Peninsula produces a very steep gradient between the two areas. The cause is associated with deep-seated rock formations. — V. S. N.

- 186-406. Bullerwell, W. The gravity map of Northern Ireland: Irish Naturalists' Jour., v. 13, no. 11, p. 254-257, 1961.

The revised gravity map of Northern Ireland, compiled from gravity surveys during the summers of 1959 and 1960, is discussed. Some 10,488 new gravity stations extending throughout Northern Ireland and spaced at about 2 stations per square mile were occupied during the surveys. A Bouguer anomaly map summarizing the survey results is presented and the major features

described. The average gravity anomaly for Northern Ireland is +20 mgals, and except for County Down the contours show an arrangement along Caledonian trends. — V. S. N.

186-407. Whetton, John T., Myers, J. O., and Burke, K. B. S. Tracing the boundary of the concealed coalfield of Yorkshire using the gravity method: *Mining Engineer*, no. 8, p. 657-668, 1961.

A gravity survey was made to determine the structures from the edge of the concealed coalfield of West Yorkshire into the drift-concealed Vale of York. The gravity measurements, which cover an area of more than 200 sq mi, reveal anomalies that indicate a well developed pattern of major faults; some of the faults probably form part of the boundary of the concealed coalfield. The evidence supports the early hypothesis of Ward (1871) of a northward extension of the coalfield into the Vale of York. — V. S. N.

186-408. Pham-Van-Ngoc. Quelques résultats de prospection gravimétrique par mesure directe des dérivées secondes verticales de l'intensité de la pesanteur [Some results of gravimetric prospecting by the direct measurement of the vertical second derivatives of the intensity of gravity]: *Acad. Sci. [Paris] Comptes Rendus.*, v. 252, no. 23, p. 3617-3619, 1961.

The method described in a previous paper (see *Geophys. Abs.* 185-307) was applied to two examples of gravity prospecting in France, one in the southern part of the Lacq oilfield and the other in the Poitou-Gabrielle mining area in Vendée. In the first area, the second derivative method gave results that were in satisfactory agreement with seismic results, in spite of complexities of topography and structure. In one place, flanked on the east and west by areas in which the seismic isobaths showed the top of the Cretaceous at depths of the order of 1,500-1,800 m, the second derivatives showed a narrow, abrupt, uplifted zone; this was confirmed by a boring that reached the Cretaceous at less than 718 m.

In the second area, the contact between granite and highly altered schists, marked by a silicified breccia about 8 m thick, was known from exploratory drilling. The second derivative survey, with a spacing of 25 m between the central station and the marginal stations, reflected the density contrast at the contact clearly with a small positive anomaly above the breccia as well. — D. B. V.

186-409. Dimitrov, Lyuben V., Dobrev, Toma B., and Pishchyalov, Stayko St. Izyasnyavane nyakoi elementy na d'lbochinniya tektonski stroeyzh na Sofiyskata kotlovina v'z osnova na geofizichny danny [Determination of some elements of the deep structure of the Sofia depression on the basis of geophysical data]: *Minno-Geol. Inst. Godishnik*, v. 6, pts. 1 and 2, p. 285-318, 1959-1960.

General information is presented on a geological-geophysical study of the Sofia depression and on the interpretation of gravimetric data. The map of the total gravity field was used for preparation of a map of the second vertical derivative of gravity potential according to Veselov's method. Seven geological-geophysical profiles were made from gravity and drilling data. The profiles intersect different parts of the depression and furnish data on structural geologic variations in both vertical and horizontal directions. As a result of these investigations a number of new tectonic lines in the south and southwest parts of the depression were discovered. The depression is bounded by a fault which extends into the basement. — A. J. S.

- 186-410. Kuznetsov, A. A., and Tavrín, I. F. Nekotoryye dannyye o tektonicheskom stroenii zelenokamennogo sinklinoriya na vostochnom sklone yuzhnogo Urala po rezul'tatam gravimetrovykh i magnitnykh s'yemok [Some data on the tectonic structure of the greenstone synclinorium on the east flank of the southern Urals according to results of gravity and magnetic surveys]: Akad. Nauk SSSR Ural. Filial, Gorno-Geol. Inst. Trudy, no. 34, p. 73-81, 1958.

Gravity and magnetic observations were made along a traverse across the greenstone synclinorium of the Bashkir A. S. S. R., and a new interpretation of the geology is made on a basis of these measurements. A deep fault separates the Ural-Tau anticlinorium on the west from the greenstone synclinorium; this zone is marked by positive magnetic and negative gravity anomalies, which are caused by serpentines. A large gravity anomaly corresponding to basic extrusives is recorded in the Irendyk subzone of the synclinorium. Large positive magnetic and gravity anomalies are located in the area east of the Ural River; these are probably due to basic extrusives. A magnetic map and a combined gravity and magnetic profile are given. — J. W. C.

- Tanaka, Akiyoshi, and Ninagawa, Shinji, Geophysical prospecting in the eastern part of Kushiro City, Hokkaidō. See Geophys. Abs. 186-591.

- 186-411. McDougal, I., and Stott, P. M. Gravity and magnetic observations in the Red Hill area, Southern Tasmania: Royal Soc. Tasmania Papers and Proc., v. 95, p. 7-15, 1961.

The results of reconnaissance gravity and magnetic traverses in the Red Hill area of Tasmania confirm the structure assumed from geological evidence. The gravity measurements proved to be most useful in delineating the structural problems in this area of dolerite intrusions. The Red Hill dike formed by differentiation of dolerite in place, but it does not seem to extend much beyond 600 m below the surface. The magnetic observations, on the other hand, are not particularly useful beyond determining the boundaries of dolerite intrusions hidden below soil or thin sedimentary cover. — V. S. N.

HEAT AND HEAT FLOW

- 186-412. MacDonald, Gordon J. F. Surface heat flow from a differentiated earth: Jour. Geophys. Research, v. 66, no. 8, p. 2489-2493, 1961.

The surface heat flow in model earths has been calculated numerically. The bulk radioactivity of the earth is assumed to be equal to that of chondritic meteorites, and the initial temperature to reach 2,600°C at 1,200 km. For a model in which the radioactivity is uniformly distributed in the outer 600 km the heat flow is 90 ergs per cm² per sec; if the radioactivity is concentrated in the outer 100 km, the present-day surface heat flow is 68 ergs per cm² per sec. Initial heat contributes about 1/5 of the surface heat flow.

The results suggest that a high initial temperature can be ruled out if the hypothesis of a chondritic composition is maintained and if heat is transferred primarily by conduction coupled with radiation; alternatively, a radioactivity lower by a factor of 2 (that is, the mantle alone is chondritic) would permit chondritic models with initially high temperatures. Clark's results (see Geophys. Abs. 185-329) and those of the present paper imply that a chondritic model requires near-surface concentration of heat sources at a temperature well below the melting temperatures. — D. B. V.

- 186-413. Jacobs, J. A. Some aspects of the thermal history of the earth: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 267-275, 1961.

A number of thermal problems connected with the earth are discussed—the early thermal history of the earth and some of its consequences, the formation and state of the inner core, convection in the core and its relation to the earth's magnetic field, and conditions in the upper mantle. — Author's summary

- 186-414. Verhoogen, John. Heat balance of the earth's core: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 276-281, 1961.

It is shown that the heat necessary to maintain convection in the core may come from slow cooling and crystallization of the core with corresponding growth of the solid inner core. The present rate of cooling would be of the order of 10° - 45° per 10^9 yr, depending on temperature. — Author's summary

- 186-415. Rikitake, Tsuneji, and Horai, Ki-iti. Studies of the thermal state of the earth. The fourth paper: Terrestrial heat flows related to possible geophysical events: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 3, p. 403-419, 1960.

A subcrustal convection current having a linear dimension of a few thousand km can account for the high heat flow observed on the East Pacific Rise, if the current velocity and temperature gradient in the mantle are several cm per yr and 1°C per km, respectively. A long-lived magma with high temperature and a phase transformation layer can account for only a fraction of the average world heat flow for conceivable cases; therefore, it is difficult to interpret heat flow anomalies alone in terms of geophysical events inside the earth. — D. B. V.

- 186-416. Simmons, Gene. Anisotropic thermal conductivity: Jour. Geophys. Research, v. 66, no. 7, p. 2269-2270, 1961.

It is shown that the use of a point source and the measurement of the thermal gradient to determine thermal conductivity (K) in material with two different principal conductivities (such as shales, slates, and some sandstones) requires two nonparallel holes. As several diamond drillholes are often drilled in different directions from the same location in the mining industry, it would appear that these offer possibilities for useful measurements. The conductivity determined by means of a line source parallel to the z -axis is the geometric mean of the other two principal conductivities. It should be emphasized that this applies to all probe methods, inasmuch as the users of probes seem to neglect the possibility of anisotropy. In particular, if $K_x = K_y \neq K_z$, measurements along z will give only the conductivity in the perpendicular direction.

The main conclusion of this note is that the conductivity determined in place in a single borehole through anisotropic material is not the conductivity parallel to the borehole. — D. B. V.

- 186-417. Kraskovskiy, S. A. O teplovom pole shchitov [On the thermal field of shields]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 387-392, 1961.

The heat flow of the crust was investigated on the basis of data on the principal structural elements of the earth with particular attention given to the

shields. The African, Hindustan, Baltic, Ukrainian, Canadian, and Indian shields were studied. The Spicer tables of geothermal gradients and heat fluxes (see Geophys. Abs. 110-6657) were used; these disclosed low geothermal gradients and low values of the heat flow as general characteristics of the thermal fields of the shields. The mean geothermal gradient of the shields is 1.2°C per 100 m, and the mean heat flux is 0.87×10^{-6} cal per cm^2 . These values are explained mainly by the high thermal conductivity of the rocks of the shields. Measurements of the thermal field of the shields hold great promise for elucidating the normal geothermal gradient and the normal heat flux of the earth. — A. J. S.

- 186-418. Reitzel, John. Some heat-flow measurements in the North Atlantic: *Jour. Geophys. Research*, v. 66, no. 7, p. 2267-2268, 1961.

Four measurements of heat flow through the sea bottom were made during the passage of the R. V. Chain from Bermuda to Helsinki in July 1960; results are tabulated. Values for three stations where the bottom had little relief range from 1.20 to 1.54×10^{-6} cal per cm^2 sec, whereas the value at the fourth station, on the Mid-Atlantic Ridge, is $>6.2 \times 10^{-6}$ cal per cm^2 sec. The high heat flow here is comparable to that observed by Bullard, as reported by Hill (see Geophys. Abs. 182-524). A pipe dredge haul near the station brought up yellow mud with shards of fresh volcanic glass; evidently the excessive heat flow here is accompanied by volcanism of Pleistocene or Recent date. — D. B. V.

- 186-419. Bullard, E. C., and Day, A. The flow of heat through the floor of the Atlantic Ocean: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 282-292, 1961.

Fifteen heat flow measurements have been made in the Atlantic and one in the Mediterranean. Heat flow is 6.5μ cal per cm^2 sec in the central valley of the Mid-Atlantic Ridge; similarly high values have been found on the crest of the East Pacific Rise. The possibility that these values represent the rising limb of a convection current is discussed. The mean of the remaining 15 values and 5 from a previous investigation is $1.06 \pm 0.55\mu$ cal per cm^2 sec, close to the mean for the Pacific measurements excluding those on the East Pacific Rise.

The equipment has been modified to determine temperature gradients in the whole probe and in its lower half separately. The lower half gives a value 8.8 percent higher than that for the whole; the reason for this is not clear.

The thermal resistivity (R) of ocean sediments is found to be a linear function of the water content (w, in percent of wet weight). At the temperature of the ocean floor the relation is $R(\text{cm sec}^{\circ}\text{C}/\text{cal}) = (168 \pm 14) + (6.78 \pm 0.31)w$. — D. B. V.

- 186-420. Olivero, Sergio, and Penta, Francesco. Sulle misure di temperatura nel traforo del Monte Bianco [On temperature measurements in the Mont Blanc tunnel]: *Accad. Naz. Lincei Atti, Cl. Sci. Fis., Mat. e Nat. Rend.*, v. 26, no. 6, p. 731-737, 1959.

The program of investigations to be carried on during the tunneling through Mont Blanc will include measurement of temperatures for comparison with theoretical values of the geothermal gradient in mountainous relief. The chief difficulties of such an investigation are of two types: one involves the temporary effect of the installation of the instruments on the original thermal state of the rocks adjacent to the point of measurement, and the other, much more relevant, involves the permanent effect of the tunnel on the thermal regime

inside the mountain. These difficulties are discussed and illustrated by graphs of data obtained in other tunnels. — D. B. V.

- 186-421. Pokrovskiy, V. A. O termal'nykh vodakh Evropeyskoy chasti SSSR [Thermal waters of the European part of the U.S.S.R.]: Akad. Nauk SSSR Lab. Gidrogeol. Problem, Trudy 30, p. 99-103, 1960.

The geothermal regimen of the European part of the U. S. S. R. was studied on the basis of more than 4,500 thermograms and 700 individual measurements of temperature on more than 5,000 deep wells. On the basis of these data a geothermal regionalization was accomplished wherein three geothermal provinces are distinguished: areas of depressed temperature (below 20°C at 1,000 m depth), areas of medium temperature (20°C-30°C at 1,000 m depth), and areas of elevated temperature (greater than 30°C at 1,000 m depth). The province of depressed temperature includes the crystalline shields and areas of projections on the basement within the Russian platform. The medium temperature province comprises the rest of the Russian platform where the crystalline basement occurs under a cover of Paleozoic and Mesozoic sediments. The province of elevated temperature includes the Mesozoic downwarps and depressions with a folded metamorphic basement of Paleozoic deposits and thick covering formations in which argillaceous facies predominate. — J. W. C.

- 186-422. Titova, Ye. A. Termal'nyye usloviya Sochi-Matsestinskogo artzianskogo basseyna [Thermal conditions of the Sochi-Matsesta artesian basin]: Akad. Nauk SSSR Lab. Gidrogeol. Problem, Trudy 30, p. 110-119, 1960.

A study was made of the geothermal regimen in the Sochi-Matsesta artesian basin, which is located just northeast of the Black Sea between Sochi and Adler in Krasnodar Territory. The search for thermal waters for balneological purposes was a motivating factor in this investigation. Isothermal lines on the top of the Upper Cretaceous are plotted on a map; these show a pronounced high along the Mzymta River to the northeast of Adler. — J. W. C.

- 186-423. Lyubimova, Ye. A., Lyusova, L. N., Firsov, F. V., Starikova, G. N., and Shushpanov, A. P. Opredeleniye poverkhnostnogo teplovogo potoka v Staroy Matseste [Determination of surface heat flux at Staraya Matsesta]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1806-1811, 1960.

None of the large number of temperature measurements taken in deep boreholes of the U. S. S. R. can be used for determination of the surface heat flux because data on the thermal conductivities of the core samples taken from these boreholes are lacking. This paper reports on temperature measurements in 20 boreholes 400 to 2,600 m deep in the Caucasus, which remained idle for 8-10 months before the measurements were made. A resistance thermometer permitted an accuracy of 0.01°C. The instruments and equipment for the temperature measurements and for determination of the thermal constants are described. Data are given for a borehole at Staraya Matsesta (Caucasus); these values are identical with measurements made in 1955 and 1957. The heat flux is 0.82×10^{-6} cal per cm^2 per sec, which is low compared with the generally accepted mean value of 1.2×10^{-6} . The difference may be due to a cooling effect by the Black Sea, but more probably it arises because the horizontal component of the flux did not enter in the data. — A. J. S.

- 186-424. Dzhibuti, S. S. Nekotoryye dannyye po geotermii Zapadno-Turkenskogo artezianskogo basseyna [Some data on the geothermy of the west Turkmen artesian basin]: Akad. Nauk SSSR Lab. Gidrogeol. Problem, Trudy 30, p. 104-109, 1960.

A provisional attempt is made at synthesizing the available geothermal data for the west Turkmen artesian basin, which lies to the east of the south part of the Caspian Sea. A characteristic feature of the ground water regimen of this basin is its elevated temperature, which in natural springs ranges from 35°C to 68°C and in individual oil wells reaches 100°C. The geothermal gradient is listed in a table for 33 boreholes in the Cheleken area, 17 in the Nebit-Dag area, and one each for 7 other areas. On the basis of these measurements it is concluded that temperatures of 55°C-60°C are present regionally at depths of 1,000 m, 80°C-82°C at 2,000-3,000 m, and 100°C at 3,500-4,500 m. —J. W. C.

- 186-425. Cheremenskiy, G. A. Vliyaniye skladchatogo fundamenta na teplovoye sostoyaniye mezokaynozoyevskikh otlozheniy Zapadno-Sibirskoy nizmennosti [The effect of folded basement on the thermal state of Meso-Cenozoic sediments of the West Siberian Lowland: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 705-709, 1961.

The correlation between the thermal state of the crust and the tectonic, lithologic, hydrologic, and other factors of the West Siberian Lowland is discussed. From the geothermal profile along the Kuznetsovo-Slavgorod traverse it was found that the position of isothermal surfaces over the basement of the lowland depends basically on the ratio of the thermal conductivities of the basement rock to those of the covering sedimentary units. An increase of geothermal gradient in the peripheral parts of the West Siberian Lowland and in regions of uplift of the basement is due largely to the thermal anisotropy of the Meso-Cenozoic rocks. —A. J. S.

- 186-426. Cheremenskiy, G. A. O vremeni vosstanovleniya termicheskogo rezhima, narushennogo bureniyem skvazhiny [On the stabilization time of the thermal regimen disturbed by drilling of a borehole]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1801-1805, 1960.

The time required for a drill hole to reestablish its thermal equilibrium after drilling was investigated. Temperature measurements were made at a depth of 1,400 m in a borehole in the Kolpashevo region of the West Siberian Lowland. Readings at 0.5, 20, and 50 days after drilling gave $t=13.5^{\circ}\text{C}$, 42°C , and 46°C , respectively. The hydrologic temperature for the stratum at a depth of 1,400 m is 64°C . A comparison is made with the cooling rate of a borehole drilled in permafrost in Alaska. (See also Geophys. Abs. 184-418.)—A. J. S.

- 186-427. Uyeda, Seiya, and Horai, Ki-iti. Studies of the thermal state of the earth. The sixth paper: Terrestrial heat flow at Innai oilfield, Akita Prefecture and at three localities in Kanto District, Japan: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 3, p. 421-436, 1960.

Terrestrial heat flow has been determined at four places in Honshu, Japan, in deep wells penetrating water-saturated sediments. The values obtained are as follows (in 10^{-6} cal per cm^2 per sec): 1.49 at Innai oilfield in Akita Prefecture; 0.74 at Tokyo University; and 0.76 at Kashima and 0.91 at Katsuta, both in Ibaraki Prefecture.

The data so far obtained suggest that in eastern Japan heat flow is less on the Pacific coast side than inland and on the Japan Sea side. Repeated measurements at Kashima and Katsuta showed that temperatures measured immediately after drilling were reliable only near the bottom of the hole. — D. B. V.

- 186-428. Horai, Ki-iti. Studies of the thermal state of the earth. The third paper: Terrestrial heat flow at Hitachi, Ibaraki Prefecture, Japan: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 4, p. 571-592, 1959.

Geothermal gradients, measured at 68 places in drifts in the Hitachi copper mine, were found to range from $0.94 \times 10^{-2} \text{ } ^\circ\text{C}$ per m in the northern part of the mine to $1.21 \times 10^{-2} \text{ } ^\circ\text{C}$ per m in the southern part. The apparent thermal conductivities of 36 rock specimens from various parts of the mine were measured by the divided-bar method and found to be $6.73\text{--}7.08 \times 10^{-3}$ cal per cm sec $^\circ\text{C}$ and $6.50\text{--}7.43 \times 10^{-3}$ cal per cm sec $^\circ\text{C}$ in the two parts of the mine, respectively. From these values the terrestrial heat flow was computed to be $0.63\text{--}0.67 \times 10^{-6}$ cal per cm^2sec for the northern part and $0.78\text{--}0.90 \times 10^{-6}$ cal per cm^2sec for the southern part. These values are slightly smaller than those already known in Japan; whether this is a local anomaly or is due to some large-scale phenomenon, such as convection in the mantle, is not clear at present. — D. B. V.

INTERNAL CONSTITUTION OF THE EARTH

- 186-429. Wegmann, E. Wege in die Tiefen [Paths to the depths (with English summary p. 701)]: Geol. Rundschau, v. 50, p. 84-93, 1960.

All interpretations of the nature of the earth's deep crust are based on principles and concepts used for the exposed parts of the crust. The deep crust probably consists of different kinds of materials whose modes of behavior overlap from our present perspective, leading to the great diversity of concepts concerning its nature. — D. B. V.

- 186-430. Howell, B[enjamin] F., Jr., and Woodtli, R. A. Factors influencing thickness of the earth's crust: Jour. Geophys. Research, v. 66, no. 8, p. 2601-2605, 1961.

If the M-discontinuity is due primarily to a phase change, its depth should vary with surface temperature. It is calculated that 12.5° change in surface temperature would be required to cause a 1-km change in depth of the M-discontinuity. Present methods at best are barely adequate for measuring crustal thickness to this accuracy; therefore, the effect of temperature on crustal thickness, if it exists, might readily have been overlooked in crustal-thickness studies.

To test this hypothesis, 21 measurements of continental crustal thickness were selected from the literature and tested for a correlation of thickness with surface temperature; the results showed no evidence of any dependence of crustal thickness on temperature. A correlation of crustal thickness with surface elevation, based on the isostatic concept, is too low (correlation coefficient 18.5 percent) to be significant. A third correlation not based on any theory explaining crustal thickness was also made, in which crustal thickness was plotted against distance from the nearest edge of the continental shelf; for a linear plot the coefficient of correlation was 23.5 percent and for a semi-logarithmic plot 43.8 percent. The poorness of all three correlations shows that no one of these factors alone is responsible for crustal thickness. One

other conclusion drawn from this study is that accurate determinations of crustal thickness are needed, preferably point-by-point determinations rather than single figures for whole profiles. — D. B. V.

- 186-431. Steinhart, J. S., and Meyer, R. P. (with contributions by Woollard, G. P., Bonini, W. E., and Smith, T. J.). Explosion studies of continental structure: Carnegie Inst. Washington Pub. 622, 409 p., 1961.

Crustal studies from observations of seismic waves generated by explosions are reported for five areas in North America selected for their gravity anomalies and tectonic associations: Mexico—high plateau with large negative Bouguer gravity anomaly; Arkansas—slightly positive craton with positive Bouguer anomalies; Wisconsin—shield area with both positive and negative Bouguer anomalies; eastern Montana—margin of a mountain system with large negative Bouguer anomalies; and the Rocky Mountains of western Montana. The past history of explosion studies; the theoretical background; the methods of data reduction, model selection, and statistical analyses; and instrumentation and field problems are discussed in five chapters. Data from each area are treated in separate chapters, and results are illustrated in tables and cross sections. A final chapter summarizes seismic evidence concerning continental crustal structure and includes a table with data for Europe, central Asia, southern Africa, Australia-New Zealand, South America, Iceland, and North America.

General conclusions are as follows: (1) The near surface velocity structure cannot be ignored without expecting errors in calculated values of crustal thickness. (2) The method of computation used in obtaining crustal thickness is important in minimizing the type of errors usually present. The crossover distance method is recommended for unreversed profiles. (3) A minimum estimate of statistical uncertainty may be obtained by straight-forward statistical techniques. (4) Difficulties in the use of absolute amplitude data because of variable response of the ground-geophone system may be eliminated by the use of amplitude ratios. (5) A velocity gradient is present near the surface of the earth due in part to pressure increase, which affects the shape of seismic traveltimes graphs. (6) A velocity increase within the crust is required by the data; it is not clear whether this increase is continuous or discontinuous. (7) Mean velocities in the crust (and presumably densities) vary from place to place. (8) No single variable can be used to predict crustal structure; the mean crustal velocity and the Bouguer anomalies together offer the most promise as a linear predictor, and there is some indication that geologically corrected isostatic anomalies can be used also. (9) Isostasy is realized, at least on a regional basis, but Pratt type compensation may be more important in some places than Airy type. This implies, and the results show, that high elevations do not always mean a thick crust and low elevations are not always associated with a thin crust. — V. S. N.

- Cameron, J. B. Earthquakes in the northern California coastal region (pt. 1). See Geophys. Abs. 186-135.

Milne, W. G., and White, W. R. H. A seismic survey in the vicinity of Vancouver Island, British Columbia. See Geophys. Abs. 186-587.

- 186-432. Gaskell, T[homas] F., Hill, M[aurice] N[eville], and Swallow, J. C. Seismic measurements made by H. M. S. Challenger in the Atlantic, Pacific, and Indian Oceans and in the Mediterranean Sea, 1950-53: Royal Soc. London Philos. Trans., ser. A, v. 251, no. 988, p. 28-83, 1958.

The seismic experiments made during the "Challenger" oceanographic cruises of 1950-52 (around-the-world) and 1953 (northeastern Atlantic Ocean) are described. Details of the methods used (refraction and some reflection) are given, and methods of analyzing the refracted wave arrivals observed in deep water experiments are discussed in full.

The results of structural interpretation of the measurements are discussed and presented in diagrams showing crustal sections in many parts of the North Atlantic, Pacific, and Indian Oceans. — D. B. V.

Hochstrasser, Urs, and Stoneley, Robert [S.]. The transmission of Rayleigh waves across an ocean floor with two surface layers, pt. 2: Numerical. See Geophys. Abs. 186-197.

Reich, H[ermann]. On the problem of the geologic interpretation of seismic discontinuities in the Alps. See Geophys. Abs. 186-588.

186-433. Shechkov, B. N. Stroyeniye zemnoy kory v Yevrazii po dispersii poverkhnostnykh voln [Structure of the crust in Eurasia according to dispersion of surface waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 694-699, 1961.

The average thickness of the crust in Eurasia is determined theoretically from the dispersion of Love and Rayleigh waves. The thicknesses of the granite and basalt layers are studied on a two-layer model, the lower layer being placed over an elastic half space. The theoretical values determined for Love and Rayleigh waves were found to agree. The results obtained were checked against the data of observations along the traverses Central Asia-Kurile Islands and European U. S. S. R. - East China Sea - Japan and found to compare favorably (see also Geophys. Abs. 166-90, 176-79). — A. J. S.

186-434. Val'dner, N. G., and Savarenskiy, Ye. F. Po povodu prirody volny Lg_1 iyeye rasprostraneniya v Severo-Vostochnoy Azii [In regard to the nature of the Lg_1 wave and its propagation in northeast Asia]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 3-24, 1961.

The recently discovered seismic waves Lg and Rg serve as a proof of continuity of the upper granitic layer in the crust in the area of propagation of these waves. The Lg_1 wave is interpreted as an overtone of the Love wave. — A. J. S.

Godin, Yu. N., Vol'vovskiy, B. S., and Vol'vovskiy, I. S. Seismic investigations of the earth's crust in the Bukhara area of the Uzbek SSR. See Geophys. Abs. 186-589.

Kosminskaya, I. P., and Krakshina, R. M. The transcritical reflections from the Mohorovičić discontinuity. See Geophys. Abs. 186-590.

186-435. Mikumo, Takeshi, and Otsuka, Michio. Seismic studies on the crustal structure in the Wakayama district [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 4, p. 199-209, 1960. Mikumo, Takeshi. Crustal structure in Wakayama district as deduced from local and near earthquake observations [English version]: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 39, 25 p., 1960.

From observation of the records of near and local earthquakes in the Wakayama district, Japan, the P- and S-wave velocities and thickness of the crustal layers in the area were determined.

For the sedimentary layer $V_p=4.3$ km/s, $V_s=2.4$ km/s, $h_1=4$ km; for the granitic layer $V_p=5.5$ km/s, $V_s=3.2$ km/s, $h_2=7$ km; for the basaltic layer $V_p=6.1$ km/s, $V_s=3.5$ km/s, $h_3=15$ km; and for the mantle surface $V_p=8.0$ km/s, $V_s=4.5$ km/s. The depth to the M-discontinuity is estimated to be about 26 km. The focuses of microearthquakes in the northern part of the district are distributed above the granitic layer. — V. S. N.

186-436. Mumme, I. A. Determination of the crustal thickness of the earth in the general region of Adelaide, South Australia: Royal Soc. South Australia Trans., v. 84, p. 61-62, 1961.

Crustal thickness in the region of Adelaide, Australia, has been determined from the average of many absolute gravity stations in the area to be 33 km. This figure is an average of the results obtained by six different methods of calculation—Andreyev's equation, Woollard's elevation, Woollard's gravity, Russian and Chinese gravity equation, Russian and Chinese elevation equation, and Heiskanen and Vening Meinesz' equation. — V. S. N.

186-437. Lazarev, G. Ye., and Ushakov, S. A. Zemnaya kora Antarktity [The earth's crust in Antarctica]: Priroda, no. 12, p. 17-22, 1960.

On the basis of Bouguer anomalies the earth's crust in eastern Antarctica is divided into three sectors: (1) the Davis Sea sector, which is a continental slope; (2) the 100 km offshore zone of the Davis Sea and the zone 50 km from Mirnyy to Pionerskaya, which form the continental shelf; and (3) the zone of the platform depressions and low plateau 950 km farther inland to Komsomol'skaya. The thickness of the crust in these zones is 32, 37, and 40 km, respectively. — A. J. S.

Kogan, S. D., Pasechnik, I. P., and Sultanov, D. D. Seismic observations in Antarctica. See Geophys. Abs. 186-153.

International Geophysical Year Bulletin No. 46. Arctic Basin seismic studies from IGY Drifting Station Alpha. See Geophys. Abs. 186-602.

186-438. Shutt, T. C. Primary magma: Univ. Sheffield Geol. Soc. Jour., v. 4, no. 2, p. 13-17, 1961.

It is suggested that there is one primary magma whose composition varies from basic to silicic according to the layer of the crust involved in the melting. Magmas are formed locally through heating by radioactivity or, preferably, through release of pressure (as in orogenic periods), and the rocks intruded from the magma reflect the environment of melting as opposed to any stage of differentiation or any degree of mixing. — V. S. N.

186-439. Kennedy, George C. Phase relations of some rocks and minerals at high temperatures and high pressures, in *Advances in Geophysics*, v. 7: New York and London, Academic Press, p. 303-322, 1961.

This is a longer version of the paper published in *Am. Geophys. Union Trans.*, v. 41, no. 2, p. 283-286, 1960 (see Geophys. Abs. 182-342). — V. S. N.

Jobert, Nelly. Approximate calculation of the period of the spheroidal oscillations of the earth. See Geophys. Abs. 186-187.

- 186-440. Gaskell, T[homas] F. The Mohole project, in Science Survey 1: New York, MacMillan Co., p. 279-289, 1960.

A popular account is given of the development of the idea to drill to the M-discontinuity, of the technical problems to be solved, and of the type of tools needed to accomplish the project. — V. S. N.

- 186-441. Wetherill, G[eorge] W. Steady-state calculations bearing on geological implications of a phase-transition Mohorovicic discontinuity: Jour. Geophys. Research, v. 66, no. 9, p. 2983-2993, 1961.

The steady-state approximation is used to calculate the temperature as a function of depth within the crust for different models, assuming that the lower boundary of the crust is a phase transition, and the depth of this transition is calculated for several typical transitions. Phase transitions that have been observed in the laboratory can be fitted with depths of the continental M-discontinuity, but it is difficult to obtain reasonable oceanic crustal thicknesses using the same phase transition. These calculations indicate that: (1) If the M-discontinuity results from a phase transition similar to albite+nepheline→jadeite, the continental crust should have had an average elevation of more than 4 km about 2,000 million years ago; (2) an increase by a factor of 1.25 in the continental heat flow can result in appreciable changes in elevation; (3) it is difficult to reconcile the absence of greater elevation and crustal thickening in the area of high heat flow in the southeastern Pacific Ocean with the phase-change hypothesis; and (4) the mechanism of mountain building discussed by Kennedy (see Geophys. Abs. 179-187) and by MacDonald and Ness (see Geophys. Abs. 182-358) can produce appreciable crustal elevations if the time is sufficiently long. — D. B. V.

- 186-442. Hoffman, John P., Berg, Joseph W., Jr., and Cook, Kenneth L. Discontinuities in the earth's upper mantle as indicated by reflected seismic energy: Seismol. Soc. America Bull., v. 51, no. 1, p. 17-27, 1961.

Thirty-three seismograms from 9 large quarry blasts (50,000-2,138,000 lb of explosives detonated at Promontory and Lakeside, Utah) obtained at 10 stations between 76 and 1,009 km from the blasts were analyzed for possible reflections from inhomogeneities in the earth's upper mantle. Arrivals having apparent velocities that could correspond to reflections from discontinuities at depths of about 190, 520, and 910 km in the mantle are reported. These depths were computed using average velocities based on velocity-depth curves given by Jeffreys and Gutenberg for the deeper portions of the upper mantle and assuming that linear ray paths pertained. More confidence is placed in the results that indicate a discontinuity at 190 km than in those indicating the discontinuities at 520 and 910 km. — D. B. V.

- 186-443. Lehmann, I[nge]. S and the structure of the upper mantle: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 124-138, 1961.

The European as well as the northeastern American observations of S at small epicentral distances indicate the presence of a low velocity layer. In Europe its upper boundary seems to be at a depth of about 140 km. Since late S phases are observed at epicentral distances down to about 10° there is likely to be an abrupt increase of velocity (as well as of velocity gradient) at the lower boundary of the layer at about 220 km depth. Late S phases beyond 20° can be accounted for if a further strong increase of velocity gradient at a greater depth is assumed. — Author's abstract

- 186-444. Rosenfeld, John L., and Chase, Armond B. Pressure and temperature of crystallization from elastic effects around solid inclusions in minerals: *Am. Jour. Sci.*, v. 259, no. 7, p. 519-541, 1961.

A new physical method for determination of the pressure-temperature conditions for crystallization of minerals deep within the earth is proposed. Earth processes commonly result in the transfer of a mineral grain from the pressure-temperature (P, T) condition of its origin to considerably different P-T conditions. If a mineral grain includes a grain of another mineral, transfer to new P-T conditions commonly will cause anisotropic elastic strain effects around the inclusion owing to different coefficients of thermal expansion and compressibility for the two minerals. To the extent that these elastic effects remain reversible over geologic time intervals, they represent stored information concerning the pressure and temperature of origin. The differential equation for the P-T curve representing absence of anisotropic stress around an inclusion of one isometric crystal (also a homogeneous fluid) inside of another isometric crystal is given. Experimental determination of two such P-T curves for a given host containing two different kinds of inclusions, known to be contemporaneous, would result in an intersection representing the pressure and temperature of origin. Suggested techniques for determination of P-T curves are discussed.

Natural examples of stress effects around inclusions in diamond and associated pyrope are consistent with extrapolations based on known values of α and β and inferred P-T conditions within the earth. Examination of these minerals, having a probably origin in the mantle but now included in the kimberlites, should allow determination of specific temperatures at specific pressures equivalent to depths within the mantle of the order of 100 miles or more. — V. S. N.

- 186-445. Egyed, L[ászló]. On the origin and constitution of the upper part of the earth's mantle: *Geol. Rundschau*, v. 50, p. 251-258, 1960.

Using the Dirac-Gilbert equation as a basis for the expansion theory (see *Geophys. Abs.* 182-59, -281), it is shown that the earth's mantle, except in the uppermost 200 km, must be similar in composition to a volatile-rich magma of intermediate composition. Density does not increase uniformly with depth; rather, it has a slight maximum between 50 and 100 km and a slight minimum below this. The low-velocity channel is due to changes in composition rather than to thermal effects. The hydrosphere and most of the atmosphere must have been formed at the same time as the crust, in the first stages of the earth's evolution. The evolution of the moon's surface closely parallels that of the earth's mantle. — D. B. V.

- 186-446. Magnitskiy, V. A. Obolochka i kora zemli [Mantle and crust of the earth]: *Sovetskaya Geologiya*, no. 5, p. 3-15, 1961.

On the basis of geophysical data and the composition of meteorites, the suggestion is made that the mantle was originally close to eclogite in composition. The existence now of two types of crust (continental and oceanic) gives a basis for supposing that they are due to different courses of development of material of the mantle. The difference between the continental and oceanic types of crust depends either on a heterogeneity of the original composition of the mantle or on a difference in heating rates in different parts of the mantle. Models of formation of a continental type crust from the mantle are given. — J. W. C.

- 186-447. Wada, Tatsuhiko. On the physical properties within the B-layer deduced from olivine-model and on the possibility of polymorphic transition from olivine to spinel at the 20° discontinuity: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 37, 18 p., 1960.

An equation of state of forsterite based upon an ionic model is deduced theoretically. Calculated variations of density and incompressibility with pressure agree with those of Bullen for the B-layer. The activation energy of forsterite, having Schottky defects, is evaluated at 3.29 eV (e =charge at definite point on crystal lattice, v =volume per ion-pair of Mg^{+2} and O^{-2}). The variation of activation energy with pressure is investigated, and it is shown that extrapolation from experimental values obtained within 10,000 bars is not reliable. Temperature distribution obtained within the B-layer is in accordance with Gutenberg's. Comparison of the lattice energies of olivine and spinel shows that the polymorphic transition from olivine to spinel is impossible although this problem is still open to question because even if the lattice energies of both phases is well evaluated the difference may not be reliable. — V. S. N.

- 186-448. Wada, Tatsuhiko. On origins of the region C and the core of the earth—Ionic-intermetallic-metallic transition hypothesis: Kyoto Univ. Disaster Prevention Research Inst. Bull. no. 38, 64 p., 1960.

A model of the interior of the earth based on modern solid-state physics is presented. The B region is considered to be mainly olivine with ionic bonding. The C region (olivine changing to periclase and coesite) is regarded as an area of transition from the ionic to the intermetallic state of MgO. The transition is due to pressure increase and is characterized by a gradual change in compressibility and density corresponding to a gradual increase of homopolar character in bonding in the originally ionic MgO crystals. The gradual increase in homopolar character results in a decrease in the energy gap of MgO and, consequently, in an increase of electrical conductivity in the C area that is compatible with geomagnetic data. The D region is composed completely of intermetallic MgO (mainly periclase with sphalerite structure) with covalent bonding, and the core is composed of metallic MgO (mainly periclase) with semimetallic bonding that becomes metallic in the liquid phase. This model with an intermetallic transitional layer makes the possibility of a metallic core more reasonable. — V. S. N.

- Rikitake, Tsuneji. The anomalous behavior of geomagnetic variations of short period in Japan and its relation to the subterranean structure. The 9th report. See Geophys. Abs. 186-488.

- 186-449. Ringwood, A. E. Silicon in the metal phase of enstatite chondrites and some geochemical implications: *Geochim. et Cosmochim. Acta*, v. 25, no. 1, p. 1-13, 1961.

Using X-ray and chemical methods, it has been established that 2-6 atomic percent of silicon occurs in solid solution in the metal phases of all of 8 enstatite chondrites that were examined. No silicon was found in the metal phase of ordinary chondrites. The significance of these data to the hypothesis that the earth's core contains silicon as a major component is discussed in some detail.

Study of the conditions accompanying segregation of the core, both in the earth and in a parent meteoritic body, lead to the conclusion that the core is probably not in chemical equilibrium with the surrounding mantle. One of the

principal effects of this disequilibrium is diffusion of silicon from the core into the adjacent mantle, resulting in reduction of oxidized iron and precipitation of metallic iron. This effect may be responsible for the anomalous seismic velocity gradients in the bottom 200 km of the mantle. Mechanically this region is unstable owing to the tendency of precipitated iron to collect and sink into the core.

Attainment of chemical equilibrium across the core-mantle boundary is accompanied by generation of electric currents. These may be relevant to the origin of the geomagnetic field and may also affect the electromagnetic coupling between core and mantle. — D. B. V.

- 186-450. Lucke, Otto. Über die Abweichungen der Gestalt des Erdkerns von der Kugelgestalt [On the departure of the shape of the earth's core from the spherical (with English summary)]: *Gerlands Beitr. Geophysik*, v. 70, no. 1, p. 1-10, 1961.

Knowledge of the pressure, density, and layering of the earth's interior is based mainly on the interpretation of seismic traveltimes with the assumption that velocity is a function of distance r from the center of the earth. Three maps are presented to prove this hypothesis, showing geoid undulations, geomagnetic non-dipole field anomalies (epoch 1945), and anomalies in the earth's core as revealed by PcP-, ScS-, PcS-, and ScP-wave traveltimes. A significant correlation exists between positive and negative areas in all three. The traveltimes of these waves represent the time it takes to traverse the distance from an earthquake focus to the reflection point T_1 plus the time from there to the station T_2 ; by constructing the surfaces $T_1+T_2=\text{const}$ for many earthquakes, information on the surface of the core can be obtained by ascertaining the reflection points as a function of the coordinates of the surface of the core corresponding to a given traveltime. — D. B. V.

- 186-451. Ledersteger, K[arl]. Die Abplattungsfunktion einparametrischer sphäroidischer Gleichgewichtsfiguren [The flattening function of one-parameter spheroidal equilibrium figures (with English summary)]: *Geofisica Pura e Appl.*, v. 46, p. 1-10, 1960.

As the density law of spheroidal equilibrium figures has been shown to be strictly unambiguous (see *Geophys. Abs.* 184-336, -337), it is possible to obtain from a given equilibrium figure an infinite series of new equilibrium figures of steadily decreasing size and mass by the method of "leaf-stripping." In this way any inner equipotential surface can be revealed and its flattening can be calculated, entirely independently of Clairaut's equation. This method can also be used for equilibrium figures with more than one parameter and discontinuous density distribution. For Wiechert's earth model it yields values of 3,864.75 km for the depth to the core and 17.84 km for the density discontinuity at the core boundary. — D. B. V.

- Verhoogen, John. Heat balance of the earth's core. See *Geophys. Abs.* 186-414.

Knopoff, Leon, and Gilbert, Freeman. Diffraction of elastic waves by the core of the earth. See *Geophys. Abs.* 186-241.

ISOSTASY

- 186-452. Lyustikh, E. [Ye.] N. Isostasy and isostatic hypotheses: Washington, D. C., American Geophysical Union, 119 p., 1960.

This is an English translation of the paper previously published in Akad. Nauk SSSR Geofiz. Inst. Trudy, no. 38(165), p. 1-90, 1957 (see Geophys. Abs. 170-214). — J. W. C.

ISOTOPE GEOLOGY

186-453. Mayne, K. I. Stable isotope geochemistry and mass spectrometric analysis, in Methods in geochemistry; New York and London, Interscience Publishers Inc., p. 148-201, 1960.

The principles of some of those processes that can lead to isotopic fractionation are described briefly, and the way in which these effects can be observed and interpreted in nature is outlined. The discussion has been limited arbitrarily to stable isotope studies. The following are discussed: physical-chemical isotope fractionations in nature including exchange equilibrium fractionation, that due to differences in vapor pressure, and organic fractionation; radioactivity and the resulting variations in isotope abundances including geochronology and the Rb, K, U, and Pb dating methods, common lead, and induced nuclear effects; mass spectrometric principles and practice including first- and higher-order focusing, fringing field effects, two-stage instruments, ion-beam detectors, ion sources and sample handling, precision isotope difference measurements, and measurement of small samples. Emphasis is placed on principles and methods rather than on experimental results and particular instruments. A list of 71 references is included. — V. S. N.

186-454. Webster, R. K. Mass spectrometric isotope dilution analysis, in Methods in geochemistry; New York and London, Interscience Publishers Inc., p. 202-246, 1960.

In the method of stable isotope dilution the quantity of an element is estimated from the change produced in its isotopic composition by the addition of a known quantity of a stable isotopic tracer of that element. The use of electromagnetic separators has permitted a rapid expansion of the method, and this type of analysis may be applied now to at least four-fifths of the elements. The following aspects are discussed: production of tracers; the method; chemical treatment of samples; summary of errors; and applications including elemental abundance determination, geological age determination, and investigation of the decay of long-lived radioactive nuclides. The main application of this method is in the field of age determination for measurement of uranium, thorium, rubidium, and potassium ages. A list of 167 references is included. — V. S. N.

Levskiy, L. K. Inert gases in two iron meteorites. See Geophys. Abs. 186-64.

186-455. Nakai, Nobuyuki. Carbon isotope fractionation of natural gas in Japan: Nagoya Univ. Jour. Earth Sci., v. 8, no. 2, p. 174-180, 1960.

Carbon isotope ratios, C^{13}/C^{12} , of methane and carbon dioxide, and dissolved carbonate and organic material in connate waters from natural gas fields in Japan have been determined. Methane is enriched in C^{12} , whereas carbon dioxide and carbonate are enriched in C^{13} as compared to source organic material. In the process of natural gas production and methane accumulation, the methane is enriched in C^{12} approximately 7 percent relative to the coexisting carbon dioxide and carbonate. — Author's abstract

- 186-456. Craig, Harmon. Standard for reporting concentrations of deuterium and oxygen-18 in natural waters: *Science*, v. 133, no. 3467, p. 1833-1834, 1961.

A "standard mean ocean water" (SMOW), based on the set of ocean water samples used by Epstein and Mayeda to obtain a reference standard for O^{18} data (see *Geophys. Abs.* 158-185) but defined relative to the National Bureau of Standards isotopic reference water sample, is proposed for reporting both D and O^{18} variations in natural waters relative to the same water.

The total variations in meteoric waters are about 360 per mil for D and about 48 per mil for O^{18} , relative to SMOW. This variation in D content corresponds to a variation of about 6 ppm in density, whereas the O^{18} variation corresponds to about 11 ppm in density. — D. B. V.

- 186-457. Bainbridge, A. E., Sandoval, Paula, and Suess, H[ans] E. Natural tritium measurements by ethane counting: *Science*, v. 134, no. 3478, p. 552-553, 1961.

A method is described for the synthesis of ethane from hydrogen that is at present used for the counting of low-level tritium activity at the La Jolla tritium laboratory. The reaction procedure is simple and involves the mixing of the hydrogen with acetylene over a colloidal palladium catalyst. Counting characteristics of ethane are found to be ideal. With a 1-liter counter filled to three atmospheres of ethane, only a tenfold tritium enrichment is necessary in order to obtain a sensitivity of 0.32 counts per minute per tritium unit. — Authors' abstract

- 186-458. Rama; Koide, M.; and Goldberg, E. D. Lead-210 in natural waters: *Science*, v. 134, no. 3472, p. 98-99, 1961.

The distribution of Pb^{210} , which enters the ocean subsequent to its production in the atmosphere by Rn^{222} decay, shows an increase with depth of sea water. By use of a simplified two-layer model of the ocean, a residence time of lead in the upper mixed layer of less than 2 years is derived. It is suggested that the marine biosphere is responsible for the conveyance of lead from surface to deeper waters. The distribution of Pb^{210} in the Colorado River indicated a rapid removal along the path from its origin in the feed waters to the reservoir at Lake Mead. — Authors' abstract

- 186-459. Chow, Tsaihua J. Lead isotopes in sea water and marine sediments: *Jour. Marine Research*, v. 17, p. 120-127, 1958; reprinted in *Calif. Inst. Technology Div. Geol. Sci. Contr.*, no. 905, [no date].

The lead concentration obtained from sea water samples of San Juan Channel, Wash., was 0.2μ g per l or less. Leads isolated from Pacific and Atlantic pelagic clay sediments show an isotopic composition similar to that of manganese nodules from the respective oceans. The Pb^{206} content in the Atlantic lead was more abundant than in the Pacific lead. This finding agrees with the postulate that the Atlantic lead was derived from rocks which contained high proportions of old granites and that the Pacific lead was from rocks containing high proportions of relatively young basalts. — Author's abstract

- 186-460. Tugarinov, A. I., Shcherbakova, R. N., and Bedrinov, V. P. Izo-topnyy sostav svintsa svintsovykh rudoproyavleniy Pridnestrov'ya [Isotopic composition of lead of the lead manifestations of the

Dniester foreland area (with English abstract]): *Geokhimiya*, no. 4, p. 298-304, 1960.

The lead isotope ratios in galena impregnations and veinlets in sandstones in the Dniester foreland area of the Ukrainian S. S. R. change noticeably with depth from Pb^{206}/Pb^{204} ; Pb^{207}/Pb^{204} ; $Pb^{208}/Pb^{204}=18.25 : 15.12 : 36.8$ to $24.25 : 17.39 : 44.05$, respectively. This is attributed to metamorphic phenomena consisting of partial solution of feldspar grains in the sandstones with selective leaching of anomalous leads present in the feldspars. — D. B. V.

186-461. Vinogradov, A. P., Tarasov, L. S., and Zykov, S. I. *Izotopnyy sostav svintsov kolchedannykh mestorozhdeniy Urala* [The isotopic composition of leads from pyrite deposits of the Urals (with English abstract)]: *Geokhimiya*, no. 6, p. 475-489, 1960.

The isotopic composition of lead impurities in the pyrite-chalcopyrite ores of the Urals was investigated in order to determine the age relations of the deposits. Results are tabulated. There are three age groups. Most of the ores are post-Lower Carboniferous; older deposits, probably Caledonian, are found on the west flank of the southern Urals; and there are some younger leads with anomalous isotopic composition.

Similarity of isotopic composition suggests that the main Ural deposits were formed in the same manner as the post-Lower Carboniferous ores of the Irtysh zone of the Altay. — D. B. V.

186-462. Vinogradov, A. P., Zykov, S. I., and Tarasov, L. S. *Izotopnyy sostav svintsa-primesi v rudakh i mineralakh kak pokazatel' ikh genezisa i vremeni obrazovaniy* [Isotopic composition of admixtures of lead in ores and minerals as an indication of their origin and of time of formation]: *Geokhimiya*, no. 6, p. 515-523, 1958.

It is shown that the isotopic composition of lead impurities in various non-lead ores can be used as a criterion for their mode of genesis and age. The method is applied to sulfide ores from the Rudnyy Altay; quartz, scheelite, wolframite, and cassiterite from the Kalba-Narym district; quartz and wolframite from the Gornyy Altay; sulfides and platinum from northern Siberia; and sulfides from the Kola Peninsula.

The isotopic composition of lead in cassiterites is anomalous, showing that minerals in which accessory radioactive minerals may be expected are not suitable for this type of genetic and age analysis. The fact, however, that relatively higher temperature cassiterites are richer in impurities, and therefore more anomalous, provides an additional criterion for distinguishing pegmatitic, pneumatolytic-hydrothermal, and hydrothermal types of cassiterite. — D. B. V.

186-463. Benson, Bruce [B.], and Parker, Peter D. M. Nitrogen/argon and nitrogen isotope ratios in aerobic sea water: *Deep-Sea Research*, v. 7, no. 4, p. 237-253, 1961.

Nitrogen gas concentration in sea water has been assumed to be conservative, that is unaltered by biological and chemical activity. If this is true, one or more physical effects must be responsible for the observed variations in the percentage saturation of nitrogen. The possible physical factors are listed. A surface equilibrium model is proposed, and results are presented to test the model and to ascertain whether or not nitrogen dissolved in sea water is biologically and chemically inert. Argon is used as a reference gas, and the analysis is carried out with a mass spectrometer. It is concluded that

nitrogen is "conservative." There is some evidence that the nitrogen 29/28 relative abundance in the dissolved gas may be greater than that in the atmosphere by approximately one part in 10,000. — V. S. N.

- 186-464. Richards, Francis A., and Benson, Bruce B. Nitrogen/argon and nitrogen isotope ratios in two anaerobic environments, the Cariaco Trench in the Caribbean Sea and Drømsfjord, Norway: Deep-Sea Research, v. 7, no. 4, p. 254-264, 1961.

Mass spectrometric measurements of nitrogen/argon and nitrogen isotope ratios are used to study the nitrogen arising from decomposition of organic matter in the anaerobic marine environments of the Cariaco Trench in the Caribbean Sea and the Drømsfjord in Norway. Values of N_2/Ar are larger than would be expected from dissolved atmospheric gases. Assuming that the argon concentration is biologically unaffected, the excess quantities of N_2 can be calculated. Results are in good agreement with amounts of nitrogen expected to arise from decomposition of organic matter. It is shown that nitrogen isotope ratios are markedly different in the nitrogen of biogenic origin from those in nitrogen dissolved from the atmosphere; and that free nitrogen can be formed from organic matter only through denitrification of nitrate formed as an intermediate step. — V. S. N.

Eberhardt, P[eter], and Eberhardt, A. Ne in some stone meteorites. See Geophys. Abs. 186-62.

- 186-465. Lowenstam, Heinz A. Mineralogy, O^{18}/O^{16} ratios, and strontium and magnesium contents of recent and fossil brachiopods and their bearing on the history of the oceans: Jour. Geology, v. 69, no. 3, p. 241-260, 1961.

The calcareous shells of recent articulate brachiopods and fossils of the same class dating back to the Mississippian are investigated for their crystal form, O^{18}/O^{16} ratios, and $SrCO_3$ and $MgCO_3$ contents. Samples as old as Early Permian were found in which the relation of O^{18}/O^{16} ratios and the $SrCO_3$ and $MgCO_3$ contents are similar to recent species. The relation of the O^{18}/O^{16} to the $SrCO_3$ contents in a Late Mississippian sample is also similar to that in recent species. These findings make it probable that the O^{18}/O^{16} ratios and $SrCO_3$ and $MgCO_3$ contents in these fossils are the original ones. The significance of the chemical similarity of the fossil samples to recent shells is discussed. It is concluded that the results are best explained if it is assumed that the O^{18} , Sr and Mg contents, and the Sr/Ca and Mg/Ca ratios in the oceans have remained essentially constant during the last $2.0-2.5 \times 10^8$ yr. — V. S. N.

- 186-466. Clayton, Robert N., and Epstein, Samuel. The use of oxygen isotopes in high-temperature geological thermometry: Jour. Geology, v. 69, no. 4, p. 447-452, 1961.

Recent measurements on the oxygen isotopic fractionation between calcite and water and the oxygen isotope measurements on coexisting minerals permit the estimation of the isotopic fractionation factor as a function of temperature for systems involving any pair of the phases: quartz, calcite, hematite, and water. The use of these calibration curves for geological thermometry is illustrated for several natural samples. The isotopic composition of oxygen in hydrothermal fluids is also estimated from the measured O^{18}/O^{16} ratios in hydrothermal minerals. The mean value thus estimated is 6 percent greater than the oxygen of mean ocean water. — Authors' abstract

- 186-467. Khitrov, L. M., and Zadorozhnyy, V. I. Fractionation of isotope oxygen in the soil [English translation]; *Pochvovedeniye*, no. 1, p. 5-14, 1960; translation p. 3-10, 1961.

The results are reported from an investigation of the isotopic composition of oxygen in the air of four groups of soils taken from various depths at different times in order to determine the possibility of fractionation. Isotopic fractionation of the oxygen tends toward enrichment with O^{18} in some places; the enrichment is comparatively slight with the fractionation coefficient varying from 1.0004 to 1.0013. In view of this insignificant fractionation it is believed that the soil exerts little influence on the general enrichment of atmospheric oxygen during gas exchange between the atmosphere and the soil. — V. S. N.

- 186-468. Tilles, David. Natural variations in isotopic abundances of silicon: *Jour. Geophys. Research*, v. 66, no. 9, p. 3003-3013, 1961.

Measurements of natural variations in isotopic abundance ratios of silicon are reported. A maximum natural range of 5.3 per mil in Si^{30} has been observed to date. Coexisting biotite, quartz, and feldspars from some specimens of igneous rock from the Yosemite region differ by as much as 3 per mil; in other grossly similar igneous rocks from the same region the same minerals differ by less than 0.3 per mil. In those rocks with large differences between the minerals, the ratio of $[Si^{30}]/[Si^{28}+Si^{29}]$ increases in the order biotite, quartz, feldspar. All granitic rocks studied are enriched in Si^{30} with respect to meteorites and basic rocks. Measurements on some sediments and biologic samples covered a range of approximately 4 per mil. A group of tektites covered a range of less than 0.7 per mil, with isotopic abundances centrally distributed within the observed normal terrestrial range. The results are interpreted, and applications of such studies to problems of geothermometry and formation of igneous rocks are discussed. — Author's abstract

- 186-469. Tilles, David. Variations of silicon isotope ratios in a zoned pegmatite: *Jour. Geophys. Research*, v. 66, no. 9, p. 3015-3020, 1961.

Isotopic abundance variations of silicon in quartz and feldspar from the Rose Quartz pegmatite of the Pala district in southern California are reported. All feldspar samples are enriched in Si^{30} with respect to adjacent quartz samples, and the magnitude of enrichment varies from 0.6 to 2.7 per mil in Si^{30} . Feldspar-quartz differences were found to increase from outer zones towards the inner quartz core. All measurements on quartz samples were within a total range of about 0.6 per mil. The feldspar most heavily enriched in Si^{30} are believed to result from Rayleigh fractionation during crystallization from a vapor phase. — Author's abstract

- 186-470. Nakai, Nobuyuki, and Jensen, Mead LeRoy. Biogeochemistry of sulfur isotopes: *Nagoya Univ. Jour. Earth Sci.*, v. 8, no. 2, p. 181-196, 1960.

The fractionation of the sulfur isotopes S^{32} and S^{34} in the reduction of sulfate to sulfide in laboratory experiments and in nature has been studied. The factors of anaerobic viability, production rates of H_2S , and the extent of isotopic fractionation of sulfur reduced from SO_4^{-2} to H_2S have been determined with raw culture cells containing Long Island Sound mud and sea water that approximate natural conditions. Results indicate that there is a greater isotopic fractionation of sulfur by anaerobes in natural samples than in similar

natural samples to which additional nutrient was added. The fractionation of sulfur isotopes between SO_4^{-2} and S^{-1} of sea water and bottom mud is 1.021-1.031, and it is larger than that (1.005-1.007) of lake water and bottom mud. — V. S. N.

- 186-471. Cherdyntsev, V. V., Isabayev, Ye. A., Surkov, Yu. A., Orlov, D. P., and Usatov, E. P. Izbytok U^{235} v magnetite s povyshennym soderzhaniyem aktiniya [Excess U^{235} in magnetite with high actinium content (with English abstract)]: *Geokhimiya*, no. 4, p. 373-374, 1960.

An excess of U^{235} has been detected in magnetites that also contain excess actinium. Both effects can be attributed to the complicated spontaneous decay of some transuranium isotope, small amounts of which still exist in nature. — D. B. V.

MAGNETIC FIELD OF THE EARTH

- 186-472. Roberts, P. H. Propagation of induced fields through the core [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 93-104, 1959.

A study is made of the hydromagnetic propagation of small magnetic disturbances from a source within a finitely conducting fluid to its boundary. The results are applied to the problem of the rate of growth of the magnetic field due to the centers of secular change. Several examples are given to illustrate that in a conducting fluid the diffusion of electromagnetic energy is generally much less rapid than its transmission by Alfvén waves; consequently, the conclusion by several authors, on the assumption that the core is a rigid conductor, that the disturbances responsible for the secular variation arise in a thin layer at the core boundary is incorrect. — V. S. N.

- 186-473. Bullard, E. C. Proiskhozdeniye magnitnogo polya Zemli [Origin of the magnetic field of the earth]: *Priroda*, no. 12, p. 80-85, 1960.

Theories of origin of the magnetic field of the earth are discussed with an emphasis on the dynamo theory presented in previous papers (see *Geophys. Abs.* 151-14015 and 160-28). — A. J. S.

- 186-474. Herzenberg, A. Geomagnetic dynamos [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 85-89, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 522-525, 1958 (see *Geophys. Abs.* 176-245). — V. S. N.

- 186-475. Runcorn, S. K. On the theory of the geomagnetic secular variation [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 105-109, 1959.

A basic assumption made in the interpretation of the directions of magnetization of rocks is that the mean direction of the field is that of a geocentric dipole oriented along the axis of the earth's rotation. The relative rotation of the core and mantle, inferred from the westward drift of the geomagnetic field and the irregular fluctuations of the length of the day, is shown to imply that even if a permanent non-dipole field could be generated in the core, the nonaxial parts would be averaged out by observations over a long time at the

earth's surface. The relative rotation also explains the clockwise rotation of the geomagnetic field vector observed at points on the earth's surface from observatory records covering a long period of time. — V. S. N.

- 186-476. McIntosh, D. H. On the annual variation of magnetic disturbance: Royal Soc. London Philos. Trans., v. 251, no. 1001, p. 525-552, 1959.

Statistical features of the annual incidence of magnetic disturbance over a wide range of intensity and latitude are exhaustively investigated by means of the K-index and related "planetary indices." Two distinct and physically significant components are identified, the annual component with summer maximum and winter minimum, and a semiannual component with equinoctial maximums. Both are found all over the world. The amplitude of the annual component increases markedly with latitude, whereas that of the semiannual component changes little with latitude.

The physical causes of the two types of variations are considered. It is concluded that the annual component is probably caused by an atmospheric dynamo effect and that the semiannual component is due to a systematic annual variation of the angle between the earth's magnetic axis and the sun-earth line, along which solar particles travel. — D. B. V.

- 186-477. Jardetsky, W. S. Polar wandering, shifting of the earth's axis and dipole variations [with French abstract]: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 63-66, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 502-505, 1958 (see *Geophys. Abs.* 176-247). — V. S. N.

- 186-478. Herzenberg, A., and Lowes, F. J. The "Eddy Model" of the non-dipole field and the secular variation [with French abstract]: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 89-92, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 526-534, 1958 (see *Geophys. Abs.* 176-246). — V. S. N.

- 186-479. Hutchinson, R., and Shuman, B. Rocket measurements of the magnetic field above New Mexico: *Jour. Geophys. Research*, v. 66, no. 9, p. 2687-2693, 1961.

Absolute value, total intensity measurements of the magnetic field above Holloman Missile Development Center, New Mexico, were obtained to an altitude of 236 km with a proton precession magnetometer aboard an Aerobee-Hi rocket. The flight took place on a magnetically quiet day during the normal midmorning variation. Comparison of the observed values with those predicted by spherical harmonic coefficients yields an anomaly of the order of 80 γ during ascent between the altitudes of 85 and 165 km, whereas no comparable effect was found for the descent portion of the flight down to 146 km. — Authors' abstract

- 186-480. Sonett, C. P., Judge, D. L., Sims, A. R., and Kelso, J. M. A radial rocket survey of the distant geomagnetic field: *Jour. Geophys. Research*, v. 65, no. 1, p. 55-68, 1960.

Data obtained by a magnetometer carried aboard the Pioneer I space probe over the intervals 3.7-7 and 12.3-14.8 geocentric radii indicate an inverse-

cube-field decrease in the region 3.7-13.6 radii, where termination takes place, with a subsequent decrease to 5×10^{-5} gauss. The surprisingly distant geomagnetic cutoff suggests a very low gas pressure on the day of the flight. Increasingly large (fractionally) fluctuations were observed with increasing radii. A gross variability in the vestigial field would suggest hydromagnetic activity of a complex gas cloud structure. — D. B. V.

186-481. Zmuda, Alfred J. Some characteristics of the upper-air magnetic field and ionospheric currents: *Jour. Geophys. Research*, v. 65, no. 1, p. 69-84, 1960.

Characteristics of the upper-air magnetic field and ionosphere currents are determined through an analysis of published rocket data on the magnetic scalar intensity. For the region between the earth's surface and the E layer of the ionosphere the observed values are compared with values obtained by extrapolating the surface vector field. Agreement is good for equatorial flights but only fair for a flight at White Sands, N. Mex. In the area above White Sands (geomagnetic lat 41° N.) a large negative anomaly exists, which may contribute to the formation of the region of low radiation intensity that lies between the two Van Allen radiation belts. — D. B. V.

Shaub, Yu. B. Interpretation of results of measurements of the angle of inclination of the polarization plane of a natural alternating magnetic field. See *Geophys. Abs.* 186-118.

Lipskaya, N. V., Deniskin, N. A., and Yegorov, Yu. M. The results of electromagnetic sounding in the central region of the Dnieper-Donets depression. See *Geophys. Abs.* 186-120.

186-482. Nicholson, Seth B., and Wulf, Oliver R[eynolds]. The diurnal variation of K indices of geomagnetic activity on disturbed days in 1940-1948: *Jour. Geophys. Research*, v. 66, no. 8, p. 2399-2404, 1961.

Local- and universal-time components of the diurnal variation of the K indexes have been computed from the 8 daily K numbers for the 5 disturbed days of each month in the 9 years 1940-48 from 6 observatories in moderately low latitudes. The local-time component shows no pronounced seasonal change. It has a maximum near 21 hr. The averages for each of the 9 years show a fairly regular change in amplitude over these years, particularly marked from 1943-47, that could be occasioned by an increase during this interval in a separate local-time component having a daytime maximum; its occurrence during these years suggests that it may be related to the solar cycle. The universal-time component shows a pronounced seasonal change. Although large differences from year to year are found, apparently at random in considerable measure, examination of the separate yearly averages shows a persistent tendency for disturbance to be somewhat less at certain universal-time hours than at others. — D. B. V.

186-483. Jacobs, J. A., and Sinno, K. Occurrence frequency of geomagnetic pulsations Pc: *Jour. Geophys. Research*, v. 65, no. 1, p. 107-113, 1960.

Analysis of the occurrence frequency of geomagnetic micropulsations Pc, using data obtained during the International Geophysical Year from a worldwide network of stations, shows that the occurrence frequency of Pc's increases as the auroral zones are approached, and depends not only on local

time but in part on universal time. The universal-time factor affects the modulation of the diurnal occurrence by about 50 percent. The time of maximum occurrence of Pc's is about 21^h G. m. t. in the northern hemisphere and opposite this in phase in the southern hemisphere. When the universal-time factor is maximum in the northern (or southern) hemisphere the north (or south) geomagnetic pole is about 16^h or 17^h L. m. t. The G. m. t. dependence derived in this investigation shows 7 hr difference compared with Troitakaya's conclusion based on data from U. S. S. R. stations (see Geophys. Abs. 154-14643, 159-31). — D. B. V.

186-484. Rao, K. S. Raja. Lunar daily variation of geomagnetic horizontal intensity at Alibag: *Jour. Geophys. Research*, v. 65, no. 1, p. 119-121, 1960.

Applying the Chapman-Miller method as described by Tschu, the lunar semi-diurnal variation of geomagnetic horizontal intensity (H) at Alibag, India, is worked out for the equinoctial season, using hourly values of H for the period 1940-44. The expression $L(H) = 1.2 \sin(2\tau + 62^\circ) \pm 0.3$ is obtained, where $L(H)$ is amplitude of lunar variation in H, and τ is lunar time reckoned from lower transit of mean moon at Alibag. $L(H)$ is maximum when the lunar time is 2 lunar hours past midnight or noon. The solar diurnal variation is also obtained up to 4 harmonics. Comparison with similar results for Kodaikanal, India, suggests that lunar and solar diurnal variations are independent of each other. — D. B. V.

186-485. Kakioka Magnetic Observatory. Geomagnetic observations made at Kakioka, Japan in 1958: [Japan] Kakioka Magnetic Observatory Rept., no. 29, 120 p., 1960.

The results of magnetic observations made at the observatory at Kakioka, Japan, during 1958 are reported in tables. The tables include hourly values of magnetic declination, magnetic horizontal intensity, and magnetic vertical intensity; mean hourly values of magnetic elements on all days, on calm days, and on disturbed days; mean hourly values of north and west components; three-hour range indices K and character figures C; and the general characteristics of principal magnetic disturbances. Magnetograms for 1958 are reproduced. — V. S. N.

186-486. Duncan, R. A. Some studies of geomagnetic micropulsations: *Jour. Geophys. Research*, v. 66, no. 7, p. 2087-2094, 1961.

Geomagnetic field oscillations with periods between 1 sec and a few minutes have been studied by means of large ground loops at Hobart, Adelaide, Camden, and Townsville, Australia. The period of the Pc's shows a diurnal variation and a marked dependence on latitude, shorter periods occurring at lower latitudes. Pt's are followed by magnetic bays with an average delay of about 15 min. "Sweepers," or oscillations with a progressive change of frequency and sometimes with aharmonic overtones, are observed during storms. — D. B. V.

186-487. Barsukov, O. M. Kvoprosu o trekh "skorostyakh" korpuskulyarnykh potokov [On the problem of three "velocities" of corpuscular streams]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 1, p. 155-157, 1960.

By comparing the time and intensity of solar flares with geomagnetic activity, three maximums in geomagnetic disturbance were determined to occur

after passage of solar active areas across the central meridian of the sun. A graph of day-average relative intensities of telluric currents is presented to illustrate the 3 maximums. These maximums are considered to correspond to different "velocities" of the sun's corpuscular streams. — A. J. S.

- 186-488. Rikitake, Tsuneji. The anomalous behavior of geomagnetic variations of short period in Japan and its relation to the subterranean structure. The 9th report: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 4, p. 545-570, 1959.

The only possible model that can explain the anomaly in short-period geomagnetic variations observed in Japan seems to be a highly conducting, roughly elliptical circuit about 200 km wide and 1,000 km long, with both ends connected with the conducting part of the earth's mantle and with a nonconducting wedge penetrating into the mantle between these connecting points. This model also fits very well with the anomalies in S_q and Dst.

A study of the electromagnetic induction within a spherical sheet having a nonconducting hole demonstrates that the Japanese anomaly cannot be ascribed to the effect of electric currents induced in the sea. (See also Geophys. Abs. 158-50, 162-39 through 43, 163-27, 166-36, 174-264, 179-308.)—D. B. V.

- 186-489. Knapp, David G. Some features of magnetic storms in high latitudes: Jour. Geophys. Research, v. 66, no. 7, p. 2053-2085, 1961.

During a severe magnetic storm, observatory records obtained in high latitudes may show a type of disturbance here called a "cusped bay," which is characterized by a marked displacement of the trace coupled with augmented short-period fluctuations. Several of these events observed during the International Geophysical Year were measured on all appropriate magnetograms and plotted on maps as equivalent overhead current vectors. They show some of the characteristics of systems based on hourly-value changes during storms; however, they afford almost no evidence of the afternoon eastward segment of the auroral electrojet, and the polar-cap effects indicate patterns more complex than the one usually ascribed to this region. It is recommended that cusped bays be studied as a supplement to the use of hourly values and as a means of probing details of magnetic activity that are difficult to approach in other ways. A catalog of storms during the International Geophysical Year is given in an appendix by Knapp and Fabiano. — D. B. V.

- 186-490. Williams, V. L. The simultaneity of sudden commencements of magnetic storms: Jour. Geophys. Research, v. 65, no. 1, p. 85-92, 1960.

Rapid-run magnetograms from the U. S. Coast and Geodetic Survey (USC and GS) and from other observatories located near the magnetic equator were used to study sudden commencements that occurred during the period October 1957 to September 1958. Analysis of these magnetograms yielded three important results: (1) the sudden commencement always occurred first in high or middle latitudes; (2) Little America, Antarctica, registered the sudden commencement first or second 85 percent of the time; and (3) the apparent propagation velocities of the sudden commencement around the magnetic equator had average values between 1,145 and 2,835 km per sec. — Author's abstract

- 186-491. Piddington, J. H. Geomagnetic storm theory: Jour. Geophys. Research, v. 65, no. 1, p. 93-106, 1960.

A discussion of the two-gas theory of the transmission of geomagnetic disturbances through the atmosphere (to several earth radii) is extended (see also Geophys. Abs. 185-434) with the following results: (1) The central problem concerning the main phase of a geomagnetic storm is the mechanism of penetration of solar ions into the geomagnetic field. An explanation is given depending on a combination of a uniform electric space-charge field and a system of irregular fields. (2) A model of the main phase of a geomagnetic storm is given, the principal feature of which is a "magnetic tail" extending from the earth to the dark side. (3) The model may help to explain some other effects. (4) All observed geomagnetic disturbances have their sources initially in current systems in the lower ionosphere. Some are subsequently maintained by current systems in the earth itself and in the region of interaction between the solar and terrestrial plasmas; others are maintained by ionospheric currents. (5) Any ring current outside the geomagnetic field could cause an increase in the horizontal component; a westward-flowing ring current in the field could cause either an increase or a decrease in the horizontal component. The basic effect is not the current but a sustained inward or outward mechanical force on the material in which the current flows. — D. B. V.

186-492. Nagata, Takesi. On the earth storms I. General introduction: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 247-249, 1960.

There is much evidence to demonstrate that magnetic storms accompanied by ionospheric storms and auroral displays in the polar regions of the earth are caused by the solar corpuscular stream trapped and interacted upon by the earth's magnetic field. A significant number of problems concerning the mechanism of individual phenomena associated with the storms in the earth's upper atmosphere and outer space remain to be solved. Some of these problems are briefly reviewed as an introduction to the five other papers included in this volume (see Geophys. Abs. 186-493 through -497). — V. S. N.

186-493. Nishida, Atsuhiko. On the earth storms II. Stability of solar corpuscular stream: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 250-258, 1960.

The stability of a nonmagnetized stream propagating from the sun through interplanetary space is examined. Although electrons in the stream are lost due to collision with interplanetary plasma leaving only protons, the space charge thus introduced is sufficiently neutralized by the change in density of the interplanetary plasma that the stream can propagate stably both when there is no magnetic field and when there is a radial magnetic field in interplanetary space. It is concluded, therefore, that a nonmagnetized stream is capable of conveying the energy of a disturbance from the sun to the earth. — V. S. N.

186-494. Matuura, Nobuo, and Nagata, Takesi. On the earth storms III. Interaction between the solar corpuscular stream and the earth's magnetic field: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 259-272, 1960.

The effect of a stream of solar particles penetrating the exosphere is examined as a possible cause of magnetic disturbance. Solar particles of energy 20 Kev may penetrate the exosphere to a depth of nearly five times the earth's radius at about 10^5 sec after the arrival of the solar stream. The maximum density of the penetrated particles becomes nearly 10^3cm^{-3} when the stream density is assumed to be 10^3cm^{-3} . The total energy of the penetrating particles is estimated to be on the order of 10^{24} ergs; this may be sufficient to

explain the energy of the main phase of the storm. Furthermore, the penetrating solar particles may contribute to magnetic disturbances in high latitude regions and to variation in the radiation belts. Compression and heating of the exospheric gas as a result of compression of the earth's magnetic field by the solar stream may not be an important factor in world wide hydromagnetic instability in the exosphere. — V. S. N.

- 186-495. Nagata, Takesi, and Kokubun, Susumu. On the earth storms IV. Polar magnetic storms, with special reference to relation between geomagnetic disturbances in the northern and southern auroral zones: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 273-290, 1960.

Characteristics of south polar magnetic disturbances are compared with those of north polar magnetic disturbances. The SD-field pattern in the south polar region is almost a mirror image of that in the north polar region with respect to the geomagnetic equatorial plane, and K-indices are almost always parallel to K_p indices. Excellent correlation between activities at stations located on geomagnetically conjugate points indicates that the corpuscular stream originating in outer space tends to flow in along geomagnetic lines of force toward both the north and south ends of the earth's surface. In the case of large magnetic storms, however, the correlation between geomagnetically conjugate points becomes much poorer, suggesting that the relation between them is much disturbed owing to a heterogeneous magnetic field in outer space. — V. S. N.

- 186-496. Oguti, Takasi. On the earth storms V. Inter-relations among the upper atmosphere disturbance phenomena over the polar regions: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 291-300, 1960.

Observations made at Syowa station (lat 69°00' S., long 39°35' E.) were used to study the interrelationship of upper atmosphere disturbance phenomena in the auroral zone. Results suggest substantial reasons for believing that the polar geomagnetic disturbances are due to the motion of an electrical charge near the lower border of auroras caused by precipitation from a solar corpuscular stream, and that simultaneous ionization causes either an ionospheric blackout or an anomalous increase in fEs to follow the geomagnetic and auroral disturbances. The differences between blackout and increase in fEs is attributable to differences in the energy of the impinging particles. — V. S. N.

- 186-497. Tohmatsu, Takao, and Nagata, Takesi. On earth storms VI. Energy and flux of corpuscular streams impinging the earth's atmosphere: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 301-319, 1960.

The energy and flux of the corpuscular streams impinging on the earth's upper atmosphere during earth storms are estimated from their ionizing and exciting effects in three zones of the polar regions—the auroral, polar cap, and subauroral. In this study the energy and flux are estimated for an idealized earth storm, and the results obtained are summarized in a table giving the structure of the storm and its variation with respect to time and space. — V. S. N.

- 186-498. Ionosphere Research Committee, Science Council of Japan. Catalogue of disturbances in ionosphere, geomagnetic field, field in-

tensity of radio wave, cosmic ray solar phenomena and other related phenomena, No. 37: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 321-383, 1960.

The results of simultaneous observations at 19 stations in Japan of the remarkable disturbances that occurred from March 29 to April 5, 1960, are presented in tables and graphs as follows: solar phenomena, solar radio emission, atmospheric radio noise, whistler occurrence number, principal magnetic storms, three-hour-range of earth-current potential, three-hour-range indices K and Ak, absolute zenith intensity of air-glow, ionosphere data, geomagnetic field and earth currents, induction magnetograms, cosmic-ray intensity, input intensity of radio waves, and field intensity of radio waves. — V. S. N.

186-499. Malurkar, S. L. Solar control of some unusually remarkable geophysical events [with Japanese abstract]: Papers in Meteorology and Geophysics, v. 11, no. 1, p. 144-150, 1960.

An examination of conditions on the sun shows that the emission of large cosmic ray bursts takes place only from limited portions—the western limb and the central meridian in a small latitudinal belt on either side of the equator—of an extremely active solar region with a long history. This area is relatively large and compact, and has a strong magnetic field. A large solar flare near the western limb of the sun gives rise only to a cosmic ray burst with no subsequent related geomagnetic storm; when the flare is near the central meridian, however, the cosmic ray burst is followed about a day later by a geomagnetic storm with corresponding world-wide cosmic ray changes. Purely geomagnetic storms follow about a day after the central meridian passage of active regions with lesser solar history. — V. S. N.

MAGNETIC PROPERTIES AND PALEOMAGNETISM

186-500. Blundell, D. J. Rock magnetism applied to some geological problems: Geol. Mag., v. 98, no. 4, p. 301-312, 1961.

Recent studies with the application of rock magnetism to several geological problems serve to illustrate the scope of the methods at present available. Rock magnetism can usefully be applied to determine the age of a rock or to correlate it with some other. It may be used in studying the structural history of a formation or the thermal history of a rock. The examples cited deal with igneous rocks in Britain, but the methods also apply to some sediments and possibly to metamorphic rocks.

It is stressed that rock magnetism can be applied quite independently of any theory concerning the earth's field. It is necessary only to establish whether the magnetism measured in the laboratory is a true record of that acquired when the rock formed, or at some other known time in its history. — Author's abstract

186-501. Smelov, A. A. Kharakter namagnichennosti rud i priroda otritsatel'nykh magnitnykh anomaly Angaro-Ilimskogo rayona [Character of magnetization of ores and nature of negative magnetic anomalies of the Angara-Ilim area]: Leningrad Univ. Uchenyye Zapiski, v. 249, no. 10, Voprosy Geofiz., p. 194-230, 1958.

The results of field investigations of the origin of negative magnetic anomalies and of the magnetization features of ores found in Angara-Ilim area are reported. Several theories of the origin are discussed, and those proposed

by Bersudskiy (see Geophys. Abs. 94-4446) and Grabovskiy and Pushkov (see Geophys. Abs. 158-59) are found plausible. Smelov considers formation of negative anomalies in the Angara-Ilim area as being due to a low temperature dissociation in three-component magnetic rock, one component of which assumes the negative magnetization due to an internal demagnetizing moment that has a higher intensity than that of the earth's field. — A. J. S.

186-502. Strangway, D. W. Magnetic properties of diabase dikes: Jour. Geophys. Research, v. 66, no. 9, p. 3021-3032, 1961.

The magnetic properties of several Precambrian diabase dikes from the Canadian shield have been studied. The dikes are of widely differing ages and belong to swarms having greatly different strikes. Before demagnetization in a-c fields of 100-200 oersteds the direction of remanent magnetization of the various dikes were quite scattered, but after demagnetization a weak stable remanent magnetization was found. In almost all cases the direction of this stable magnetization was found to lie close to the plane of the dike, although the various dike swarms had different inclinations within the plane. Experiments showed that typical samples acquire a large soft thermoremanent magnetization at 585°C when cooled in the earth's field; a second weak but very stable component was also found that had a Curie temperature considerably lower than 585°C. It is postulated that the component with the high Curie temperature produced internal demagnetization that cancelled out the component of the earth's magnetic field normal to the dike; the component with the lower Curie temperature then acquired a magnetic moment parallel to the internal field of the dike, which would be nearly in the plane of the dike. This stable component may have been preserved since the time of formation. — D. B. V.

186-503. Grabovsky, M. A. (A) Magnetic properties of anisotropic rocks; and (b) The problem of the formation of remanence with an opposite polarity in rocks: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 67-69, 1959.

Anisotropy in rocks and its effect upon the magnetic properties of ferromagnetic stratified rocks are discussed in part A. From investigation of the structural anisotropy of a lamellar micaceous magnetic quartzite, it is shown that in a weak field the magnetic permeability of a sample in a direction parallel to the layers is tens of times more than that in a direction transverse to the layers. Moreover, given similar anisotropic samples, all magnetic values of thermomagnetized samples are greater than the values of isothermally (normally) magnetized samples. These studies are important in interpretation of magnetic and gravitational anomalies. Stratified rocks with layers parallel to the earth's surface will not be magnetized in the direction of the magnetic field and thus will not distort the earth's magnetic field, in which case regional gravity anomalies are not accompanied by magnetic anomalies. Under natural conditions the formation of remanence in stratified ferromagnetic rocks takes place as a result of thermomagnetization.

A series of model experiments to investigate ore deposits that show magnetic fields directed opposite to that of the earth's modern magnetic field are discussed in part B. [See also Geophys. Abs. 166-270, 176-267.] — V. S. N.

186-504. Chevallier, R[aymond], and Mathieu, S[uzanne]. Susceptibilité magnétique spécifique de pyroxènes monocliniques [Specific magnetic susceptibility of monoclinic pyroxenes]: Soc. Chim. France Bull., pt. 5, Mem. no. 131, p. 726-729, 1958.

The results are reported of a theoretical determination of the magnetic susceptibility of monoclinic pyroxenes from the basaltic rocks of the Skaergaard intrusion and of a comparison with actual values determined by Brown and Vincent (1957) in the geology laboratory at Oxford University. Theoretically the lines of magnetic force are not rectilinear but, in intense fields, tend toward the right: where σ =the specific magnetization, σ_0 =a ferromagnetic impurity (10^{-3} to 10^{-4} percent magnetite, H =the magnetic field, and χ =the specific magnetic susceptibility of the pyroxene, then $\sigma=\sigma_0+\chi H$. By solving this formula for each sample of the Skaergaard pyroxenes it is possible to determine the value of χ . Precise chemical analysis of these pyroxenes has shown that the magnetic ions are Fe^{2+} , Fe^{3+} , and Mn^{2+} . If it is assumed that these magnetic ions are free and without interaction, then using their known magnetic moments it is possible, by applying Langevin's law of paramagnetics (Curie's law), to calculate the susceptibility of the pyroxenes at 20°C. Comparison of the results with the measured susceptibilities shows very satisfactory agreement. — V. S. N.

- 186-505. Grabovskiy, M. A., Zherdenko, O. M., and Skovorodkin, Yu. P. O vozmozhnosti primeneniya metoda magnitnykh poroshkov pri issledovanii pirrotinovykh rud [On the feasibility of use of the method of magnetic powders in studies of pyrrhotite ores]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 737-743, 1961.

This is the continuation of a study of iron ores using magnetic powder (see Geophys. Abs. 184-484). Polished sections of pyrrhotite covered with cobalt ferrite powder of 1μ grain-size show magnetic nonuniformity not only for different grains of the rock but also within the area of individual grains. Lower temperature pyrrhotite takes a better coverage of powder than does the higher temperature. The crystallographic form and optical orientation can be determined by the character of settling of the powder with respect to the elongation of the grains. — A. J. S.

- 186-506. Nagata, T[akesi], Yukutake, T[akesi], and Uyeda, S[eiya]. On magnetic susceptibility of olivines: Jour. Geomagnetism and Geoelectricity [Kyoto], v. 9, no. 1, p. 51-56, 1957.

Measurement of the magnetic susceptibility of several olivines, $xFe_2SiO_4 \cdot (1-x)Mg_2SiO_4$ with varying x , has shown that the olivines are paramagnetic and that their molecular magnetic susceptibility can be expressed empirically by $X_{mol}=2x \cdot 10^{-2} emu/mol$ at room temperature. Using the accepted value of the Bohr magneton number of Fe^{+2} ions and assuming that these ions are embedded in an isolated fashion in the crystal, the paramagnetic susceptibility of olivines at room temperature can be calculated as $X_{mol}=2.2x \cdot 2.6x \cdot 10^{-2} emu/mol$, provided that other constituents such as Mg^{+2} and SiO_4 are only diamagnetic. — V. S. N.

- 186-507. Uyeda, Seiya. Thermo-remanent magnetism and coercive force of the ilmenite-hematite series: Jour. Geomagnetism and Geoelectricity [Kyoto], v. 9, no. 2, p. 61-78, 1957.

The thermoremanent magnetism and the coercive force of the ilmenite-hematite solid solution $(1-x)Fe_2O_3 \cdot xFeTiO_3$ are examined for the range $0 < x < 0.7$ in synthesized specimens; in the range $x > 0.7$, the solid solution is only paramagnetic at room temperature. In the parasitically ferromagnetic region ($x < 0.5$), $J(T)$ and $J_r(T)$ show an increase below the Curie point, while $H_c(T)$ and $H_{cr}(T)$ decrease monotonously with temperature. Thermoremanent mag-

netism is strong in comparison with $J(T)$ in this region, the Q -ratio amounting to several hundred. In the ferrimagnetic region ($0.7 > x > 0.5$), $J(T)$ and $J_r(T)$ show the typical straight decrease with temperature rise; H_c and the Q -ratio are considerably smaller than for the parasitically ferromagnetic region. Remarkable reverse TRM appears for specimens of the range bordering ferrimagnetic and parasitically ferromagnetic regions ($0.6 > x > 0.45$), which indicates that the phenomenon is inherent to this substance and closely related to fundamental magnetic properties of this series. A tendency for reverse TRM appears for $x \approx 0.1$; this may be similar to the natural reverse remanence of Adirondack rocks reported by Balsley and Buddington (see *Geophys. Abs.* 163-35). Stability against the AC demagnetization and the field dependence of the thermoremanent magnetism of this series also have been examined. — V. S. N.

- 186-508. Balsley, J[ames] R., and Buddington, A. F. Puzzles in the interpretation of paleomagnetism: *India Geol. Survey Recs.*, v. 86, pt. 4, p. 553-580, 1960.

Paleomagnetic data are currently interpreted to indicate continental drift, polar wandering, and periodic reversal of the sense of polarity of the earth's magnetic field. Theory, experiment, and some geologic phenomena indicate that mineralogical factors should play a prominent role in evaluation of paleomagnetic data; yet, present interpretations largely ignore these factors and nevertheless arrive at a consistent picture. This puzzle is discussed, and major contributions in the field are reviewed and appraised. Until the role of minerals in the interpretation of paleomagnetism is satisfactorily understood and delineated, judgement on the validity of current interpretations must be suspended. — V. S. N.

- 186-509. Kalashnikov, A. G. Paleomagnetism i yego znachenije dlya poznaniya zemli [Paleomagnetism and its importance to knowledge of the earth]: *Akad. Nauk SSSR Vestnik*, no. 1, p. 27-38, 1961.

Paleomagnetism as applied to the history, dynamics, and structure of the earth is described. After an explanation of the fundamentals of paleomagnetic phenomena, methods of paleomagnetic investigations are reviewed. Generalizations from the observed variations of remanent magnetization vectors in space and time are summarized briefly and existing hypotheses of paleomagnetism given. The migration of the magnetic poles of the earth is discussed, and the correlation between paleomagnetism and paleoclimatology is considered to confirm the hypothesis of displacement of the earth's surface in relation to the earth's axis of rotation. In conclusion, the contribution of paleomagnetism to earth science is outlined. — A. J. S.

- Hodgson, R. L. Drift or shift. See *Geophys. Abs.* 186-378.

- 186-510. Bigarella, João José, and Salamuni, Riad. Early Mesozoic wind patterns as suggested by dune bedding in the Botucatú sandstone of Brazil and Uruguay: *Geol. Soc. America Bull.*, v. 72, no. 7, p. 1089-1106, 1961.

Early Mesozoic wind patterns and pressure belts, as determined from 2,892 measurements of eolian cross-bedding dip directions at 51 outcrops of the Botucatú sandstone in Brazil and Uruguay, are found to be in agreement with the paleomagnetic results reported by Creer and others (see *Geophys. Abs.* 176-273, 179-321). — D. B. V.

- 186-511. Rutten, M. G., and Veldkamp, J. Paleomagnetic research at the Utrecht University [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 60-62, 1959.

The results of paleomagnetic studies at the University of Utrecht on Miocene-Pleistocene basalts of the Coirons (southern France), Permian trachyandesites and basalts of the Oslo graben, and Permian rhyolites in the Esterel (southeastern France) are reported briefly. The pole deduced from the Esterel rhyolites (lat 45° N., long 130° E.) corresponds much more closely with the Permian poles found by Runcorn (Geophys. Abs. 163-46, 165-273) and Doell (Geophys. Abs. 164-234) in the United States than with the Permian pole found by Creer (Geophys. Abs. 173-292, -296) in England or by the Utrecht studies in the Oslo graben (lat 46° N., long 168° E.). In the Coirons the mean direction of the remanent magnetization coincides with the present field, thus supporting the conclusion of Hospers and others (Geophys. Abs. 157-40, 160-39) that the geomagnetic pole had already arrived in its present position in the Miocene. — V. S. N.

- 186-512. Bobier, Claude, and Glangeaud, Louis. Géodynamique et volcanisme du fossé de Montbrison et du horst du Forez (Morphotectonique, paléovolcanique et paléomagnétisme [Geodynamics and volcanism of the Montbrison graben and the Forez horst (Morphotectonics, paleovolcanology, and paleomagnetism)]: *Soc. Géol. France Bull.*, ser. 7, v. 1, no. 8, p. 867-880, 1960.

This is virtually the same as the paper published in *Acad. Sci. [Paris] Comptes Rendus*, v. 250, no. 1, p. 162-164, 1960 (see Geophys. Abs. 181-387). — D. B. V.

- 186-513. Vlasov, A. Ya., Popova, A. V., Zvegintsev, A. G., and Rodicheva, E. K. Paleomagnitnyye issledovaniya osadochnykh tolshch devona tsentral'noy chasti Krasnoyarskogo kraya [Paleomagnetic study of sedimentary Devonian formations of the central part of the Krasnoyarsk district]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 7, p. 1022-1024, 1961.

The results of an investigation of natural remanent magnetization of Devonian sediments of the Krasnoyarsk area (central Siberia) are reported. A total of 380 samples from 13 outcrops were studied by measuring their vectors of remanent magnetization twice during an 8 months interval. The magnitude of the vectors was found to range from 0.1 to 40×10^{-6} CGSM, 12×10^{-6} CGSM being the average. The magnetic susceptibility is 15×10^{-6} CGSM. The accuracy of measuring remanent magnetization was established to be $\pm 0.2 \times 10^{-6}$ CGSM. The coordinates of the north magnetic pole for the Devonian period were found to be $\lambda_E = 155^\circ$ and $\phi_N = 28^\circ$. — A. J. S.

- 186-514. Nagata, Takesi, and Yama-ai, Mitsuko. Palaeomagnetic studies on rocks on the coast of Lüt-zow-Holm Bay [with Japanese abstract]: *Antarctic Rec.*, no. 11, p. 225-227, 1961.

As a continuation of earlier studies on Cambrian gneiss of the Ongul Islands (see Geophys. Abs. 180-291) results of paleomagnetic studies on a new collection of Cambrian specimens from the Ongul Islands and from the coast of Lüt-zow-Holm Bay are reported. Magnetic orientation and the corresponding North pole positions obtained in the previous and present studies give nearly the same results. Uncorrected N-pole positions for the three collections are: East Ongul Island (1957-58) lat 19° N., long 163° W., East and West Ongul

Island (1959-60) lat 9° N., long 148° W., and east coast of Lützow-Holm Bay lat 21° N., long 156°W. A summary of these results and those of studies on Paleozoic, Mesozoic, and Cenozoic rocks in East Antarctica by others (see Geophys. Abs. 179-324, 184-497), when plotted together with the present geomagnetic pole, shows that the pole has shifted rather systematically from a position at the equator in Cambrian time toward the present position. — V. S. N.

MAGNETIC SURVEYS

- 186-515. Troshkov, G. A. K voprosu ob interpretatsii magnitnykh i gravitatsionnykh anomalii trekhmernykh tel [On the problem of interpretation of magnetic and gravity anomalies of three-dimensional bodies]: Razvedka i Okhrana Nedr., no. 12, p. 28-32, 1960.

A mathematical treatment is given for reducing three-dimensional anomalous gravimetric and magnetic fields to two-dimensional fields. The cases of a point pole, a spherical deposit, and a vertical prism of infinite depth are treated separately, and formulas are given for conversion of respective three-dimensional vertical components Z into two-dimensional components Z . The method proposed was tested on several objects and gave satisfactory results. — A. J. S.

- 186-516. Berkman, R. Ya., and Mikhaylovskiy, V. N. Izmeneniye napryazhenosti peremennyy magnitnykh poley nizkoy chastoty metodom dvoynogo preobrazovaniya signala [Variation of intensity of alternating magnetic fields of low frequency by the method of double transformation of the signal]: Prikladnaya Geofizika, no. 27, p. 212-222, 1960.

The problem of measurement of weak alternating magnetic fields in magnetic logging, in airborne electrical prospecting, and in other methods of geophysical exploration is discussed. The method of self-inductive coils presently in use is considered not sensitive enough, and a new method based on the principle of magnetic modulation by the investigated field of an auxiliary field of a stepped up frequency induced in a ferromagnetic element (the sounding device) is proposed. The application of magnetic modulation pickup for increasing the sensitivity of the field measurements is discussed. — A. J. S.

- 186-517. Wolf, H. Aeromagnetik im Dienste der Geophysik [Aeromagnetism in the service of geophysics]: Zeitschr. Angew. Geologie, v. 6, no. 6, p. 285-286, 1960.

This is a summary of a report on the literature dealing with aeromagnetic surveying, prepared in the VEB Geophysik at Leipzig in connection with plans for aeromagnetic investigations in East Germany. — D. B. V.

- 186-518. Haalck, Fritz, and Schulze, Reinhard. Die mit UTM erreichbare Genauigkeit [The accuracy attainable with the universal torsion magnetometer (with English abstract)]: Zeitschr. Geophysik, v. 26, no. 5, p. 246-270, 1960.

The accuracy of measurements with the new Askania universal torsion magnetometer (UTM), the first of which went into service in 1958, is examined critically. Adjustments are described that make all second-order errors negligible. A measurement procedure that can eliminate first order errors is described, and the necessary formulas are given. If the suggested procedure is followed, with the temperature kept constant by means of the built-in

thermostat, the only constants that enter into the measurements are C_H and C_Z , which can be obtained by connecting measurements, and the induction coefficient k , which can be calculated with sufficient accuracy. Provided that the horizontal intensity H_0 is known accurately enough when the instrument is calibrated, a precision of $\pm 1\gamma$ may be achieved in measuring ΔH or ΔZ differences up to 10,000 γ between stations. — D. B. V.

- 186-519. Research Group for Proton Magnetometers (Japan). Proton magnetometers: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 1, p. 125-143, 1960.

The design and construction of three magnetometers developed by the Research Group for Proton Magnetometers in Japan are described and their performance is discussed, where results are available. The sea-borne proton magnetometer, used mainly by the Japanese Antarctic Expedition, has a theoretical accuracy of ± 1 to 2γ and a practical accuracy (depending on the rotation of the detector coil in the wake and on the magnetization of the ship) of $\pm 15\gamma$. The direct-reading proton magnetometer with a signal counter was designed for use at the Syowa Station in the Antarctic; its accuracy should be $\pm 1\gamma$, but no observations are yet available. The portable transistorized proton magnetometer proved to be almost as accurate as the station-type proton magnetometer. It was used in the magnetic survey of Hakone Volcano (see Geophys. Abs. 186-530). — D. B. V.

- 186-520. Johnson, Robert W., Jr. Dimensions and attitude of the peridotite in Clark Hollow, Union County, Tennessee: An aeromagnetic study: Southeastern Geology, v. 2, no. 3, p. 137-154, 1961.

An aeromagnetic survey was made of an area in Union County, Tenn. underlain by an altered mica peridotite body. Resulting data indicate that the peridotite is a nearly vertical, elliptical cylinder approximately 1,500X3,000 feet in cross-section. It does not dip along the Wallen Valley fault and apparently was emplaced before the formation of the fault or before the last significant movement along the fault. — V. S. N.

- 186-521. Allan, Thomas Donald. A magnetic survey in the western English Channel: Geol. Soc. London Quart. Jour., v. 117, pt. 2, p. 157-168 (with discussion), 1961.

A magnetic contour map of the western English Channel is presented and interpreted. The map was compiled from profiles made during 6 expeditions of the R. R. S. Discovery II and the R. V. Sarsia; a nuclear spin magnetometer was towed behind the ships to measure the earth's total field. The most striking feature of the map is an anomaly 15 miles south of the Eddystone with a peak value of 360 γ and a total area of 360 sq mi. This is probably caused by basic rock brought up on a thrust-plane south of the Eddystone thrust. Sharp magnetic anomalies to the east of the Lizard show good correlation with basic intrusives on land. The boundary of the New Red Sandstone outcrops on the sea-floor, postulated from coring results, shows a remarkable coincidence with the extent of the sharp anomalies off the Lizard and off Start Peninsula. — V. S. N.

- 186-522. Park, R. Graham. A vertical force magnetic survey over part of the Dusk Water fault of North Ayrshire: Geol. Soc. Glasgow Trans., v. 24, pt. 2, p. 154-168, 1961.

A magnetic survey covering a square mile in the area of the Dusk Water fault in the Auchenmade district, near Dalry, North Ayrshire, Scotland is de-

scribed. The only important rocks of high magnetic susceptibility in the district are the basic lavas of the Calciferous Sandstone series; this series is cut by the Dusk Water fault which was found by the magnetic survey to swing smoothly from a northeasterly into an easterly direction. Both field mapping and magnetic results thus confirm that the northeast continuation of the Dusk Water fault (Waterside fault) is a splinter that branches from the main Auch-enmade fault. The thickness of the lavas was determined from magnetic profiles, depth and throw values were determined geologically, and susceptibility values of the lavas were determined experimentally. Several prominent anomalies are discussed. — V. S. N.

- 186-523. Angenheister, Gustav [H.], Dengler, Heinrich, and Hahn, Albrecht. Erdmagnetischen Messungen bei Waldhausen (Lahnmulde) als Hilfsmittel zur Aufsuchung devonischer Eisenerze [Geomagnetic measurements near Waldhausen (Lahn basin) as an aid in the search for Devonian iron ores]: Hesse Landesamt für Bodenforschung Notizbl., v. 87, p. 434-449, 1959.

A magnetic survey in the vicinity of the red ironstone occurrence of the Waldhausen mine indicates that the ore horizon, which in places is partially altered to magnetite by contact action with diabase, extends to the southwest. Two strongly magnetic layers younger than the ore bed—a diabase intrusion in the Lower Devonian and a diabase sheet in the Lower Culm—can be used as key beds in magnetic surveying. — D. B. V.

- 186-524. Bosum, W. Erdmagnetische Messungen im Deckdiabasgebiet der Dillmulde und ihre Auswertung [Geomagnetic measurements in the diabase sheet region of the Dill basin and their evaluation [with English abstract]: Zeitschr. Geophysik, v. 26, no. 3, p. 144-157, and no. 4, p. 177-216, 1960.

Geomagnetic measurements were made in the Dill basin in Hesse, Germany, in order to determine whether the different types of diabase could be distinguished by magnetic surveying. The results showed that continuous diabase sheets could be detected and their strike and dip could be determined from the vertical anomalies. Faults were also indicated. The magnetic interpretation was supported by geologic mapping, drilling, and measurements of the magnetic susceptibility and remanence of drill cores and hand specimens.

In the second part formulas for computing magnetic anomalies of two-dimensional bodies are established; this task was simplified considerably by the use of complex functions. A diagram (Komplexrechenplatte) is given for direct evaluation of the anomalies. Magnetic anomalies above the edges of disturbing bodies show less sharp maximums and minimums in real profiles than in theoretical ΔZ profiles, except above faults. Possible reasons for this discrepancy are discussed. — D. B. V.

- 186-525. Kalashnikov, A. G. Opyt primeneniya modelirovaniya dlya resheniya obratnoy zadachi magnitnoy razvedki [Experiment in the use of modeling for solution of the inverse problem of magnetic prospecting]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 345-348, 1961.

The Shchigry magnetic anomaly of the Kursk magnetic anomaly was investigated in the field and on a model of the ore body made of magnetite on a 1:22,000 scale, with a magnetic susceptibility $K=0.22$. By comparing the curve of the Z-component of the field data (maximum 1.25 oersted) with that of the model for $Q=0, 3, 5.7, \text{ and } 8.5$ ($Q=I_r/I_{ind}$), a difference in the form of the

curves was found. Deviation of the field curve is due to nonuniform magnetization of the ore body because of its excessive magnetic susceptibility, considerable remanent magnetization of iron quartzites ($Q=8.5$), and nonuniform distribution of magnetized rocks in the upper parts of the ore body (Q up to 10-12). — A. J. S.

186-526. Pavlovskiy, V. I., and Rabinovich, V. B. Zadachi po poiskam bogatykh zheleznykh rud KMA s uchetom novykh geofizicheskikh dannykh [Problems in prospecting for rich iron ores of the KMA on the basis of new geophysical data]: Razvedka i Okhrana Nedr, no. 12, p. 32-35, 1960.

A general discussion is presented of anomalous areas of the Kursk magnetic anomaly where large deposits of rich iron ores have been discovered by detailed geophysical explorations in the regions that were considered exhausted of new iron ore deposits. — A. J. S.

186-527. Mikhaylova, N. P. Magnitne pole ta deyakī rysy struktury Nikopol'-Kryvoriz'kohu rayonu [The magnetic field and some structural patterns of the Nikopol-Krivoy Rog region (with Russian summary)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 19, no. 6, p. 44-53, 1959.

A schematic structural map of the Nikopol-Krivoy Rog region in the Ukraine S. S. R. has been compiled on the basis of the physical properties of the rocks, the magnetic field, and a few gravity survey data. The region appears to be the nose of a broad northwest-plunging syncline that involves amphibolites and granites and is cut by faults. — D. B. V.

Kuznetsov, A. A., and Tavrin, I. F. Some data on the tectonic structure of the greenstone synclinorium on the east flank of the southern Urals according to results of gravity and magnetic surveys. See Geophys. Abs. 186-410.

186-528. Borisov, A. A., and Rymanov, V. M. O geologicheskoy interpretatsii magnitnykh anomalii yuga Sredney Asii [On the geologic interpretation of magnetic anomalies of southern central Asia]: Akad. Nauk SSSR Doklady, v. 133, no. 6, p. 1395-1397, 1960.

The magnetic anomalies in an area bounded on the north by the Zeravshan, on the east by the Darvaza and Pamir, and on the south by the Paropamisus Range are generally small, seldom exceeding $+250\gamma$. Their distribution reflects the structure of the folded Paleozoic complex. Sketch maps show the distribution and intensity of positive and negative anomalies and their relation to structural elements. — D. B. V.

186-529. Bernshteyn, V. A. O vozmozhnykh izmeneniyakh magnitnogo polya v rayone vulkana Zavaritskogo v pervoye polugodiye 1958 g. [On possible changes in the magnetic field in the region of Zavaritskiy Volcano in the first half of 1958]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulcanol. Sta., no. 30, p. 69-74, 1960.

Comparison of the results of a magnetic survey of Zavaritskiy Volcano in the Kurile Islands in August 1958 (see Geophys. Abs. 185-481) with those of a survey on December 19, 1957, just a month after the beginning of the eruption, shows a change of at least 450γ . Such a difference, although possibly due to the methods used, could be a real one, related to displacement of the isothermal surface of the Curie point. The volcanic apparatus, a system of

fissures, might serve as a sensitive indicator of changes in volcanic activity by markedly influencing the magnetic field in the neighborhood of the volcano. Periodic magnetic measurements in the vicinity of volcanoes could give useful information on their activity, but for the data to be reliable it is necessary to use absolute measurements of the geomagnetic elements. — D. B. V.

- 186-530. Yukutake, Takesi, and Tanaoka, Iwao. Magnetic survey on Hakone Volcano by use of a proton magnetometer: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 1, p. 41-54, 1960.

A magnetic survey of Hakone Volcano in Japan was undertaken in October 1959 in connection with the swarm of volcanic earthquakes that began the previous month. The new portable proton magnetometer developed by the Research Group for Proton Magnetometers (see Geophys. Abs. 186-519) was used.

The magnetic anomalies were found to reflect differences in magnetization of the different volcanic formations in the central part of the caldera—the Kamiyama, Komagatake, and Futagoyama lavas and the Kanto ash. The intensity of magnetization of the central cone, Mt. Kamiyama, is unexpectedly large for an andesitic volcano. A resurvey in the future should elucidate the relation between volcanic activity and geomagnetic changes. — D. B. V.

- McDougal, I., and Stott, P. M. Gravity and magnetic observations in the Red Hill area, Southern Tasmania. See Geophys. Abs. 186-411.

MICROSEISMS

- 186-531. Monakhov, F. I. Chastotnaya selektsiya okeanicheskikh shtormovykh mikroseyism [Frequency selection of ocean storm microseisms]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 393-401, 1961.

Microseisms experience much greater loss of energy during propagation on the ocean floor than on continental paths. Tracing cyclones passing over the open ocean is thus greatly limited. Microseisms from sources at great distances from the coast are found to be so weakened that their recognition on the records of ordinary seismic stations is not possible. Experiments were made to distinguish such microseisms at stations on continents and islands by the method of frequency selection using multicascade apparatus of 7.5 sec period natural oscillation. — A. J. S.

- 186-532. Monakhov, F. I. Mikroseyismy na dne Chernogo Morya [Microseisms on the bottom of the Black Sea]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 710-711, 1961.

Microseismic oscillations passing from the open ocean and sea to the land are discussed. A case is reported where microseisms on the bottom of the Black Sea 70 km west of Sochi were recorded as having a predominant period of 2 sec and maximum amplitudes up to 2μ . At the same moment the station of Sochi recorded microseisms of the same period with a 0.1μ amplitude. This phenomenon of a rapid drop in the amplitude of microseisms during the passage from sea to land is explained by considerable damping in the transition zone between the sea and the continent. — A. J. S.

- 186-533. Rykunov, L. N. Korrelyatsionnyy sposob izucheniya mikroseyism [Correlation method of study of microseisms]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 1037-1039, 1961.

A correlation analysis of microseisms is presented whereby the Rayleigh, Love, and Lg wave microseismic components can be evaluated simply in any region where regular seismic stations are located. The results open a new possibility for study of transverse microseismic components whereby the information thus obtained is applied to the study of the nature and mechanism of production of microseisms and to the study of the upper part of the crust. — A. J. S.

186-534. Akamatu, Kei. On microseisms in frequency range of 1 c/s to 200 c/s: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 1, p. 23-75, 1961.

The spectrum of short-period microseisms (frequency 1-200 c) has a characteristic "dominant frequency" at every observation point. At some places the spectrum may be remarkably sharp, at others it may be flat; the differences appear to be independent of the nature of the ground and of the time of day or night. Short-period microseisms appear to consist of surface waves, either Rayleigh or Love type or both. If so, the frequency corresponding to the minimum group velocity is apt to predominate. The ground layer acts as a kind of filter, and the dispersion curve inherent in the ground structure may be regarded as a characteristic frequency curve of the filter. — D. B. V.

186-535. Kishinouye, Fuyuhiko. Further studies of microseisms by observation: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 1, p. 77-84, 1961.

Results of tripartite observations of microseisms at Shinkawa in Mitaka, at Tokyo, and at Tateno in Ibaraki Prefecture are presented graphically, together with weather maps for the observation days. — D. B. V.

186-536. Santo, Tetsuo A[kima]. Investigations into microseisms by the observational data of many stations (Part 2). — Further considerations on the origin of microseisms: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 483-494, 1959.

The suggestion made in the first part (see Geophys. Abs. 179-351) that microseisms of 3-7 sec period originate near the coast is reexamined in the light of additional data on microseismic storms due to passing typhoons, registered at many Japanese stations during the International Geophysical Year, together with oceanographic data on the distribution of swells around the running center of the typhoons. It was found that in all cases, regardless of the strength and distance of the cyclone center, microseisms in a given district occur simultaneously with the arrival of swells at some coast in the same district. This confirms the previous conclusion that the transformation of energy from swells to microseisms occurs somewhere near the coast. — D. B. V.

186-537. Santo, Tetsuo A[kima]. Where do swells turn into microseisms? [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 3, p. 150-162, 1960.

During the International Geophysical Year period, observations of microseisms were made at many stations in Japan. Microseisms, resulting from the passing of a cyclone or typhoon near Japan, appear to occur at the time when swells from the meteorological disturbance reach some coast near the station. Comparison of microseismic amplitudes and swell heights at the same station supports this conclusion. Results of investigation of the period relation between microseisms and swells and of the spectrum of swells sup-

port Longuet-Higgin's standing wave theory (see Geophys. Abs. 144-12573). It is concluded that swells that are due to a single disturbance source in an ocean become microseisms at the point on a steep coast where standing waves are generated as a result of the interference of the incident and reflected swells. — V. S. N.

- 186-538. Hatherton, T. A note on the amplitude-period relationship of earth noise in the one to eight second range: *Seismol. Soc. America Bull.*, v. 51, no. 1, p. 13-16, 1961.

Maximum values of surface particle displacement due to microseisms recorded at an Antarctic seismological station (Scott Base) are compared with the displacements obtained by Romney [1953] at Harvard and Pinewoods. The relation of the displacement to the fourth power of the period obtained by Romney is confirmed by the Antarctic data. — Author's abstract

- 186-539. Byrne, C. J. Instrument noise in seismometers: *Seismol. Soc. America Bull.*, v. 51, no. 1, p. 69-84, 1961.

Methods are developed to analyze the effects of thermal noise and seismic noise in masking small earth vibrations. The procedure is applied to a simple seismometer, seismometers with electronic and galvanometer amplifiers, and a seismometer with a shunt capacity. A numerical example is worked out for the Benioff one-second instrument. In the 0.1 sec to 10 sec band, thermal noise is not limiting. — Author's abstract

- 186-540. Carron, Jean-Paul, Nozières, Philippe, and Rocard, Yves. Correlations entre sismographes voisins [Correlations between neighboring seismographs]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 16, p. 2430-2431, 1961.

Experiments were made in the Paris Basin in order to determine whether information on the residual agitation of the ground could be obtained by correlating seismic signals received by seismographs separated by a short distance. Two short-period (1 sec) instruments were used. When the seismographs were close together, the difference between signals (Δ) was zero. At 200 m apart, Δ was small and consisted only of high-frequency components. At a spacing of about 600-800 m the signals began to be out of phase, and at more than 800 m there was no correlation.

The range of correlation suggests a velocity of 1,000 m per sec, distinctly lower than the local P-wave velocity. This anomaly can be interpreted by assuming that the observed microseisms consist of surface waves resulting from nearby atmospheric disturbance or from settling of surface layers (over a thickness much less than the wavelength). — D. B. V.

- 186-541. Longuet-Higgins, M. S. Discussion of paper by J. N. Nanda, "The origin of microseisms": *Jour. Geophys. Research*, v. 66, no. 3, p. 994, 1961.

Nanda, J. N. Discussion on "The origin of microseisms": *Jour. Geophys. Research*, v. 66, no. 8, p. 2597-2598, 1961.

Longuet-Higgins calls attention to some misstatements in Nanda's paper (see Geophys. Abs. 181-403) that refer to Longuet-Higgins' paper on the origin of microseisms (see Geophys. Abs. 144-12573).

Nanda replies, giving reasons why he did not put too much reliance in Longuet-Higgins' theory applied to the incoherent sea. — D. B. V.

- 186-542. Shutt, T. C. Radioactivity and some of its geologic applications: Univ. Sheffield Geol. Soc. Jour., v. 3, no. 3, p. 77-81, 1959.

Radioactivity is defined and its natural occurrence and measurement discussed briefly. The direct effects and application of radioactivity to the following aspects of geology are summarized: the constant temperature of the earth, continental drift, dating the age of the earth, radioactive logging, and source of power. — V. S. N.

- 186-543. Savinskiy, I. D. O reshenii obratvoy zdachi pri γ -izmereniyakh [On solution of the inverse problem in γ -measurements]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 379-386, 1961.

The problem of finding the density distribution of radioactive sources from their γ -radiation is discussed. A method of investigation of the possibilities for solving this inverse problem by employing the Fredholm integral equation of the first kind is proposed. The method is in principle applicable to cases of practically arbitrary distribution of radioactive material. — A. J. S.

- 186-544. Kenna, B. T., and Kuroda, P[aul] K. The ratio of induced fission vs. spontaneous fission in pitchblende and natural occurrence of radiochlorine: Jour. Inorg. Nucl. Chemistry, v. 16, no. 1/2, p. 1-7, 1960.

Chlorine was isolated from kilogram quantities of both Canadian and African pitchblende, exhaustively purified, and counted. The specific activity of chlorine obtained from African pitchblende was found to be (7 ± 1) disintegrations per minute per gram of chlorine, while that from Canadian pitchblende was (4 ± 1) disintegrations per minute per gram of chlorine. The ratio of induced fission of U^{235} vs. spontaneous fission of U^{238} in these minerals was calculated from the radiochlorine data. A value of 0.33 was obtained for the African pitchblende and a value of 0.19 for the Canadian pitchblende. — Authors' abstract

- 186-545. Goldsztein, M., and Guillermo, S. Radioactivité des laves de la Chaîne des Puys [Radioactivity of the lavas of the Chaîne des Puys]: Soc. Française Minéralogie et Cristallographie Bull., v. 84, no. 1, p. 6-8, 1961.

The distribution of radioactivity and of uranium in the lavas of the volcanic chain of the Puys in France has been measured; results are presented in graphs. The lavas form a perfectly continuous differentiation series. The correlation diagrams show that the uranium content varies systematically with the petrographic position of the rock in the series, confirming the tendency of uranium to be concentrated in the alkaline part of magmas. — D. B. V.

- 186-546. Hamilton, E. The uranium content of the differentiated Skaergaard intrusion: Grønlands Geol. Undersøgelse Misc. Papers, no. 22, 35 p., 1959; reprinted in Medd. om Grønland, v. 162, no. 7, 1959.

This paper was previously published in Univ. Copenhagen Mus. Minéralogie Géologie, Commun. Géol., no. 93, 35 p., 1959 (see Geophys. Abs. 181-410). — V. S. N.

- 186-547. Ueji, Torajiro. Some results obtained by the measurements of radioactivity in a certain bath-room of radioactive spring in Hyogo

Prefecture, Japan [in Japanese with English abstract]: *Balneol. Soc. Japan Jour.*, v. 9, no. 2/3, p. 52-57, 1958.

The results of radioactivity measurements with a scintillation counter of the water and air in a hot spring bathhouse are reported. It was found that the higher the temperature of the mineral water in the bathtub, the larger the radon emanation from the water. Readings of the counts in the air of the bathhouse proved to be irregular but were generally higher on the floor than in the upper parts of the room. — V. S. N.

186-548. Ueji, Torajiro. Radioactive mineral springs in Mt. Rokko and its environs near Kobe, Japan [in Japanese with English abstract]: *Balneol. Soc. Japan Jour.*, v. 11, no. 2/3, p. 29-33, 1960.

The results of an investigation of the radioactivity, temperature, and geologic relations for 65 mineral springs in the Mt. Rokko, Japan, area are reported. Radioactivity was found to be higher in springs of lower temperature. Zuihoji and Kurakuen springs have the highest radioactivity; both issue from biotite granite. — V. S. N.

186-549. Shimokata, K[ouzo], and Ishihara, H[iraku]. Radioactivity of mineral springs in middle Japan (VI). Radon and thoron content of mineral springs in Kiso district in the northern part of Aichi Prefecture [in Japanese with English abstract]: *Balneol. Soc. Japan Jour.*, v. 12, no. 1, p. 29-32, 1961.

The radon and thoron contents were determined for waters from 12 mineral springs in the Kiso district of Nagano Prefecture and in the northern part of Aichi Prefecture. The radon content of waters in the Kiso district was fairly high; the highest value was 106.2 Mache's units. Thoron was not detected. — V. S. N.

Rama; Koide, M.; and Goldberg, E. D. Lead-210 in natural waters. See *Geophys. Abs.* 186-458.

186-550. Sano, Shun-ichi. On the distribution of gamma ray intensity due to natural radioactivity near the earth's surface [with Japanese abstract]: *Japan Geol. Survey Rept.*, no. 188, 44 p., 1961.

The distribution of gamma-ray intensity due to terrestrial radioactivity was investigated by applying the inverse-square exponential law for a point isotropic source combined with a linear buildup factor to the calculation of distribution of gamma-ray intensity in the air and in a drill hole. The main purpose of the survey was to establish principles for outlining areas to be prospected for uranium ores. Measurements of the intensity in the air from a broad source or an effective half-space were made at various altitudes over a sand area on the coast of the Sea of Japan. The intensity distributions in a bare drill hole from a horizontal radioactive layer were calculated by substituting a line detector for an actual one. The effects expected theoretically are shown in figures that give examples of charts estimating the grade and thickness of an ore-bearing layer from a radioactivity log. The product of the grade and the thickness of the horizontal ore-bearing layer are obtained by integrating the intensity in the drill hole with respect to its depth, independently of the hole diameter or of the dynamic character of the ratemeter. — V. S. N.

- 186-551. Jurain, Georges. Sur la possibilité d'utiliser le dosage du radon des eaux souterraines dans la prospection des gîtes uranifères [On the possibility of using the determination of radon in ground waters in prospecting for uranium deposits]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 20, p. 3090-3092, 1961.

Recent work on radon activity of ground water (see Geophys. Abs. 177-323, 183-515) led to the conclusion that systematic determination of the radon content in such waters could be used to distinguish mineralized and nonmineralized zones in uranium prospecting. This conclusion has now been corroborated by tests in an area that has been surveyed geologically, radiometrically (on 25 m and 5 m grids), geophysically, by trenching and drilling, and geochemically. The method is rapid, accurate, and cheap, and can either replace airborne radiometric reconnaissance surveying or be used in a semisystematic phase of exploration. — D. B. V.

- 186-552. Singh, B. D. Radiometric prospecting: Jour. Mines, Metals, and Fuels, v. 9, no. 3, p. 16-20, 1961.

The instrumental principles of the Geiger and scintillation counters and their application to prospecting for nuclear raw material are discussed briefly. — V. S. N.

- 186-553. Matthews, W. L. Scintillometer survey in the Rossarden area: Tasmania Dept. Mines Tech. Repts., no. 4 for 1959, p. 12-17, 1960.

A ground survey for radioactive minerals was made in the Rossarden area, Tasmania, to check anomalies that had been indicated by an aerial scintillometer survey. Isorads drawn on a map show large areas to be from 1 1/2 to 2 times background count, a comparatively small area from 2 to 2 1/2 times background, and small isolated spots with readings greater than 3-4 times background. The higher readings are usually obtained from joint and fracture planes in granite. No new uranium deposits were discovered. The only method of finding possible deposits is to test fractures and joints for high counts. — V. S. N.

- 186-554. Dewan, J. T., Stone, O. L., and Morris, R. L. Chlorine logging in cased holes: Jour. Petroleum Technology, v. 13, no. 6, p. 531-537, 1961.

A chlorine logging tool developed primarily for detection of oil saturation behind casing is described. The principle of the method is based on the fact that chlorine has a large cross section for the capture of thermal neutrons, and in this capture process the chlorine nucleus emits characteristic gamma rays that can be measured. The usefulness of the method derives from the fact that most strata of interest for oil production contain saline formation water. When this water is replaced by oil, the chlorine content of the stratum is decreased significantly. The salinity resolution of the instrument is greatest at low salt concentrations and when the casing is empty. A method of interpreting the chlorine log based on response curves is explained and illustrated by several field examples from the Gulf Coast. — J. W. C.

- 186-555. Glauberman, A. E., and Tal'yanskiy, I. I. O raspredelenii neytronov v sredakh s zadannymi svoystvami pri tsilindrisheskoy granitse razdela [Distribution of neutrons in mediums with given properties and with a cylindrical interface]: Atomnaya Energiya, v. 3, no. 7, p. 23-27, 1957.

An analytical treatment is presented of the distribution of neutrons from a point source in a medium containing a cylindrical interface where the regions inside and outside the cylinder have different neutron properties. The two-group approximation method, introducing fictitious sources at the interface of the regions, is employed. This permits a derivation of mathematical expressions for the fast and slow neutrons in both regions. — A. J. S.

Plewa, Stanisław. Problems of identification and correlation of coal seams by means of mining geophysics methods. See *Geophys. Abs.* 186-314.

Klyucharev, V. S., Shevkunov, Ye. N., and Lazarev, V. N. Study of carbonate rocks according to geophysical data. See *Geophys. Abs.* 186-316.

SEISMIC EXPLORATION

186-556. Tolstoy, I[van]. Elastic wave interferometry—a new tool: *Jour. Geophys. Research*, v. 66, no. 8, p. 2485-2488, 1961.

A harmonic source in a vertically stratified waveguide excites a number of propagating modes, each having its own characteristic wavelength in the horizontal direction. These modes interfere, giving characteristic oscillations of the wave field amplitude as a function of range from the source. In the case of a three-layered half-space the interference wavelength Λ of the first two modes is very sensitive to layer properties; in particular, if one examines the effect of the second layer, this wavelength is most sensitive in the range of parameters for which the usual seismic techniques are mostly inadequate. In principle, the method can be used in any properly chosen frequency range for both elastic and liquid mediums. Transient wave recordings (explosions, earthquakes, microseisms) obtained by a sufficient number of receivers could also be filtered to determine Λ and thus utilize this technique. Tables covering a wide variety of model types could be calculated with the aid of available computing machinery. — D. B. V.

186-557. O'Brien, P. N. S. A discussion on the nature and magnitude of elastic absorption in seismic prospecting: *Geophys. Prosp.*, v. 9, no. 2, p. 261-275, 1961.

Field measurements of the amplitude attenuation of direct, reflected, and refracted pulses give values consistent with laboratory findings that seismic absorption in sedimentary rocks lies in the range 0.1-1.0 db per wavelength. It is shown that absorption must be nonlinear. It is assumed that for large values of "Q" the nonlinear equation of motion may be linearized and Fourier synthesis used. If this is valid, then attenuation per unit distance must be practically independent of frequency and dispersion must be negligible. Whatever mechanism is acting, it must produce an attenuation of about 1 db per 1,000 feet and a pulse broadening of about 1-2 percent in the same distance. More field and laboratory experiments to determine the physical mechanism of absorption would be extremely desirable. — D. B. V.

186-558. Weber, Max. Das ebene Interpretationsproblem der seismischen Lotung in einem zweiachsig inhomogenen Körper [The plane problem of interpretation of seismic sounding in a biaxial inhomogeneous body (with English summary)]: *Geofisica Pura e Appl.*, v. 46, p. 33-36, 1960.

An exact solution is given for the general two-dimensional interpretation problem in seismic surveying, and illustrated by a simple example. — D. B. V.

- 186-559. Szendrei, M. E. The frequency content and attenuation of seismic wavelets along the surface of different types of soil: *Geofisica Pura e Appl.*, v. 46, p. 47-65, 1960.

An experimental investigation was conducted over six widely different types of soil in order to gain some reliable information on the wave properties relevant to seismic prospecting. The elastic constants of the surface layers were also found from the compressional and Rayleigh wave velocities. While the predominant frequencies of the compressional and Rayleigh waves both decrease with distance from the source, they are in most cases of the same order of magnitude. The amplitude of the particle velocity for the compressional wave was found to decrease inversely as the square of the distance, while that for the Rayleigh wave decreased more slowly; wide variations occur between different localities. The significance of these results to seismic prospecting instrumentation is discussed. — Author's abstract

- 186-560. Petrov, L. V. Osvyazi mezhdu chastotnymi kharakteristikami diskretanykh i nepreryvnykh grupp [On the relationship between frequency characteristics of discrete and continuous groups]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 3, p. 402-406, 1961.

A new expression for the frequency characteristic of a discrete group of seismic receivers in terms of the frequency characteristic of the reproducing continuous group, convenient for an array consisting of an even number of receivers, is given. It is shown that frequency characteristics of triangular groups of an even number of receivers for all frequencies do not have a modulus greater than the characteristics of groups of an odd number of receivers, provided the initial sensitivity characteristic and the interval between receivers are identical. — A. J. S.

- 186-561. Kitsunezaki, Choro. Study on high frequency seismic prospecting (I). On its application to exploration in metal mines [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 2, p. 102-107; and no. 3, p. 137-146, 1960.

The practical application of high frequency techniques of seismic prospecting to two metal mines in Japan is reported. The experimental instruments, essentially conventional instruments extended to high frequencies of 50-3,000 cycles per second, are described. Such problems as the effect on the seismic record of rock fissures and the sound, wind, and electrical disturbance resulting from the explosions are discussed. — V. S. N.

- 186-562. Suzuki, Takeo. On the velocity of elastic waves in a porous medium [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 3, p. 147-159, 1960.

The unconsolidated materials near the earth's surface—the sedimentary layer, clastic rocks, and others—are treated as a porous medium, the elasticity of which is defined by the modulus of elasticity of the solid and liquid or gas constituents and of the framework. According to a formula by Gassmann (assuming that Poisson's ratio varies with the porosity) the velocity of the elastic wave in such a medium is considered as a function of the elastic constants of framework and porosity. The relations between the velocities of longitudinal and distortional waves and the bulk modulus of the framework are graphically represented for various values of porosity; from these, a chart that uses velocities of the longitudinal and distortional waves as parameters is constructed to show the relations. Young's modulus of a foundation rock for a dam site may be calculated by using seismic data and the charts. — V. S. N.

- 186-563. Kanda, Yutaro. Application of the values of velocity of elastic wave in the bed rock on the standpoint of engineering geology. Part II [in Japanese with English abstract]: Butsuri-Tanko, v. 13, no. 3, p. 160-166, 1960.

The geologic information obtained during excavation of a tunnel is compared with the information previously obtained on the same area from a seismic survey. Techniques of interpretation of longitudinal wave velocities to obtain adequate geologic information for construction of civil engineering earthwork are discussed. — V. S. N.

- 186-564. Van Melle, F. A. Current research to improve the effectiveness of standard geophysical methods: Oil in Canada, v. 13, no. 29, p. 32-34, 1961.

The trend in current seismic research may be described as one of sophistication, of the application of modern analytical and statistical theories to the seismic field. This can be illustrated by tying various research developments to a diagram representing the factors which affect the seismogram by their equivalent electrical circuits. Although this trend seems to imply an increased premium on bigness of operations, there still is room for the small independent operator with an original approach and the ability to deliver quality data. — Author's abstract

- 186-565. Oilweek. Northern seismic costs cut in half by basic operation: Oilweek, v. 12, no. 11, p. 20-22, 1961.

A new method of conducting seismic exploration in the far north during the winter months is described. The heart of the method is the elimination of shot-hole drilling and the use of air shooting. Four-foot, hand-cut seismic trails are cut and recordings are made with light weight, portable transistorized magnetic instruments. The seismic crew is housed in snow-banked tents, and transportation consists of a small helicopter, a small supply plane, motorized toboggans, and snow shoes. This stripped-down operation cuts costs for operating in the far north in half and brings them to a level comparable with operations on the Alberta plains. — V. S. N.

- Bulin, N. K., and Savarenskiy, Ye. F. About short-period surface seismic waves. See Geophys. Abs. 186-199.

- 186-566. Gal'perin, Ye. I., and Frolova, A. V. Trekhkomponentnyye seismicheskiye nablyudeniya v skvazhinakh. I. Vertical'noye seismicheskoye profilirovaniye [Three-component seismic observations in boreholes. I. Vertical seismic profiling]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 793-809, 1961.

The methods of vertical seismic profiling and of seismic wave polarization are discussed, and their applicability to geophysical prospecting is considered. The application of correlation principles in tracing and separation of transmitted, reflected, and head (longitudinal and reflected transformed) waves is analyzed, using wave polarization data for a quantitative treatment of seismic observation data. The combined horizontal-vertical travelttime curves are given, and the nature of the reflected transformed wave of PS type is determined. — A. J. S.

- 186-567. Gal'perin, Ye. I., and Frolova, A. V. Trekhkomponentnyye seismicheskiye nablyudeniya v skvazhinakh II [Three-component seis-

mic observations in boreholes, II]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 979-993, 1961.

This is a continuation of the authors' previous paper (see Geophys. Abs. 186-566). The directions of displacement of ground particles by seismic waves are investigated in homogeneous and gradient mediums and in layered (thin and thick) mediums for the first and subsequent arrival waves. The three-component system consists of an assembly of three mutually perpendicular seismographs (2 horizontal and 1 vertical). The apparatus can be used for vertical seismic profiling with polarized waves, determination of a correlation between seismic horizons and stratigraphic contacts, determination of the nature of seismic waves and the boundaries producing the transformed (head and reflected) waves, determination of dynamic parameters of waves and characteristics of mediums, experimental determinations of various coefficients and parameters in studying methods and problems related to propagation of elastic waves, and study of velocity profiles in seismic logging. — A. J. S.

186-568. Offshore. Electronic filters eliminate seismic "singing": Offshore, v. 14, no. 6, p. 31, 1961.

A new and unique electronic filter designed to suppress the recording of interfering waves in reflection surveying over water is reported. The interference or singing is common in areas where the ocean floor is excessively hard or soft producing a rapid change in velocity of the wave as it moves from the water to the rock. This change causes much of the wave energy to bounce back and forth in the water reflecting alternately from the bottom and the surface. — V. S. N.

186-569. Dobrev, Toma B. Prilagane na reguliranoto nasocheno priyemane (RNP) na seizmichnite v"lny v Severoiztochna B"lgariya [Application of the method of controlled directional reception (RNP) of seismic waves in northeastern Bulgaria]: Minno-Geol. Inst. Godishnik, v. 6, pts. 1 and 2, p. 333-361, 1959-1960.

The seismogeologic characteristics of northeastern Bulgaria are discussed, and the quality of the seismic records available for the region are evaluated. The effectiveness of seismic exploration was found to depend largely on the depth of a rigid, high velocity (5.0-5.8 km/s) unit 700-900 m thick. It was found that the seismograms obtained by the method of reflected waves showed a "chaotic" pattern which prevented identification of informative waves. The method of controlled directional reception (RNP) applied to the field observations and laboratory experiments is described and found to produce data of a high resolving power. — A. J. S.

186-570. Khudzinskiy, L. L. Ob opredelenii nekotorykh parametrov sloyev promezhutochnoy moshchnosti po spectram otrazhennykh voln [On determination of certain parameters of layers of intermediate thickness from the spectrums of reflected waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 676-684, 1961.

A method is proposed for determination of the thickness of a layer when the elastic wave velocity in it is given, or for determination of the wave velocity in the layer when its thickness is given. Analytical and graphical determinations of both parameters, the magnitude of the errors involved, and the limits for the method are discussed. The method is based on the position of the zero and minimum components in the spectrum of the wave reflected from the layer. — A. J. S.

- 186-571. Kametani, Takuya; Tabata, Takeo; and Kawamura, Takashi. Checking deep reflection phases by vertical spread [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 3, p. 167-171, 1960.

The deep and steep phases on routine reflection records were examined to determine whether they represent true underground structures or the misreading of such coherent noises as superficial waves. By using a vertical spread of velocity type geophones, records were obtained showing that the phases were not from superficial waves. — V. S. N.

- 186-572. Kawashima, Takeshi, and Nagumo, Shozaburo. On the interpretation of seismic reflection method (1). Picking of reflections: *Japan Geol. Survey Bull.*, v. 11, no. 10, p. 619-630, 1960.

A systematic procedure is presented for picking up reflections and as much other information as possible from a seismic record. Special attention is paid to the handling of poor records. — V. S. N.

- 186-573. Clément, A., and Layat, C. Correlation à distance constante en sismique réfraction [Correlation at a constant distance in seismic refraction surveying (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 2, p. 296-314, 1961.

Ordinary computation methods in refraction surveying in the Sahara involve considerable shot point distances, causing difficulties in operation and interpretation and high consumption of explosives. A method of reducing these distances is proposed, based on correlations of traces located in a critical zone, where waves have high relative energy due to the sudden increase of reflected energy beyond the critical angle and to the sudden appearance of refracted energy. In order to avoid certain difficulties, a constant correlation distance is selected, at least for sections of the profile.

The set-up and procedure of the proposed method are described in detail, and its advantages and limitations are discussed. — D. B. V.

- 186-574. Weber, Max. Zur Methode der fortgesetzten Auslage in der Refraktionsseismik [On the continuous profiling method in seismic refraction surveying (with English summary)]: *Geofisica Pura e Appl.*, v. 47, p. 12-16, 1960.

A general mathematical treatment of the continuous profiling method is given and applied to the cases $c_1 = \text{const}$, to the plane n -layer problem, and to the case where c_1 is not dependent on z . — D. B. V.

- 186-575. Dobrev, Toma B., and Dachev, Khristo. Povtornite udary—precheshch faktor pri seyzmoprouchvaneto po korelatsionniya metod na prechupenite v'' lny (KMPV) [Secondary pressure bubble pulses as an interfering factor in seismic prospecting by the correlation method of refracted waves (KMPV)]: *Minno-Geol. Inst. Godishnik*, v. 6, pts. 1 and 2, p. 319-331, 1959-1960.

The results of observations of secondary pressure bubble pulses from underwater explosions carried out in the Black Sea are discussed. The empirical formulas and the statistical graph of the most probable zone where the records of the secondary pulses could appear do not confirm Yepinat'yeva's formula (see *Geophys. Abs.* 147-13222) derived to correlate the amount of explosive and the depth of the charge. Examples illustrating the interfering effect of the secondary pressure bubble pulses on the seismic records in un-

derwater exploration by the correlation method of refracted waves are discussed. — A. J. S.

- 186-576. Latypov, Zh. Uskorennyy sposob postroyeniya prelomyayushchikh granits metodom okruzhnostey [A rapid method of construction of refracting boundaries by the method of circles]: Akad. Nauk Kazakh. SSR Izv. Ser. Geol., no. 1 (42), p. 100-103, 1961.

Using a system of oppositely directed and mutually correlated point by point traveltime curves of refracted waves, and applying principles of analytical geometry, a family of circles is constructed, the envelope of which represents the refracting boundary sought. The method is applicable to the boundaries of various forms having a moderate radius of curvature, provided the mean and boundary seismic velocity values are given. — A. J. S.

- 186-577. Seya, Kiyosi [Kiyoshi]. On an influence of anisotropy in a seismic refraction method [in Japanese with English abstract]: Butsuri-Tanku, v. 13, no. 2, p. 89-95, 1960.

It is assumed that in an anisotropic medium the wave surface of a P-wave is an ellipsoid. The general refraction law is reduced, and the influence of anisotropy is discussed for several basic geological formations. It is concluded that the true thickness of the layers is less than the thickness obtained by mathematical analysis. — V. S. N.

- 186-578. Voskresenskiy, Yu. N. O nekotorykh tipakh diffragirovannykh voln, obnaruzhyvayemykh metodom regulirovannogo napravlennogo priyema (RNP) [On certain types of diffracted waves observed by the method of controlled oriented reception (RNP)]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 197-204, 1961.

Seismic data are analyzed for seismic waves of $P_{12}P_{21}$ and $P_{112}P_{21}$ type, generated by diffraction at the intersection of a fault and a shallow rigid interface. Among the recorded waves there were waves that were diffracted-refracted while traveling a certain part of their paths. — A. J. S.

- 186-579. Oblogina, T. I. Nekotoryye amplitudnyye osobennosti voln v sredakh s krutopadayushchimi granitsami razdela [Some amplitude features of waves in mediums with steeply dipping interfaces]: Moskov. Univ. Vestnik, no. 2, p. 52-60, 1961.

Wave diffraction must be taken into account in interpretation of seismic data in sections that contain steeply dipping interfaces. Examples of such structures are the sides of igneous intrusions and of salt domes. A graphic method is presented that treats diffraction at the points of acute, right, and obtuse angles. Where a contact dips steeply under an intrusion, diffraction is from an acute angle, and the amplitude of the curve of diffraction waves diminishes evenly along the profile with distance from the contact. Where a contact dips steeply under the country rock of an intrusion, diffraction is from an obtuse angle, and the amplitude of the diffracted waves first decreases but then increases and may become larger than that of the head waves being analyzed. — J. W. C.

- 186-580. Wyllie, M. R. J., Gardner, G. H. F., and Gregory, A. R. Some phenomena pertinent to velocity logging: Jour. Petroleum Technology, v. 13, no. 7, p. 629-636, 1961.

The major experimental facts that must be considered in interpreting continuous velocity logging data are reviewed. Velocity through liquid-saturated rocks depends primarily on porosity, and the time-average formula is reliable to within 5 percent for this parameter. An exception occurs in the case of shallow unconsolidated sands. Data are given for the dilatational and shear velocities through dry rocks under a high confining stress. A correction made for pressure increase or porosity reduction with depth in the interpretation of a velocity log is unwarranted because of the many uncertain parameters involved.

The theory of Biot concerning wave propagation in a porous elastic solid is used to show the probable influence of the viscosity, density, and velocity of the fluid saturants on the velocity through saturated rocks. This theory, although plausible, has not yet been subjected to rigorous experimental tests. It cannot be used to predict wave velocities in the absence of a fluid or in different porous media, and it does not lead to an evaluation of the effect of stress on velocity. Nevertheless, the theory is helpful in leading to a better understanding of the effects of various saturants and of signal frequency on measured velocity. — J. W. C.

186-581. Clarke, W. F. Sonic log applications—Eastern Venezuela [with Spanish abstract]: *Bol. Inf.*, v. 4, no. 4, p. 119-130, 1961.

The general theory of the measurement of acoustic velocities in porous mediums and the various factors affecting these velocities are discussed, and the application of the sonic log as a porosity and (or) hydrocarbon indicator in several areas in eastern Venezuela is described. Good conformity is found between the actual field data and the experimental and theoretical results although more field data are needed at shallower depths and at higher porosities to evaluate the tool further. A specific application of the sonic log would be in an area of low permeability, such as the Cascaroncito area, Venezuela, where the economic potential is dependent on the sand permeability. Should comparison of sonic-derived porosities with core porosities from an intermediate depth show good correlation, then expensive coring at greater depths could be eliminated. — V. S. N.

Müller, Gerhard. Velocity determinations of elastic waves in frozen rocks and the application of acoustic measurements to investigations of the frozen belt at frozen shafts. See *Geophys. Abs.* 186-269.

186-582. Hobson, George D., and Collett, L. S. Some observations with a hammer refraction seismograph: *Canadian Inst. Mining and Metallurgy Trans.*, v. 63, p. 449-456, 1960.

The methods used and results from reconnaissance surveys in Ottawa, to the south of Montreal, and in southwestern Ontario by the Geological Survey of Canada using a Model MD-1 refraction seismograph are described. Measurements of depths of overburden were successful to a maximum depth of 190 feet; accuracy was found to decrease from about ± 10 percent to depths of 75 feet to about ± 15 percent below 100 feet. At the greater depths or on days of high noise level, primacord and seismic caps were used. It is concluded that this apparatus is useful and economical for certain applications. Perhaps the most important use to the geologist would be in groundwater studies and to the engineer in the search for gravel and clay deposits, dam sites, sewer work, and tunnel and pipeline construction. — V. S. N.

- 186-583. Ewing, J[ohn] I., and Tirey, G. B. Seismic profiler: *Jour. Geophys. Research*, v. 66, no. 9, p. 2917-2927, 1961.

A seismic profiler designed to reduce the time required for analysis of marine seismic refraction and reflection data and to display the data in profile form to facilitate correlation of arrivals, is described. The detector is a piezoelectric crystal hydrophone, the amplifiers are transistorized, modeled after those normally used in seismic refraction work, and the recorder is a modified Times Facsimile drum recorder. Profiling is achieved by initiating the drum rotation with the shot-instant signal. Refraction data are displayed in the form of a standard time-distance plot, the distance scale being determined by the speed of the shooting ship and the time scale by the speed of rotation of the drum, which can be preset. Reflection data are recorded in section form, analogous to standard echo sounder records. A choice of full-wave or half-wave rectification is available, and logarithmic or linear amplifier response can be selected as desired. — D. B. V.

- 186-584. Hersey, J. B., Edgerton, H. E., Raymond, S. O., and Hayward, G. Pingers and thumpers advance deep-sea exploration: *ISA Jour.*, v. 8, no. 1, p. 72-77, 1961.

Two new sonic transducers—a pinger and a thumper—which provide much increased accuracy to underwater exploration are described. The sonar pinger makes it possible to lower equipment into deep water to a desired position above the bottom. The instrument sends out short bursts of sound periodically that travel directly up to the ship as well as reflect off the bottom. Both pings are sensed by a sonar receiver on the ship and the time difference between their arrival measures the pinger-to-bottom distance. The pinger may be used to position under water cameras, water-sampling bottles, coring tools for deep ocean floor samples, and geothermal probes for measuring temperature of ocean floor sediments. It is also usable for making detailed topographic surveys of the ocean floor.

The sonar thumper is designed to generate sound waves for seismic exploration of the crust under the ocean floor. The instrument puts a large amount of acoustical energy into the water in the form of a clean, low-frequency, repeatable pulse. The actual transducer consists of a flat aluminum plate held against the face of a flat coil by means of a spring. When current flows through the coil the plate is driven away from the coil to produce a "thump" in the water. Sub-bottom penetrations of several hundred feet have been obtained using the present 1,000 w-sec input thumper. The thumper can be designed as a part of a ship or can be a submersible unit equipped with batteries which can be lowered to great depth. — V. S. N.

- 186-585. Ivakin, B. N., and Vasil'yev, Yu. F. Yemkostnyye priyemniki ul'trazvukovykh impul'sov [Capacity receivers of ultrasonic impulses]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 5, p. 725-729, 1961.

A capacity receiver is proposed that is based on the change of capacity of a plane-parallel condenser when the distance between its plates is changed by an ultrasonic wave passing through the plates and an acoustically soft dielectric layer (air). Under these conditions absolute ultrasonic displacements can be determined in a model or in the field. The circuit and construction diagrams of the device are given. Model tests show that capacity receivers can be used advantageously in ultrasonic seismic investigations. — A. J. S.

- 186-586. Hoskins, Hartley, and Knott, S. T. Geophysical investigation of Cape Cod Bay, Massachusetts, using the continuous seismic profiler: *Jour. Geology*, v. 69, no. 3, p. 330-340, 1961.

The Woods Hole Oceanographic Institution's continuous seismic profiler was used in Cape Cod Bay to make 200 miles of reflection profiles and to establish 8 oblique reflection-refraction stations. From these the areal extent and velocities of the principal seismic layers were determined. The deepest layer, 4.6-5.0 kmps, is interpreted as Paleozoic in age; its top surface forms an open-end basin which deepens northeastward from the northeast entrance of Cape Cod Canal. Erosional remnants of Cretaceous sediments, 3.0-4.0 kmps, overlie the Paleozoics. Three horizons in the 1.8-2.4 kmps range are of still younger age; the deepest is probably marine Tertiary; the intermediate is glacial till, and the shallowest is a thin covering of postglacial sediments. The paper is well illustrated with maps and cross sections. — V. S. N.

- 186-587. Milne, W. G., and White, W. R. H. A seismic survey in the vicinity of Vancouver Island, British Columbia: *Dominion Observatory Ottawa Pubs.*, v. 24, no. 7, p. 145-154, 1960.

Information on crustal structure in the area adjacent to Vancouver Island, British Columbia, has been obtained from the seismic records of a series of depth charges detonated in the vicinity of the island. In general the area has a granitic basement (seismic velocity of 6.29 kmps) that crops out on Vancouver Island and on the mainland; this layer may or may not extend to the base of the crust. South of Victoria the granitic layer is covered by a volcanic rock (velocity of 5.4 kmps); measurements of depth and of the dip of the bottom interface of this bed were obtained. A considerable thickness of low-velocity material was found under the Strait of Georgia, and near the site of the Ripple Rock explosion a low-velocity volcanic rock rests on the basement. Surface velocities were measured in all of these areas using portable refraction equipment. — V. S. N.

- 186-588. Reich, H[ermann]. Zur Frage der geologischen Deutung seismischer Grenzflächen in den Alpen [On the problem of the geologic interpretation of seismic discontinuities in the Alps (with English summary, p. 697)]: *Geol. Rundschau*, v. 50, p. 465-473, 1960.

Reflection and refraction observations of large quarry and borehole blasts in the Helvetic zone and in the Flysch at the edge of the Alps in Upper Bavaria indicate the presence of two discontinuities, at 5 km and 11 km below sea level, respectively. The former represents the basement surface; the latter the Försch discontinuity. Several other discontinuities were noted above the basement; these indicate the presence of Mesozoic formations. Some steeply dipping boundaries must be thrust planes. — D. B. V.

- 186-589. Godin, Yu. N., Vol'vovskiy, B. S., and Vol'vovskiy, I. S. Seismicheskiye issledovaniya zemnoy kory v Bukharskom rayone Uzbekskoy SSR [Seismic investigations of the earth's crust in the Bukhara area of the Uzbek SSR]: *Akad. Nauk SSSR Doklady*, v. 134, no. 5, p. 1069-1072, 1960.

Crustal structure in the Bukhara-Khivin region of the Uzbek S. S. R. was investigated seismically in 1959. A low-frequency modification of the correlation refraction method and the deep reflection method were used simultaneously to determine the relief and depth of the Paleozoic basement and for detecting waves from the lower boundaries of the crust. Waves from horizons

in the sedimentary layer and from the surface of the Paleozoic basement were detected using shot-point spacings of 12-17 km and waves from the base of the crust using shot-point spacings of 40-70 km. Results are given in a profile from the Amu Dar'ya River on the west to the Nuratau Paleozoic massif on the east. The average thickness of the crust is 45 km, ranging from 40 km in the east to 48 km in the Amu Dar'ya area. The granitic and basaltic layers are fairly constant and can be estimated approximately as 15-17 km and 18-20 km thick, respectively.

Comparison with the Fergana intermontane basin suggests that the thickness of the crust diminishes abruptly toward the northern Tien Shan and evidently would not exceed 40 km in the very center of the range. — D. B. V.

- 186-590. Kosminskaya, I. P., and Krakshina, R. M. O zakriticheskikh otrazheniyakh ot granits Mohorovichicha [The transcritical reflections from the Mohorovičić discontinuity]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 822-834, 1961.

Fundamental data on the kinematics and dynamics of the transcritical waves (reflected waves recorded at distances from the shot point greater than distances to the initial point of the traveltime curves of the waves refracted at the same boundary) reflected from the M-discontinuity are given. Seismograms obtained in the northwest and central parts of the Sea of Okhotsk and in the Pacific Ocean east of the Kurile-Kamchatka trench are analyzed. The effective seismic velocities in the crust are determined, and the M-discontinuity is constructed from the traveltime curves of the transcritical waves. An attempt was made to determine if a specific layer occurs over the M-discontinuity. Some indications were obtained that the transcritical and P-waves refracted at the M-discontinuity travel through a medium composed of more than a single layer.—A. J. S.

- 186-591. Tanaka, Akiyoshi, and Ninagawa, Shinji. Geophysical prospecting in the eastern part of Kushiro City, Hokkaidō [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 11, no. 8, p. 503-518, 1960.

Results of seismic refraction and gravity surveys carried out in the eastern part of Kushiro City, Hokkaidō, Japan, in 1957 and 1959 are presented. The surveys were for the purpose of determining the subsurface structure as a guide in the exploitation of the coal field in the area. Five seismic velocity layers were identified; the fifth or the basement rock (Cretaceous) forms a shallow basin, which is approximately 860 m below the surface at its deepest part. The gravity map indicates that the basement deepens toward the northwest from the Harutori district. Residual gravity anomalies suggest the presence of minor subsurface structures. — V. S. N.

International Geophysical Year Bulletin No. 46. Arctic Basin seismic studies from IGY Drifting Station Alpha. See Geophys. Abs. 186-602.

STRENGTH AND PLASTICITY

- 186-592. Brace, W. F. Mohr construction in the analysis of large geologic strain: Geol. Soc. America Bull., v. 72, no. 7, p. 1059-1080, 1961.

A semigraphical method of analysis of large strain based on Nadai's strain component and utilizing a Mohr construction is outlined for problems of in-

terest in structural geology. Finite homogeneous strain theory is applicable to measurement and analysis of strains from geologic features small enough to be included within regions of homogeneous strain. Use of this theory and of the strain ellipsoid and its properties implies nothing about isotropy or homogeneity of the rocks or about the stress-strain relation during deformation and therefore its application is valid over a much wider range of phenomena than usually realized. Examples of strain analysis are worked out in detail to illustrate both the versatility and the limitations of the method. — D. B. V.

- 186-593. Matsushima, Shogo. On the flow and fracture of igneous rocks: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 36, p. 1-9, 1960.

The stress-strain relations of some igneous rocks were observed in both longitudinal and lateral direction at atmospheric pressure and room temperature using a strain gauge of the electric resistance type. Curves of longitudinal strain versus stress were approximately linear up to the moment of rupture, but the strain in the lateral direction showed an abrupt increase in the fracture range. This abrupt increase of lateral strain was found to be closely related to the flow. Longitudinal creep during moderate pressure recovered almost entirely upon removal of load, but in the lateral direction a large amount of residual strain was observed after the removal of load. The empirical formulas for creep in granite are $S=A_0+A_1e^{-\alpha_1 t}+A_2e^{-\alpha_2 t}+A_3e^{-\alpha_3 t}+B \log t+Ct$ for the longitudinal direction, and $S=A+B \log t+Ct$ for the lateral direction, in which α_1 , α_2 , and α_3 denote the retardation times. — V. S. N.

- 186-594. Matsushima, Shogo. On the deformation and fracture of granite under high confining pressure: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 36, p. 11-20, 1960.

The stress-strain relations for granite were observed experimentally under various high confining pressures. It was found that the mean Young's modulus is numerically constant independent of increasing pressure. However, low pseudo-Poisson's ratio, characteristic of the first stage of loading, is gradually lost with increase of the confining pressure, and the volume increase in the fracture range decays. The empirical formula for the pressure-strength relationship is given by: $P^*=P_0*(kP_H+1)^{\frac{1}{2}}$. Since the above phenomena are closely connected with compressibility (porosity), the pressure-strength relation was calculated using Griffith's pore theory. This calculated relationship, deduced from the empirical equation of compressibility with pressure, gives the same formula as the above empirical one. — V. S. N.

- 185-595. Adadurov, G. A., Balashov, D. B., and Dremine, A. N. Issledovaniye ob'emnoy szhimayemosti mramora pri vysokikh davleniyakh [Research on volume compressibility of marble under high pressure]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 712-716, 1961.

The compressibility of marble under confining pressure up to 500,000 kg per cm^2 was investigated. The compressibility up to 30,000 kg per cm^2 and temperatures of 20°C to 95°C was investigated by the method of piston displacement in a piezometer (isothermic data), and in the interval between 50,000 and 500,000 kg per cm^2 by the method of shock compression. Polymorphic transitions accompanied by a jump in density were observed at pressures of 11,000, 16,000, 22,000, and 150,000 kg per cm^2 . The compression values obtained by the isothermic and the shock methods do not lie on the same curve. This implies that polymorphic changes due to isothermal compression are not accomplished by the shock compression. — A. J. S.

- 186-596. Langleben, M. P. Some physical properties of sea ice, pt. 2: Canadian Jour. Physics, v. 37, no. 12, p. 1438-1454, 1959.

Some properties of annual sea ice at mid-temperature latitudes were investigated. Salinity is comparable to and density much lower than that in annual arctic sea ice. Tensile strength depends on crystal size rather than on brine content. (See also Geophys. Abs. 177-184.)—D. B. V.

- 186-597. Mathews, W. H., and MacKay, J. R. Deformation of soils by glacier ice and the influence of pore pressures and permafrost: Royal Soc. Canada Trans., ser. 3, v. 54, sec. 4, p. 27-36, 1960.

Deformation of unconsolidated material by glacier ice has been observed in the Western Canadian Arctic and has been reported in other glaciated regions. It is believed to result from thrusting near the terminus of an actively moving lobe of ice, and available evidence suggests that mixed and cohesionless soils, if not the clays, were frozen when deformed, thus indicating the presence of permafrost. High pore pressures which might develop below the permafrost may facilitate thrusting by reducing the shear strength of the soils. The conditions sufficient for a moderate thickness of permafrost to develop under an advancing ice lobe and for pore pressures to build up are discussed.—V. S. N.

- 186-598. Austin, Carl F. Impulse loading of rock targets to produce fracture patterns similar to naturally occurring radial dyke systems: Nature, v. 190, no. 4772, p. 227-229, 1961.

Experiments to investigate the striking similarity between fractures induced by impulsive loads in some rock types and the great dike swarms occasionally encountered in volcanic provinces are described. Heavy cast-iron lined-cavity shaped charges were fired into light-colored limestone targets. Three basic patterns were observed in the plane perpendicular to the axis of penetration: penetration with essentially no fracturing; radial fractures around a circular or elliptical penetration; and fractures at right angles to the walls of a penetration having a rectangular or angular cross section.—D. B. V.

- 186-599. Hobbs, D. W. The strength and stress-strain characteristics of Oakdale coal under triaxial compression: Geol. Mag., v. 97, no. 5, p. 422-435, 1960.

Laboratory measurements on the Oakdale metallurgical coking coal show that the effect of an applied confining pressure produces considerable changes in the strength and stress-strain characteristics of the coal. Several fold increases in axial fracture stress, axial yield stress, Young's modulus, and elastic strain at the yield point were observed as the confining pressure was increased from 0 to 5,000 psi. The results are discussed in relation to various criteria of failure. It was found that failure was represented by Coulomb's equation relating shear stress and normal stress, provided the observed angles of fracture were not influenced by local edge stress concentrations.—V. S. N.

- 186-600. Scheidegger, A[drian] E[ugen]. On the connection between tectonic stresses and well fracturing data: Geofisica Pura e Appl., v. 46, p. 66-76, 1960.

In hydraulic fracturing treatment of wells, the pressure required to cause formation breakdown depends in part on prevailing geologic stresses. A new

model is proposed in which the stress state produced by the fluid pressure in the well is no longer fundamentally two-dimensional. It is assumed that the pressure in the well is equivalent to a spherical pressure center. The fracture condition is formulated, and the model is applied to the calculation of underground stresses from well data. — D. B. V.

- 186-601. Yuan, T'ieh-chang. Slow shearing on a strain shearing instrument [translation from Chinese]: Shui-wen Ti-chih Kung-ch'eng Ti-chih [Hydrogeology and Engineering Geology], no. 4, p. 21-26, 1960.

The laboratory method used to determine the shear strength of soft soil is described. The stress-control, strain-control shearing instruments are described and illustrated. Because the shear strength of the same soil as determined by the stress instrument is always larger than that determined by using the strain instrument, studies were conducted to determine the elements that affect the shear strength of the soil. It was found that the time elapsed during the course of shearing has an important effect on the strength of the soil. — V. S. N.

SUBMARINE GEOLOGY

- 186-602. International Geophysical Year Bulletin No. 46. Arctic Basin seismic studies from IGY Drifting Station Alpha: Am. Geophys. Union Trans., v. 42, no. 2, p. 239-243, 1961.

Reflection and refraction seismic measurements made between July 1957 and November 1958 from Drifting Station Alpha in the Arctic Ocean pack ice reveal the Alpha Rise, one of the large positive features of Arctic Ocean topography. Relief on the rise is rugged, apparently due to block faulting.

Refraction results show that the average thickness of the unconsolidated layer is 0.38 km, compared to $\frac{1}{2}$ -1 km in the North Atlantic; a deeper, 4.7-kmps layer is 2.8 km thick; and this is underlain by an "oceanic" layer having a velocity of 6.44 kmps, in close agreement with the 6.5 kmps velocity found in the North Atlantic. — D. B. V.

- 186-603. Miyake, Yasuo, and Sugimura, Yukio. Ionium-thorium chronology of deep-sea sediments of the western North Pacific Ocean: Science, v. 133, no. 3467, p. 1823-1824, 1961.

The rate of deposition of deep-sea deposits collected at depths of 6,215-8,450 m in the northwest Pacific Ocean was estimated from the ionium/thorium ($\text{Th}^{230}/\text{Th}^{232}$) ratio, determined by means of an alpha-ray spectrometer, to be 0.5-0.8 mm per 10^3 yr for the upper 10 cm of the sea floor. — D. B. V.

- 186-604. Dulberger, Leon H. Sonar to survey Arctic Ocean shelf transmits through ice and water: Electronics, v. 34, no. 31, p. 44-45, 1961.

Sonar designed to survey the Arctic Ocean continental shelf through surface ice or directly in water is now in use. The sonar's transducer is coupled to the ice by a layer of high-viscosity oil to achieve maximum sound transfer. The instrument is described and a schematic diagram is presented. — V. S. N.

- 186-605. Seibold, Eugen. Der Boden der Ozeane und die Erdgeschichte [The floor of the oceans and earth history]: Naturwissenschaften, v. 48, no. 9, p. 319-323, 1961.

This is a review of deep sea geologic research. After a discussion of the horizontal and vertical distribution of deep sea sediments and their dating, the late history of the Pacific Ocean as deduced from the sedimentary record is outlined to illustrate the results obtained with new methods and the problems remaining to be solved. — D. B. V.

186-606. Leonov, A. K. Regional'naya okeanografiya, chast' 1 [Regional oceanography, pt. 1]: Leningrad, Gidrometeoizdat, 765 p., 1960.

This is a predominantly hydrological treatise based on theoretical and observational data. The geologic history and morphology of the basins of the Bering, Okhotsk, Japanese, Caspian, Black, and Azov Seas are discussed separately. The geology of the sea floor, the bottom sediments, and the tectonics of the basin margins are treated for each. — A. J. S.

Hersey, J. B., Edgerton, H. E., Raymond, S. O., and Hayward, G. Pinners and thumpers advance deep-sea exploration. See Geophys. Abs. 186-584.

VOLCANOLOGY

186-607. Rittmann, A[lfred]. Fortschritte der Vulkanologie [Progress in volcanology]: *Experientia*, v. 16, no. 6, p. 232-237, 1960.

The chief results of recent volcanological research along different lines are reviewed. The most important of these concern the origin of magma (primarily and anatectic), the mechanism of eruptions, the geographic distribution of volcanoes and "magma series," and the intimate relations between volcanic and tectonic phenomena. The general conclusions are drawn that volcanism should be regarded as a process of degasification of the earth, and that use of physical and chemical methods contributes to the ultimate progress of the essentially geologic science of volcanology. — D. B. V.

186-608. Shimazu, Yasuo. A thermodynamical aspect of volcanic gas: *Nagoya Univ. Jour. Earth Sci.*, v. 8, no. 2, p. 197-221, 1960.

The role of water vapor at the final stage of magmatic differentiation and the intimate relation between volcanic eruption and development of volcanic gas phases are discussed. The solubility of water in residual melts is not so large that melts become saturated with water by cooling and crystallization, but a solubility gradient is set up and a local supersaturated state realized when temperature and (or) pressure gradients exist within a magma reservoir. Assuming an albite-H₂O binary magma and applying the thermodynamics of irreversible processes the following results are found: (1) In an undersaturated magma when an upward decreasing temperature gradient and the height of the magma reservoir are fixed as constants, crystallization and melting take place at the top and bottom of the reservoir respectively. (2) In a super saturated magma, when hydrodynamic flow exists within the reservoir both water vapor and albite melts develop at the top and albite crystallizes at the bottom. Under these conditions the pressure at the top is 1.25 kb greater than that of the surrounding rocks and an explosion of the reservoir may occur when the height becomes >1 km. When floating-up of gas bubbles is possible a large pressure rise occurs at the top and explosions of the magma take places easily. The numerical values of gradients of temperature, pressure, concentration, transfer rates of magma and gas, and reaction rates are given in a table. Varia-

tions in composition of volcanic gas emitted at the surface from a magma reservoir and the relationship to the physical conditions of the magma reservoir are discussed also. — V. S. N.

- 186-609. Matsuo, Sadao. On the origin of volcanic gases: Nagoya Univ. Jour. Earth Sci., v. 8, no. 2, p. 222-245, 1960.

A theoretical study of the chemical composition of magmatic gases in three different kinds of magma (basaltic, dacitic, and granitic) is reported. It is believed that many of the gaseous components are produced in a magma by the oxidation-reduction reactions between water vapor and the component minerals. A very close correlation is found between chemical composition of the magmatic gases and the mineral assemblage of the magma; the more basic the magma the higher is the hydrogen content and the lower is the content of sulfur compounds in the magmatic gases under conditions of constant temperature-pressure. The content of sulfur dioxide in the gases is highly sensitive to variations in pressure and temperature, whereas, the content of other components is rather insensitive to such variations. This may afford a chemical means of forecasting volcanic eruptions. The chemical compositions of lavas observed at Kilauea in Hawaii and at Showashinzan in Hokkaido, Japan, are discussed. The analyzed composition of the Kilauea lava-lake gases and the calculated composition (at 1 atm pressure and 1,500°K) of the gases in the basaltic magma agree with each other within the range of scattering of analytical results and thermodynamic uncertainties. At Showashinzan Volcano estimates based on the composition of the volcanic gases suggest a depth of a few kilometers for the magma reservoir with a magma at 1,300°K under pressures of $2\sim 3 \times 10^2$ atm. — V. S. N.

- 186-610. Castello Branco, A. de, Zybszewski, G., Moitinho de Almeda, F., and Veiga Ferreira, O. da. Rapport de la première mission géologique [Report of the first geologic mission], in *Le volcanisme de l'Île de Faial et l'éruption du volcan de Capelinhos* [The volcanism of Fayal Island and the eruption of Capelinhos Volcano]: Portugal Serviços Geol. Mem., no. 4, p. 9-27, 1959.

This report begins with an outline of the geology of the western part of Fayal Island in the Azores; then presents observations on the activity of Capelinhos Volcano up to the first appearance of lava. During the period September 27-November 3, 1957, the volcano was born and the first two islands were formed and destroyed. In the period November 4-December 16, 1957, a third island appeared and joined the mainland as it grew. The first lavas appeared on December 17. Activity in the period covered in this report was typical of submarine volcanoes. (See also Geophys. Abs. 173-361, 175-409, -410, 178-429.) — D. B. V.

- 186-611. Zbyszewski, G., and Veiga Ferreira, O. da. Rapport de la deuxième mission géologique sur le volcanisme de l'Île de Faial [Report of the second geologic mission on the volcanism of Fayal Island], in *Le volcanisme de l'Île de Faial et l'éruption du volcan de Capelinhos* [The volcanism of Fayal Island and the eruption of Capelinhos Volcano]: Portugal Serviços Geol. Mem., no. 4, p. 29-55, 1959.

The volcanism of eastern and central Fayal Island in the Azores, the geologic structure of the island, and natural resources related to volcanism (mineral waters and building materials) are discussed; then observations of the

activity of Capelinhos from December 17, 1958 to November 30, 1959 are presented. Activity during that time can be divided into three distinct periods: Lava began to flow on December 17, 1958, but explosive activity and ejection of pyroclastic material predominated until May 12, 1959; after the strong earthquake of May 13 and until October 25, activity was predominately effusive and typically strombolian, particularly in August; after October 25 all activity ceased except fumarolic. — D. B. V.

186-612. Tazieff, H[aroun]. L'éruption de 1957-58 et le tectonique de Faial (Açores) [The eruption of 1957-58 and the structure of Fayal (Azores)], in *Le volcanisme de l'Île de Faial et l'éruption du volcan de Capelinhos* [The volcanism of Fayal Island and the eruption of Capelinhos Volcano]: Portugal Serviços Geol. Mem., no. 4, p. 71-88, 1959.

This paper is almost identical with that published in the Soc. Belge Géologie, Paléontologie, et Hydrologie Bull., v. 67, no. 1, p. 13-36, 1959 (see Geophys. Abs. 178-429). — D. B. V.

186-613. Machado, Frederico. A erupção do Faial em 1672 [The Fayal eruption in 1672], in *Le volcanisme de l'Île de Faial et l'éruption du volcan de Capelinhos* [The volcanism of Fayal Island and the eruption of Capelinhos Volcano]: Portugal Serviços Geol. Mem., no. 4, p. 89-99, 1959.

The 1672 eruption on the island of Fayal in the Azores is reconstructed on the basis of contemporary reports and field study of the lava flows. The eruption was preceded by a swarm of earthquakes with focuses located near the active vents at a depth of about 3 km. Activity began on April 24 with short-lived explosive activity followed by extrusion of lavas, which flowed for 10 months and covered the western part of the island. The volume of lava is estimated at about $360 \times 10^6 \text{ m}^3$ (of which only $16 \times 10^6 \text{ m}^3$ remained above sea level), averaging a little more than $1 \times 10^6 \text{ m}^3$ per day. Total energy liberated during the whole activity is calculated as about 10^{25} ergs. — D. B. V.

Yukutake, Takesi, and Tanaoka, Iwao. Magnetic survey on Hakone Volcano by use of a proton magnetometer. See Geophys. Abs. 186-530.

186-614. Kizawa, Takashi. A study of earthquakes in relation to volcanic activity (3)—Earthquakes during the period of activity of Volcano Usu (1934-1945), two new phases of the earthquakes, and earthquakes of crypto-volcanic activity at Ito [with Japanese abstract]: Papers in Meteorology and Geophysics, v. 11, no. 1, p. 30-96, 1960.

The principal results of a study of earthquakes associated with the activity of Usu Volcano, Hokkaido, Japan, from 1943 to 1945 are reported. The distribution of epicenters of A-type (prior to eruption) earthquakes was determined from the value of the distance coefficient ($k=8.2$ km/s) obtained by analysis of 7 A-type earthquakes associated with formation of the new cone, Showa Shinzan; the depth of the hypocenter was determined to be about 10 km. Study of the decay in frequency and amplitude with time shows that eruptions occurred after the earthquakes had declined. The value of the absorption coefficient for two major A-type earthquakes in January 1944 was determined from the maximum ground amplitude and epicentral distance as $5.8 \times 10^{-3} \text{ km}^{-1}$ when $25 < \Delta < 700$ km, and as $5.6 \times 10^{-3} \text{ km}^{-1}$ when $25 < \Delta < 800$ km. These values

are almost identical with the values determined by Wadati (1931) for tectonic earthquakes within the same magnitude range (6.2 to 5.4); thus it is concluded that the A-type volcanic earthquakes of Usu are similar to tectonic earthquakes. A crustal model in the vicinity of Usu giving the depth to the M-discontinuity as $H=25.0$ km was derived from the reflected S-waves.

From a study of both A- and B-type earthquakes on the seismograms at Mori Observatory two new phases of waves with paths largely in shallow sea water were observed. These are treated as Rayleigh waves. Detailed results have been published previously (see *Geophys. Abs.* 182-134, 183-159).

The mean values of m in the Ishimoto-Iida formula, $ndA=KA^{-m}dA$, which expresses the relationship between frequency n and amplitude A of an earthquake, are calculated from data of the Itô crypto-volcanic activity and the Kita-Izu earthquake swarms in 1930 as $m=1.85$ and 1.50 , respectively. The value of 1.85 for the Itô activity is nearly equivalent to values obtained from A-type earthquakes of volcanic origin, whereas the lower value of m for the Kita-Izu earthquake swarms suggests a different mechanism. The values of m for the earthquakes at Tesikaga, Tango, Nankai, and Fukui have been calculated as 1.91 , 1.7 , 1.8 , and 1.9 , respectively. — V. S. N.

186-615. Shima, Michiyasu. Volcanic micro-tremors at the Volcano Aso: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 34, 17 p., 1960.

The results of an investigation of microtremors at Aso Volcano, Japan, since 1950 are reported. Microtremors of Love (type 1) and Rayleigh (type 2) types, according to Sassa's classification of four types (1935), are discussed here. These microtremors stop suddenly before an eruption and increase again following an eruption; this phenomenon was observed during the period of the eruptions of April 1953, December 1957, and June 1958. At the time of an eruption the value of the NS-EW components of amplitude of type-2 microtremors increases from 0 to 1, and it is assumed that the fracture paralleling the row of craters vibrates along with the magmatic reservoir after an eruption. The azimuthal distribution of amplitude is calculated, and the results indicate that the transverse component is of the same order of magnitude as the longitudinal component. — V. S. N.

186-616. Yuhara, Kozo. On the Uchinomaki hot springs in Aso Caldera: Balneol. Soc. Japan Jour., v. 11, no. 4, p. 61-71, 1960.

Ninety hot springs have been bored at Uchinomaki in Aso Caldera. They range from 50 to 190 m in depth, from 32°C to 49°C in temperature, and have a combined flow rate of 3,084 l per min. Since investigations in 1940 and 1952, the mean depth and total flow rate of the springs have increased noticeably while the maximum temperature has remained the same. The content of Cl, SO_2 , HCO_3 , Na, and Ca of the water varies roughly with temperatures. In the center of the hot spring area the waters are high in N_2 and low in O_2 suggesting that the source is from vadose waters, moreover the present activity of Aso Volcano does not affect the hot springs. The heat source is unquestionably volcanic, however. — V. S. N.

186-617. Koga, Akito. Chemical studies on the hot spring of Beppu (13). The local specific feature of the Beppu hot spring (1) [in Japanese with English abstract]: Balneol. Soc. Japan Jour., v. 9, no. 2/3, p. 63-68, 1958.

The deviation of the SO_4/Cl ratio from that of sea water was determined for the waters of 80 hot springs in the Beppu area, Kyushu, Japan. In general,

this deviation was found to be larger in the hilly districts than near the sea coast. — V. S. N.

186-618. Sahara, Ryotaro. The chemical studies of the hot spring waters in Akita Prefecture: Akita Univ. Mining Coll., Research Inst. Underground Resources Rept., no. 22, p. 32-69, 1960.

The results of chemical analyses of waters from 122 hot springs in Akita Prefecture, Japan, are reported. It was found that the waters of hot springs along the Ōu mountains in the Nasu volcanic zone have compositions characteristic of hot springs of volcanic origin. These springs along the coast of the Japan Sea and Lake Hachiro have saline waters related to the brine waters found in the nearby oil and natural gas zones. —V. S. N.

INDEX

	Abstract		Abstract
Academy of Sciences of the U. S. S. R. -----	111	Báth, Markus -----	155, 191
Adachi, Ryuzo -----	279	Baumgarte, J -----	246
Adadurov, G. A -----	595	Bayuk, Ye. I -----	273
Adams, W. M -----	166, 203	Bedrinov, V. P -----	460
Adams, W. S -----	238	Beiser, Arthur -----	336
Aebersold, P. C -----	337	Belotelov, V. L -----	162
Afanas'yev, N. L -----	395	Belousov, V. V -----	367, 374
Akamatu, Kei -----	534	Bemmelen, R. W. van -----	368
Aki, Keiiti -----	201	Benioff, Hugo -----	183
Alberta Society of Petroleum Geologists -----	207, 371	Ben-Menahem, Ari -----	155
Alfano, Luigi -----	291	Benson, B. B -----	463, 464
Alford, J. L -----	281	Berg, G. V -----	165
Alger, R. P -----	343	Berg, J. W., Jr -----	442
Allan, T. D -----	521	Berkman, R. Ya -----	516
Allen, D. C -----	203	Berlin, T. S -----	326
Alsop, L. E -----	184, 195	Bernard, M. C -----	169
Alter, Dinsmore -----	84	Bernshteyn, V. A -----	529
Alterman, Z -----	188	Bhattacharji, J. C -----	347
Amstutz, G. C -----	360	Bigarella, J. J -----	510
Anders, Edward -----	59, 60, 65	Birch, Francis -----	267
Anderson, D. L -----	240	Blake, Weston, Jr -----	382
Andreyev, S. S -----	158	Blundell, D. J -----	500
Angenheister, G. H -----	523	Bobier, Claude -----	512
Anokhina, L. K -----	40	Bogdanoff, J. L -----	169
Aoki, Harumi -----	286, 287	Bolt, B. A -----	202, 255
Arima, Sumiteru -----	304	Bonchkovskiy, V. F -----	351
Arkhangel'skiy, V. T -----	214	Bondarenko, A. T -----	325
Artamonov, L. V -----	307	Bonhomme, Michel -----	24, 25, 30
Asimov, Isaac -----	93	Bonini, W. E -----	431
Astier, J. L -----	324	Borchert, Hermann -----	359
Aswathanarayana, U -----	344	Borisov, A. A -----	528
Atkins, E. R., Jr -----	311	Bosschart, R. A -----	290
Ault, W. U -----	178	Bosum, W -----	524
Austin, C. F -----	598	Brace, W. F -----	592
Austin, C. R -----	177	Brekhovskikh, L. M -----	243
Aver'yanova, V. N -----	149	Brereton, R. G -----	91
Baadsgaard, Halfdan -----	16, 38	Brockamp, Bernhard -----	97
Backus, George -----	186	Bronshten, V. A -----	107
Bagdasarova, A. M -----	149	Brouwer, Dirk -----	230
Bainbridge, A. E -----	457	Brown, Harrison -----	83
Balakrishna, S -----	270	Brune, J. N -----	183, 195
Balashov, D. B -----	595	Bubnova, V. I -----	147
Ball, R. M -----	133	Buddington, A. F -----	508
Balsley, J. R -----	508	Buffington, P. G -----	154
Bancroft, A. M -----	398	Bulin, N. K -----	147, 199
Barabashev, N. P -----	102, 112	Bullard, E. C -----	419, 473
Barnes, V. E -----	81	Bullen, K. E -----	245
Barsukov, O. M -----	487	Bullerwell, W -----	406
Bascom, Willard -----	340	Bune, V. I -----	142, 148
		Burke, K. B. S -----	407
		Burša, Milan -----	350
		Butcher, N. E -----	32, 36

	Abstract		Abstract
Byrne, C. J -----	539	Dingle, Herbert -----	56
Byström-Ask Lund, A. M -----	38	Dix, C. H-----	239
Cadisch, Joos -----	356	Dmitriyev, V. I -----	297
Caloi, Pietro -----	192	Dobrev, T. B -----	409, 569, 575
Cameron, J. B -----	135	Dodson, M. H-----	33, 34
Carder, D. S -----	238	Donati, G. L-----	400
Carron, J. -P -----	540	Dooley, J. C-----	72
Castello Branco, A. de -----	610	Dorman, James -----	255
Chakrabarty, S. K-----	204	Dremin, A. N -----	595
Chakraborty, S. K-----	248	Dubin, Maurice -----	76
Chapman, Sydney-----	342	DuFresne, E. R-----	61
Chase, A. B -----	444	Dulberger, L. H -----	604
Cherdyntsev, V. V-----	471	Duncan, R. A -----	486
Cheremenskiy, G. A -----	425, 426	Dzhibuti, S. S-----	424
Cheremnykh, G. D -----	386	Eaton, J. P-----	178
Chessex, Ronald -----	27	Eberhardt, A -----	62
Chevallier, Raymond -----	504	Eberhardt, Peter-----	62
Chow, T. J -----	459	Eckels, Ann -----	389
Christiansson, Hans -----	383	Edgerton, H. E -----	584
Clark, J. F -----	70	Egyed, László -----	362, 372, 445
Clarke, W. F -----	581	Epstein, Samuel-----	466
Clayton, R. N-----	466	Eskola, Pentti -----	358
Clément, A -----	573	Evans, J. W -----	337
Cloud, W. K -----	205	Evernden, J. F -----	1, 23, 28
Cobb, J. C -----	37	Ewing, J. I -----	583
Collett, L. S -----	582	Ewing, Maurice -----	183, 184, 198
Collier, J -----	11	Fairbairn, H. W -----	6, 20
Cook, A. H -----	392	Fairbridge, R. W -----	338, 339
Cook, K. L -----	442	Fedorov, Ye. P -----	224
Corbett, J. D -----	305	Fedotov, S. A -----	149
Craig, Harmon -----	456	Feofilaktov, V. D -----	211, 275
Crary, A. P -----	385	Ferchev, M. D -----	143
Crea, Antonio-----	292	Ferrians, O. J., Jr -----	18
Crozier, W. D -----	77	Feyling-Hanssen, R. W-----	39
Curtis, G. H -----	1, 23	Fiji Geological Survey Department -----	47
Dachev, Khristo -----	575	Fireman, E. L-----	79
Danilevich, S. I -----	4	Firsov, F. V -----	423
Danjon, André-----	232	Fischer, W. A -----	126
Day, A -----	419	Fisher, D. E -----	55, 68
Defant, Albert-----	222	Fleming, H. W -----	306
Dengler, Heinrich -----	523	Focken, C. M -----	50
Deniskin, N. A -----	120	Folinsbee, R. E-----	38
De Noyer, John-----	260	Fremd, V. M -----	215
Deresiewicz, H-----	259	Frolov, A. D -----	278
der Waerden, B. L. van -----	229	Frolova, A. V -----	566, 567
de Sitter, L. U-----	361	Fukuzawa, Hiroshi -----	304
Deutsch, E. R -----	370	Fullam, E. F -----	74
de Waard, H -----	22	Fultz, Dave -----	335
Dewan, J. T -----	554	Gal'perin, Ye. I -----	566, 567
Dey, A. K -----	73	Gamow, George -----	387
Dietz, R. S -----	71, 352	Gane, P. G -----	329
Diggelen, J. Van -----	96		
Dimitrov, L. V -----	409		

Abstract		Abstract	
Gardner, G. H. F	580	Hill, M. N	432
Gar'kovets, V. G	330	Hirono, Takuzo	136
Garland, G. D	404	Hobbs, D. W	599
Garlick, W. G	329	Hobson, G. D	582
Gaskell, T. F	432, 440	Hochstrasser, Urs	197
Geis, Hans-Peter	355	Hodge, P. W	78
Geochron Laboratories	51	Hodgson, R. L	378
Gerling, E. K	45	Hoffman, J. H	16
Gilbert, Freeman	186, 241	Hoffman, J. P	442
Gilmour, A. E	179	Hoinkes, H	333
Gilvary, J. J	88, 353	Holmes, C. R	134
Gladkiy, K. V	394	Horai, Ki-iti	415, 427, 428
Glangeaud, Louis	512	Hosaya, Noboru	309
Glauber, A. E	555	Hoskins, Hartley	586
Glyuzman, A. M	296, 300, 301	Housner, G. W	165
Godin, Yu. N	589	Howell, B. F., Jr	322, 430
Goldberg, E. D	458	Hoyle, F	66
Goldberg, J. E	169	Hudson, D. E	205, 281
Goldich, S. S	16	Hunter, W	94
Goldsztein, M	545	Hurley, P. M	6, 20
Goles, G. G	59	Hutchinson, R	479
Goodman, A. J	369		
Gorelikov, S. A	140	Ichikawa, M	168
Goto, Hisao	176	Iida, Kumizi	286
Gougenheim, André	221	Innes, M. J. S	70
Grabovskiy, M. A	503, 505	Inoue, Eiji	381
Grechukhin, V. V	318	International Geophysical Year	
Green, D. H	35	Bulletin No. 46	602
Gregory, A. R	580	Ionosphere Research Com-	
Grünenfelder, M	29	mittee, Science Council of	
Guillermo, S	545	Japan	498
Gzovskiy, M. V	142	Irie, Tsuneji	303
		Isabayev, Ye. A	471
Haalck, Fritz	518	Ishihara, Hiraku	549
Hadley, J. B	129	Ishii, Fujio	310
Hafner, S	29	Itenberg, S. S	319
Hahn, Albrecht	523	Ito, Junji	320
Hai, Nguyen	193	Ivakin, B. N	585
Hamilton, A. C	399	Ivanov, A. I	44, 46
Hamilton, E	546	Ivanov, I. V	3
Harada, Yoshimichi	402	Iwan, W. D	281
Hart, S. R	8, 19		
Haskell, N. A	237	Jackson, J. E	397
Hassen, E. S. M	223	Jacobs, J. A	413, 483
Hatherton, T	334, 538	Jardetszky, W. S	477
Hattori, Yasuzo	309	Jarosch, H	188
Hayward, G	584	Jastrow, Robert	90
Heaps, C. W	337	Jeffreys, Harold	225
Hemenway, C. L	74	Jensen, M. L	470
Hersey, J. B	584	Jobert, Nelly	187
Herz, Norman	20	Johnson, R. W., Jr	520
Herzenberg, A	474, 478	Joplin, G. A	379
Heusser, C. J	21	Jordan, P	373
Hibbs, A. R	76	Judge, D. L	480
Hiersemann, Lothar	363	Jurain, Georges	551

	Abstract		Abstract
Kaiser, T. R -----	80	Krauskopf, Konrad-----	336
Kakinuma, Seiichi -----	402, 403	Krestnikov, V. N-----	142
Kakioka Magnetic Observatory-----	485	Krey, Theodor -----	246
Kalashnikov, A. G-----	509, 525	Krueger, H. W-----	16
Kametani, Takuya -----	571	Krummenacher, Daniel-----	28
Kanai, Kiyoshi -----	172, 173	Kryukova, N. F-----	41
Kanasewich, E. R -----	404	Kubotera, Akira -----	285
Kanda, Yutaro -----	563	Kuchina, G. N-----	41
Kaneta, Kiyoshi -----	176	Kulp, J. L-----	37
Kanroji, Yasuo -----	309	Kumar, Sudhir -----	265
Kaula, W. M -----	348	Kunori, Shoichi -----	310
Kawamura, Takashi-----	571	Kuroda, P. K -----	67, 544
Kawashima, Takeshi-----	572	Kutschale, Henry-----	280
Kaydanovskiy, N. L-----	105	Kuzin, A. P -----	149
Kazakov, G. A -----	10	Kuznetsov, A. A -----	410
Kelso, J. M -----	480	Kuznetsov, V. P-----	157
Kenna, B. T -----	544	Laevastu, Taivo -----	75
Kennedy, G. C -----	439	Langleben, M. P -----	596
Keylis-Borok, V. I -----	142, 266	Lapwood, E. R -----	256
Khakakov, A. V-----	106, 326	Latter, A. L -----	236
Khajibullin, Sh. T-----	99	Latypov, Zh -----	576
Khain, V. Ye -----	144	Layat, C-----	573
Khalturin, V. I-----	142	Lazarev, G. Ye -----	437
Khanutina, R. V-----	251	Lazarev, V. N -----	316
Khitrov, L. M-----	467	Leakey, L. S. B -----	23
Khorosheva, V. V -----	272	Lederstegger, Karl-----	451
Khristichenko, P. I-----	212	Leet, L. D -----	282
Khudzinskiy, L. L -----	570	Lehmann, Inge -----	198, 443
Khvalovskiy, A. G-----	330	Leonov, A. K -----	606
King-Hele, D. G-----	390	Levskiy, L. K -----	45, 64
Kirillova, I. V -----	144, 146	Liberty, B. A -----	70
Kirnos, D. P -----	214, 216	Licastro, P. H-----	322
Kishinouye, Fuyuhiko -----	535	Linder, I -----	115
Kistler, R. W -----	1	Lin'kov, Ye. M-----	210
Kistner, G. A -----	79	Lipschultz, M. E-----	60
Kitsunezaki, Choro -----	561	Lipskaya, N. V-----	120
Klyucharev, V. S -----	316	Lipskiy, Yu. N-----	110, 114
Kizawa, Takashi-----	614	Lister, H-----	332
Knapp, D. G -----	489	Logan, John -----	321
Knopoff, Leon -----	241, 261	Lomnitz, Cinna -----	123
Knott, S. T -----	586	Longinelli, A -----	26
Kobayashi, Naota -----	185, 200, 263	Longuet-Higgins, M. S -----	541
Koga, Akito -----	617	Lowenstam, H. A -----	465
Kogan, S. D -----	153	Lowes, F. J -----	478
Koide, M -----	458	Lucke, Otto -----	450
Kokubun, Susumu -----	495	Lum, Daniel -----	313
Kolmakov, M. V-----	117, 121	Lyubimova, Ye. A -----	423
Komlev, L. V -----	41	Lyusova, L. N -----	423
Kondorskaya, N. V-----	162	Lyustikh, Ye. N-----	144, 452
Kosminskaya, I. P-----	590	McAleer, J. F -----	131
Kovach, R. L -----	196	MacCarthy, G. R-----	125
Krakshina, R. M -----	590	McCrea, W. H -----	52
Kraskovskiy, S. A-----	417	MacDonald, G. J. F-----	87, 226, 412
Kraus, E. C -----	365		

Abstract		Abstract	
McDougal, I -----	411	Murphy, Thomas -----	405
McDougal, Ian -----	9	Murray, B. C -----	83
McIntosh, D. H -----	476	Myers, J. O -----	407
MacKay, J. R -----	597		
MacMillan, W. G -----	236	Nafe, J. E -----	195
Machado, Frederico -----	613	Nag, K. R -----	257
Magnitskiy, V. A -----	446	Nagata, Takesi -----	492, 494, 495
Makhmudova, V. M -----	315		497, 506, 514
Malinovskaya, L. N -----	142	Nagumo, Shozaburo -----	572
Malurkar, S. L -----	499	Nakai, Nobuyuki -----	455, 470
Markov, A. V -----	100, 103, 109	Nanda, J. N -----	541
Markowitz, William -----	234	Nemiro, A. A -----	233
Marler, G. D -----	132	Nersesov, I. L -----	142
Martinelli, E. A -----	236	Newfarmer, L. R -----	327
Marussi, Antonio -----	346	Nicholson, S. B -----	482
Mashiko, Yasushi -----	309	Nier, A. O -----	16
Mathews, J -----	236	Nikiforova, N. N -----	119
Mathews, W. H -----	597	Nile, S. W -----	127
Mathieu, Suzanne -----	504	Ninagawa, Shinji -----	591
Matsuo, Sadao -----	609	Nishida, Atsuhiko -----	493
Matsushima, Shogo -----	593, 594	Nomoto, Morikazu -----	58
Matthews, W. L -----	553	Nordquist, J. M -----	201
Matumoto, Hideteru -----	217	Nozières, Philippe -----	540
Matumoto, Tosimatsu -----	141, 194	Nurlybayev, A. N -----	44
Matuura, Nobuo -----	494	Nutli, O. W -----	190, 242
Mayne, K. I -----	453	Nygaard, K. J -----	12
Melchior, P. J -----	228		
Mellis, Otto -----	75	Oblogina, T. I -----	579
Mendès, Francisco -----	25	Obradovich, J -----	1
Merson, R. H -----	391	O'Brien, P. N. S -----	557
Meyer, R. P -----	431	Ochapovskiy, B. L -----	180
Michot, Paul -----	357	Offshore -----	568
Migaux, Léon -----	324	Ogurtsov, K. I -----	250
Mikhaylov, A. A -----	113	Oguti, Takasi -----	496
Mikhaylova, N. P -----	527	Ohashi, Shin-ichi -----	402, 403
Mikhaylovskiy, V. N -----	516	Oilweek -----	328, 565
Mikumoto, Takeshi -----	435	Okano, Kennosuke -----	285
Miller, J. A -----	33, 35	O'Keefe, J. A -----	389
Miller, R. D -----	17	Oliver, J. E -----	189
Millman, P. M -----	70	Olivero, Sergio -----	420
Milne, W. G -----	587	Olsson, Ingrid -----	39
Miyamoto, Sadao -----	161, 163, 164	Omori, Keiichi -----	54
Miyake, Yasuo -----	603	Öpik, E. J -----	92, 95, 116, 337
Miyamura, Setumi -----	150, 151, 152	Orlov, D. P -----	471
Moitinho de Almeda, F -----	610	Osipov, I. O -----	253
Monakhov, F. I -----	531, 532	Otsuka, Michio -----	435
Monich, V. K -----	44	Ovchinnikov, L. N -----	43
Montandon, Frédéric -----	341	Ovchinnikova, G. V -----	7, 45
Moorbath, S -----	34	Owen, T. R -----	36
Morris, R. L -----	554		
Mueller, I. I -----	349	Page, Thornton -----	337
Müller, Gerhard -----	269	Panasenko, G. D -----	138
Mumme, I. A -----	436	Pannekoek, A. J -----	364
Munk, W. H -----	223, 226	Park, R. G -----	522
Murina, G. A -----	10	Parker, P. D. M -----	463

	Abstract		Abstract
Parkin, D. W -----	94	Roques, Maurice -----	30
Pasechnik, I. P -----	153	Rose, H. J., Jr -----	5
Pasechnik, I. P -----	283, 284	Rosenfeld, J. L -----	444
Pasteels, Paul -----	15	Rösler, R -----	122
Pavlov, N. N -----	233	Rothé, J. -P -----	124
Pavlova, G. I -----	142	Roy, S. K -----	61
Pavlovskiy, V. I -----	526	Runcorn, S. K -----	475
Pekeris, C. L -----	188, 244	Ruprekhtova, L -----	159
Pellas, Paul -----	14	Rutten, M. G -----	511
Penta, Francesco -----	420	Rybakova, Ye. V -----	295
Petrov, L. V -----	560	Rykov, A. V -----	216
Pettersson, Hans -----	56	Rykunov, L. N --	272, 275, 277, 533
Pham-Van-Ngoc -----	408	Rymanov, V. M -----	528
Philibert, Josette -----	30	Sahara, Ryotaro -----	618
Phillips, Laurence -----	74	Saito, Masanori -----	258, 262
Piddington, J. H -----	491	Saito, Nobufusa -----	48
Pinson, W. H. Jr -----	6, 20	Salamuni, Riad -----	510
Pishchyalov, S. St -----	409	Salisbury, J -----	86
Plewa, Stanisław -----	314	Sandoval, Paula -----	457
Pod'yapol'skiy, G. S -----	252	Sanford, A. R -----	134
Pokrovskiy, V. A -----	421	Sano, Shun-ichi -----	550
Polevaya, N. I -----	2, 10	Santo, T. A -----	536, 537
Popov, G. I -----	181	Sarkisov, I. K -----	315
Popov, I. I -----	214	Sato, Kazuo -----	48
Popova, A. V -----	513	Sato, Koji -----	309
Press, Frank -----	196	Sato, Konosuke -----	331
Pronyayeva, Ye. A -----	147	Sato, Yasuo -----	170, 264
Pros, Zdeněk -----	271	Savarenskiy, Ye. F -----	199, 434
Quiring, Heinrich -----	377	Savinskiy, I. D -----	543
Rabinovich, V. B -----	526	Savonenkov, V. G -----	41
Rama -----	458	Schatzmann, Evry -----	227
Rao, K. S. R -----	484	Scheidegger, A. E -----	600
Rapoport, M. B -----	274	Schulz, Gerhard -----	247
Rastvorova, V. A -----	144	Schulze, Reinhard -----	518
Rautian, T. G -----	142	Scott, G. R -----	17
Raymond, S. O -----	584	Sedov, V. V -----	272
Reich, Hermann -----	588	Seibold, Eugen -----	605
Reitzel, John -----	418	Selyuminov, S. D -----	277
Research Group for Proton Magnetometers (Japan) -----	519	Seshadri, S. R -----	293
Revol, Philippe -----	324	Shaya, Kiyoshi -----	577
Reysner, G. I -----	142	Shakhsuvarov, D. N -----	295, 298
Richards, F. A -----	464	Shamina, O. G -----	249, 251
Richter, C. F -----	380	Shansi Provincial Depart- ment of Agricultural Construction -----	308
Richter, D. H -----	178	Sharonov, V. V -----	108
Rikitake, Tsuneji -----	415, 488	Sharp, R. P -----	384
Ringwood, A. E -----	57, 449	Shaub, Yu. B -----	118, 294, 299
Rittmann, Alfred -----	607	Shcherba, G. N -----	46
Riznichenko, Yu. V ---	142, 249, 251	Shcherbakova, R. N -----	460
Roberts, P. H -----	472	Shechkov, B. N -----	433
Rocard, Yves -----	540	Shestakov, G. I -----	3
Rodicheva, E. K -----	513	Shevkunov, Ye. N -----	316
Roever, W. L -----	268	Sheynmann, Yu. M -----	375

Abstract	Abstract
Shima, Etsuzo ----- 218	Tabata, Takeo ----- 571
Shima, Michiyasu ----- 615	Tabulevich, V. N ----- 139
Shimazu, Yasuo ----- 608	Takeuchi, Hitoshi ----- 185, 258
Shimokata, Kouzo ----- 549	----- 262, 263
Shirokova, Ye. I ----- 167	Tal'yanskiy, I. I ----- 555
Shoemaker, E. M ----- 85	Tamers, M. A ----- 11
Shuman, B ----- 479	Tanabashi, Ryo ----- 174, 175
Shushpanov, A. P ----- 423	Tanaka, Akiyoshi ----- 591
Shutt, T. C ----- 438, 542	Tanaka, Teiji ----- 173
Shuval-Sergeyev, N. M ----- 307	Tanaoka, Iwao ----- 530
Siderov, A. A ----- 345	Tandon, A. N ----- 204
Sil'nitskaya, V. I ----- 386	Tarakanov, R. Z ----- 149
Simmons, Gene ----- 416	Tarasoy, L. S ----- 461, 462
Sims, A. R ----- 480	Tarasov, O. A ----- 325
Singh, B. D ----- 552	Tarkhov, A. G ----- 302, 345
Sinno, K ----- 483	Tatsumi, Tatsuo ----- 48
Skovorodkin, Yu. P ----- 505	Tavrin, I. F ----- 410
Skur'yat, A. N ----- 351	Tazleff, Haroun ----- 612
Smelov, A. A ----- 501	Tengström, Erik ----- 388
Smith, T. J ----- 431	The Polar Record ----- 49
Solov'yev, S. L ----- 143, 182	Thompson, T. L ----- 404
Solov'yev, V. N ----- 214	Tikhonov, A. N ----- 298
Sonder, R. A ----- 366	Tilles, David ----- 468, 469
Sonett, C. P ----- 480	Tillotson, Ernest ----- 137
Sorskiy, A. A ----- 144	Tirey, G. B ----- 582
Squires, R. K ----- 389	Titova, Ye. A ----- 422
Stacey, F. D ----- 323	Tohmatsu, Takao ----- 497
Stanyukovich, K. P ----- 107	Tolstoy, Ivan ----- 556
Starikova, G. N ----- 423	Tripol'nikov, V. P ----- 210
Stauder, William ----- 166	Troshkov, G. A ----- 515
Stauffer, Heinz ----- 63	True, W. P ----- 337
Steinhart, J. S ----- 431	Trümpy, Rudolf ----- 354
Stern, T. W ----- 5	Tskhakaya, A. D ----- 145
Stipp, J. J ----- 11	Tsuboi, Chuji ----- 393, 396
Stone, O. L ----- 554	Tugarinov, A. I ----- 42, 460
Stoneley, R. S ----- 197	Tupper, W. M ----- 19
Stott, P. M ----- 401, 411	
Stoyko, Nicolas ----- 231	Ueji, Torajiro ----- 547, 548
Straka, Herbert ----- 13, 22	Ulomov, V. I ----- 276
Strangway, D. W ----- 502	Usami, Tatsuo ----- 254
Street, Norman ----- 312	Usatov, E. P ----- 471
Strick, E ----- 268	Ushakov, A. P ----- 319
Stupnikova, N. I ----- 42	Ushakov, S. A ----- 437
Subbotin, S. I ----- 376	Uyeda, Seiya ----- 427, 506, 507
Suess, H. E ----- 337, 457	
Sugimura, Yukio ----- 603	Val'dner, N. G ----- 156, 434
Sultanov, D. D ----- 153	Vanék, Jiří ----- 271
Surkov, Yu. A ----- 471	Van Melle, F. A ----- 564
Sutton, G. H ----- 184	Vasil'yev, Yu. F ----- 585
Suvorov, N. P ----- 53	Veiga Ferreira, O. da ----- 610, 611
Suzuki, Hiromiti ----- 402, 403	Veldkamp, J ----- 511
Suzuki, Takeo ----- 562	Verhoogen, John ----- 414
Swallow, J. C ----- 432	Vialette, Yves ----- 25, 30, 31
Sytinskaya, N. N ----- 101	Vilczek, Else ----- 69
Szendrei, M. E ----- 559	Vining, T. F ----- 268

	Abstract		Abstract
Vinnik, L. P -----	213	Witkind, I. J -----	128
Vinogradov, A. P -----	42, 461, 462	Wolf, H -----	517
Vladimirov, N. P -----	117, 119, 121	Woodtli, R. A -----	430
Vlasov, A. Ya -----	513	Woodward, F. W -----	130
Volarovich, M. P -----	325	Woolard, E. W -----	235
Vol'fson, N. B -----	330	Woollard, G. P -----	431
Vol'vovskiy, I. S -----	589	Wulf, O. R -----	482
Vol'vovskiy, B. S -----	589	Wyllie, M. R. J -----	580
Vorob'yev, G. G -----	82		
Voskresenskiy, Yu. N -----	578	Yakovkin, A. A -----	98
Voytkevich, G. V -----	40	Yama-ai, Mitsuko -----	514
Vuagnat, Marc -----	27, 28	Yamaguchi, Rinzo -----	170
Vvedenskaya, A. V -----	159, 160	Yamaguti, Seiti -----	171
		Yashchenko, M. L -----	45
Wada, Tatsuhiko -----	447, 448	Yazaki, K -----	219
Wait, J. R -----	288	Yegorov, Yu. M -----	120
Wänke, H -----	69	York, D. -----	33
Ward, S. H -----	289	Yoshizumi, Eizaburo -----	303
Warner, Brian -----	89	Yuan, T'ieh-chang -----	601
Watson, Kenneth -----	83	Yuhara, Kozo -----	616
Weber, Max -----	208, 209, 558, 574	Yukutake, Takesi -----	506, 530
Webster, R. K -----	454		
Wegmann, E -----	429	Zadorozhnyy, V. I -----	467
Wetherill, G. W -----	441	Zamyatin, N. I -----	44
Whetton, J. T -----	407	Zapol'skiy, K. K -----	142
Whipple, F. L -----	337	Zaporozhets, V. M -----	317
White, W. R. H -----	587	Zbyszewski, G -----	611
Whitmore, J. D -----	190	Zel'tser, M. S -----	104
Williams, J. R -----	18	Zherdenko, O. M -----	505
Williams, L. W -----	400	Zmuda, A. J -----	481
Williams, V. L -----	490	Zvegintsev, A. G -----	513
Willmore, P. L -----	70, 206, 220	Zybszewski, G -----	610
Wilson, C. R -----	385	Zykov, S. I -----	42, 461, 462