

Geophysical Abstracts 187 October-December 1961

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

GEOLOGICAL SURVEY BULLETIN 1146-D

*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 -----	531
Extent of coverage -----	531
List of journals -----	531
Form of citation -----	533
Abstracters -----	533
Age determinations -----	533
Cosmogony -----	547
Earth currents -----	555
Earthquakes and earthquake waves -----	557
Earth tides and related phenomena -----	568
Elasticity -----	570
Electrical exploration -----	575
Electrical logging -----	584
Exploration summaries and statistics -----	587
General -----	590
Geodesy -----	592
Geotectonics -----	596
Glaciers -----	601
Gravity -----	606
Heat and heat flow -----	620
Internal constitution of the earth -----	625
Isotope geology -----	631
Magnetic field of the earth -----	634
Magnetic properties and paleomagnetism -----	650
Magnetic surveys -----	661
Microseisms -----	670
Radioactivity -----	671
Radioactivity surveying and logging -----	673
Seismic exploration -----	678
Strength and plasticity -----	687
Submarine geology -----	689
Volcanology -----	694
Index -----	701

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 187 that have not been listed previously.

- Am. Assoc. Adv. Sci. Pub. -- American Association for the Advancement of Science Publication. Washington, D. C.
- Australasian Inst. Mining and Metallurgy Proc. -- The Australasian Institute of Mining and Metallurgy Proceedings. Melbourne, Australia.
- Azerbaydzhan. Nauchno-Issled. Inst. po Dobyche Nefti Trudy -- Azerbaydzhanskiy Nauchno-Issledovatel'skiy Institut po Dobyche Nefti Trudy -- [The Azerbaijan Research Institute for Oil Production Transactions]. Baku, U. S. S. R.
- Géodésie et Géophysique Comptes Rendus -- Comptes Rendus du Comité National Français de Géodésie et Géophysique. Au Secretariat General du Comité Français [Proceedings of the French National Committee of Geology and Geophysics. At the Secretariat General of the French Committee]. Paris, France.
- Geofísica Internac. -- Geofísica Internacional. Revista de la Unión Geofísica Mexicana, auspiciada por el Instituto de Geofísica de la Universidad Nacional Autónoma de México [International Geophysics. Journal of the Geophysical Union of Mexico, Sponsored by the Institute of Geophysics of the National University of the State of Mexico]. Mexico, D. F., Mexico.
- Geol. Soc. London Proc. -- Geological Society of London Proceedings. London, England.
- Geologie u. Bauwesen -- Geologie und Bauwesen [Geology and Construction]. Springer Verlag, Wien (Vienna), Austria.
- Inst. Physique du Globe Paris Annales -- Annales de l'Institut de Physique du Globe de l'Université de Paris et du Bureau Central de Magnétisme Ter-

- restre [Annals of the Institute of Physics of the Globe of the University of Paris and of the Central Bureau of Terrestrial Magnetism]. Paris, France.
- Internat. Jour. Appl. Radiation and Isotopes -- International Journal of Applied Radiation and Isotopes. Pergamon Press Ltd. London, England.
- Israel Ministry of Devel., Geol. Survey Bull. -- State of Israel, Ministry of Development, Geological Survey Bulletin. Jerusalem, Israel.
- Kentucky Geol. Survey Spec. Pub. -- Kentucky Geological Survey Special Publication. University of Kentucky. Lexington, Kentucky.
- Kyoto Univ. Eng. Research Inst. Tech. Rept. -- Technical Reports of the Engineering Research Institute, Kyoto University. Kyoto, Japan.
- Kyushu Inst. Technology Bull. -- Bulletin of the Kyushu Institute of Technology. Fukuoka, Japan.
- Maine Geol. Survey Rept. -- Maine Geological Survey Report, Department of Economic Development. Augusta, Maine.
- New Zealand Geographer -- New Zealand Geographer. New Zealand Geographical Society. Auckland, New Zealand.
- Norske Inst. Kosmisk Fysikk Pub. -- Publikasjoner fra Det Norske Institutt for Kosmisk Fysikk [Publication from the Norwegian Institute for Cosmic Physics]. Magnetisk Byrd, Bergen, Norway.
- Northern Ireland Geol. Survey Mem. -- Memoirs of the Geological Survey, Ministry of Commerce, Government of Northern Ireland. Belfast, Ireland.
- Nyasaland Geol. Survey Rec. -- Records of the Geological Survey of Nyasaland. Zomba, Nyasaland.
- Oceanus -- Oceanus. The Woods Hole Oceanographic Institution. Woods Hole, Massachusetts.
- Oklahoma Geology Notes -- Oklahoma Geology Notes. Oklahoma Geological Survey. Norman, Oklahoma.
- Pakistan Jour. Sci. and Indus. Research -- Pakistan Journal of Scientific and Industrial Research. Pakistan Council of Scientific and Industrial Research. Karachi, Pakistan.
- Saskatchewan Dept. Mineral Resources Rept. -- Province of Saskatchewan, Department of Mineral Resources, Petroleum Lands Branch, Geophysical and Evaluation Division Report. Regina, Saskatchewan, Canada.
- Sierra Leone Geol. Survey Bull. -- Bulletin of the Sierra Leone Geological Survey. Published in London, England, for the Sierra Leone Geological Survey.
- Smithsonian Inst. Misc. Colln. -- Smithsonian Institution, Smithsonian Miscellaneous Collections. Washington, D. C.
- Space Sci. -- Space Science. Benjamin Adelman, Publisher. Silver Spring, Maryland.
- Terra -- Terra [Earth]. Suomen Maantieteellisen Seuran Aikakauskirja (Geografiska Sällskapet i Finland Tidskrift) [Geographical Society of Finland Journal]. Helsinki, Finland.
- Ti Chih Lun P'ing [Geological Review] -- Ti Chih Lun P'ing [Geological Review]. Geological Society of China. Peiping, China.
- Uppsala Univ. Geol. Inst. Bull. -- Bulletin of the Geological Institution of The University of Uppsala. University of Uppsala. Uppsala, Sweden.
- Vrania -- Vrania. Sugranes Hnos., Editores. Tarragona, Spain.
- Vses. Nauchno-Issled. Geologorazved. Neft. Inst. Trudy -- Trudy, Vsesoyuznyy Nauchno-Issledovatel'skiy Geologorazvedochnyy Neftyanoy Institut (VNIGNI) [Transactions, All-Union Scientific Research Geological Exploration Petroleum Institute]. Moskva (Moscow), U. S. S. R.
- West Virginia Geol. and Econ. Survey Rept. Inv. -- State of West Virginia Geological and Economic Survey Report of Investigations. Morgantown, West Virginia.

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 Henry Faul, Ruth M. Gove, Wanda L. Grimes, 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

- 187-1. Rubinshteyn, M. M. O prodolzhitel'nosti Yurskogo perioda [On the length of the Jurassic period]: Akad. Nauk SSSR Doklady, v. 136, no. 6, p. 1432-1435, 1961.

On the basis of 5 K-Ar age determinations on critical samples from the U. S. S. R.—biotites from the Kelasur and Gumista granites and hornblende-biotite fractions from the Khev (Khevisdzhvar) quartz diorite—the duration of the Jurassic period is established as $50-60 \times 10^6$ yr, and the lower limit is pushed back to $190-200 \times 10^6$ yr ago. — D. B. V.

- 187-2. Polevaya, N. I. Shkala absolyutnoy geokhronologii po glaukonitam [Scale of absolute geochronology according to glauconite]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 123-132, 1961.

The results of absolute age determinations on paleontologically dated glauconites are documented, their suitability for absolute dating is demonstrated, and a comparison is made with data obtained for these same intervals of geologic time by other authors. In conclusion, a first variant is presented for the scale of absolute geochronology, compiled on a basis of glauconites and confirmed by data on contemporaneous micas and volcanic rocks. — Author's abstract, J. W. C.

- 187-3. Picciotto, Edgard E. Geochemistry of radioactive elements in the ocean and the chronology of deep-sea sediments, in *Oceanography: Am. Assoc. Adv. Sci. Pub.*, no. 67, p. 367-390, 1961.

In the study of the many types of information to be deduced from cores of deep-sea sediments one particular problem arises, that of fixing a time scale in order to date in an absolute manner the observed phenomena. This paper reviews the present state of research in the field of chronological methods based on radioactive disintegrations and describes the outlook for progress in the near future. The principles of radioactive methods of age determination, the natural radioactive nuclides in the ocean, and the radioactive nuclides present in pelagic sediments are discussed. Possible chronological methods based on the decay of cosmogenic radionuclides, ionium or protactinium, and

growth of ionium and protactinium are described briefly. Various miscellaneous methods are mentioned also. (See also Geophys. Abs. 185-11.)— V. S. N.

- 187-4. Firsov, L. V. Predlozheniye o standartizatsii sistemy publikatsii materialov po absolyutnomu vozrastu [Proposed standardization in the format of publishing absolute age data]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 148-150, 1961.

A uniform system of units for data reporting and constants for age calculation is proposed. Publications should include an adequate geologic discussion of the samples and description of analytical methods and their errors. — H. F.

- 187-5. Kozhina, T. K. Geologo-mineralogicheskaya kharakteristika etalonnoy proby dlya metodicheskikh issledovaniy svyazannykh s opredeleniem absolyutnogo vozrasta (pegmatitovaya zhila no. 9, Chernaya Salma, Severnaya Kareliya) [Geologic-mineralogic characteristics of the reference sample for methodology research in absolute age determination (pegmatite vein no. 9, Chernaya Salma, Northern Karelia)]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 8-19, 1961.

The muscovite-microcline-plagioclase pegmatite vein no. 9 occurs in the plot of the Chernaya Salma deposit, 1 mile northeast of the Chkalov mine in the Loukhov region, in a complex of Byelomoryan age. Clean microcline, biotite, and muscovite were taken from this vein and prepared into reference standards in 1958. About 20 kg of each of the micas was split into sheets about 0.1 to 0.2 mm thick and mechanically sheared into slivers about 3 cm long and 2 mm wide and passed over a sieve with 0.5 mm openings. Rose and grey microcline were selected, crushed, sieved into various size fractions, washed in water, dried at 80°C, and mixed to produce about 20 kg samples of each color and size (1-0.5 mm, 0.5-0.25 mm, and minus 0.25 mm). Optical data, differential thermal analyses, and detailed chemical analyses for the samples are given. — H. F.

- 187-6. Pekarskaya, T. B. O nauchno-issledovatel'skikh rabotakh po probleme "Geokhronologicheskaya Shkala SSSR, vyrazhennaya v absolyutnom letochislenii" [Research on the problem "geochronologic scale of the USSR, expressed in absolute time"]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 20-29, 1961.

Recent geochronological research in the U. S. S. R. is reviewed. — H. F.

- 187-7. Chantret, Francis. Essai de datage de minéraux d'uranium de formation récente par autoradiographie [Attempt at dating of uranium minerals of recent formation by autoradiography]: Acad. Sci. [Paris] Comptes Rendus, v. 253, no. 3, p. 500-501, 1961.

A method of dating uranium minerals is proposed that is based in principle on the ratio (k) of the apparent uranium content, determined by autoradiography, to the true uranium content, determined chemically. A curve is constructed showing k as a function of time. Precision is good to 250,000 yr; the method is therefore applicable to supergene minerals, which are generally recent.

The finely powdered sample is formed into two tablets 5 mm in diameter, one of the pure mineral and the other mixed with 50 percent silica (to deter-

mine the coefficient of absorption of the mineral). After 30 days, during which the radon displaced in grinding should return to equilibrium with radium, the tablets are set on film for a time sufficient to count several thousand alpha-tracks. A series of minerals is now being studied. One of these, an autunite, has given an age of $34,000 \pm 3,000$ yr, which is in good agreement with the age obtained by radiometric analysis of ionium after chemical separation. — D. B. V.

187-8. Brodskiy, A. I., and Goldenfeld, I. V. Ob otsenke dostovernosti opredeleniya geologicheskogo vozrasta svintsovymi izotopnymi metodami [Appraisal of the trustworthiness of geologic age determination by lead isotope methods]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 98-108, 1961.

Chemical and mass-spectrometric errors in the isotopic U-Th/Pb method of age determination are discussed analytically with reference to measurements on the same sample from several laboratories. Pertinent coefficients in the resulting equations are shown in graphs as a function of age or non-radiogenic lead content. — H. F.

187-9. Starik, I. Ye., Sobotovitch, E. V., and Lovtsyus, G. P. Pirokhimicheskiye metody vydeleniya svintsa iz prirodnykh obrazovaniy [Pyrochemical methods of extracting lead from natural samples]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 114-127, 1961.

A pyrochemical method of lead analysis of rocks, minerals, and meteorites is described. A horizontal quartz retort with a tapered ground joint containing a water cooled quartz target is placed in a furnace heated by 4-6 silicon carbide rods with a total power input of about 3-6 kw. The sample is placed in a quartz boat and can be heated to about $1,400^{\circ}\text{C}$; however, operation at such a high temperature presents various difficulties, and it is preferable to work around $1,100^{\circ}\text{C}$ - $1,200^{\circ}\text{C}$. Dithizone-cleaned borax containing about 10^{-8} g/g of lead is used as flux. In a few hours at temperatures of $1,000^{\circ}\text{C}$ - $1,200^{\circ}\text{C}$ in hydrogen, lead is released almost completely from such minerals as thorite or cyrtolite; other minerals require more time, and it is almost impossible to release all the lead from monazite or whole granite. Therefore, it is necessary to equilibrate completely the Pb^{212} tracer with the sample by pre-fusing them 3-4 h in a stream of air without the loss of lead. The lead deposited on the target is washed off with nitric acid; the yield is determined by counting the Pb^{212} , and the total lead is determined with dithizone with an error of ± 8 percent. The 3-5 μg necessary for isotopic analysis of lead can be advantageously released from samples by the pyrochemical method without the danger of contamination by atmospheric lead. — H. F.

187-10. Karpinskaya, T. B., Ostrovskiy, I. A., and Shanin, L. L. Iskusstvennoye vnedreniye argona v slyudu pri vysokikh davleniyakh i temperaturakh [Artificial introduction of argon into mica at high pressures and temperatures]: Akad. Nauk SSSR Izv. Ser. Geol., no. 8, p. 99-100, 1961.

Natural muscovite ground to 0.2 mm dimensions and also 40X30 mm sheets of the mineral were subjected to temperatures of about 750°C - 850°C and pressures of 3,000-5,000 atm in an atmosphere of argon; the argon content was then determined by means of a mass spectrometer. The results show that appreciable amounts of argon are absorbed, in many cases exceeding the radiogenic argon content, and that the degree of fragmentation evidently plays an es-

sential role in determining the amount absorbed (the powdered muscovite absorbed up to 10 times as much as the laminae). When one of the powdered samples was subsequently heated, it was found that 60 percent of the introduced argon was retained at temperatures up to 520°C. These preliminary results suggest that a significant part of the argon absorbed by mica at high pressure is securely retained by the mineral and enters into the crystal structure, for in the case of surface adsorption the argon should be driven off at low temperatures. — D. B. V.

- 187-11. Firsov, L. V. O vybore konstant razpada kaliya-40 dlya opredeleniya vozrasta porod po otnosheniyu argona-40 k kaliyu-40 [Selection of potassium-40 decay constants for determination of the age of rocks by the argon-40/potassium-40 ratio]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 87-92, 1961.

Western literature is reviewed and adoption of constants essentially identical with those used in the United States is recommended: $\lambda_K = 0.585 \times 10^{-10} \text{yr}^{-1}$, $\lambda_\beta = 4.68 \times 10^{-10} \text{yr}^{-1}$, $R = 1.25$. (See also Geophys. Abs. 182-8.) — H. F.

- 187-12. Rubinshteyn, M. M., Grigoryev, I. G., Uznadze, E. D., and Gel'man, O. Ya. Fotometricheskoye opredeleniye kaliya i natriya v ammiachno-kislородnom plameni [Photometric determination of potassium and sodium in an ammoniac-oxygen flame]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 109-113, 1961.

A flame photometer using a flame of ammonia burning in oxygen is described. Oxygen is introduced in the center of the flame and carries the solution to be analyzed. Ammonia enters the flame from a concentric circle of small holes. The flame has a temperature around 1,720°C as measured with an optical pyrometer. For potassium the 7,665 and 7,699 Å lines are used; a significant interfering effect of sodium concentration on the intensity of the potassium lines is observed and is shown in graphs. Lithium chloride as a radiation buffer, in concentrations up to 10 g/l, does not reduce the interference materially. The calibration curve for sodium, using the 5,890-5,896 Å lines, is flatter than for potassium, and the precision of the sodium determinations is consequently lower. Preliminary results indicate no interference from calcium in concentrations up to 400 mg/l. The method allows quantitative analysis with a maximum relative error of ±5 percent for potassium and ±8 percent for sodium. — H. F.

- 187-13. Aleksandruk, V. M. K voprosu opredeleniya absolyutnogo geologicheskogo vozrasta renyevym metodom [Determination of absolute geologic age by the rhenium method]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 144-147, 1961.

The western literature on age determinations by the rhenium method is reviewed. — H. F.

- 187-14. Bloom, Arthur L. Late Pleistocene changes of sea level in southwestern Maine: Maine Geol. Survey Rept., 143 p., 1960.

Carbon-14 age determinations on marine shells from Waterville, Maine, indicate that late Pleistocene marine submergence of the coastal plain of southwestern Maine may have been in progress 11,800 yr before present; be-

tween 7,000-8,000 and 4,200 yr before present the coast emerged at least 2 feet and possibly as much as 8-9 feet greater than present. Progressive submergence has continued since then. If eustatic sea level has been near its present position for the past 5,000 yr, as accumulating evidence suggests, then either the isostatic movement of the coast of Maine has reversed its direction, or other tectonic movements are causing coastal subsidence. — V. S. N.

- 187-15. Basset, W. A. Potassium-argon age of Devils Tower, Wyoming: *Science*, v. 134, no. 3487, p. 1373, 1961.

Potassium-argon age determinations on orthoclase phenocrysts from Devils Tower, Wyo., indicate an age of 40.5×10^6 yr ± 4 percent. This is consistent with the geologically accepted Tertiary age. — R. M. G.

- 187-16. Silverman, A., Long, A., and Kulp, J. L[aurence]. Age of Coeur d'Alene mineralization: An isotopic study; *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, p. 117-118, 1960; also in *Mining Eng.*, v. 12, p. 470-471, 1960.

The geologic interpretation of the history of the deposits surrounding the Gem stocks in the Coeur d'Alene district, Idaho, are discussed in light of a recent isotopic study of this district. Leads from ten widely scattered mines north and south of the Osburn fault and through a vertical distance of more than 5,000 feet were dated. Also included were galenas from stringers which cut the Gem stocks in various places. Results indicate that the entire mineralization of the Coeur d'Alene-British Columbia base metal belt was derived from a deep source and emplaced in the Precambrian. The Gem stocks area, however, presents geologic relations that may be in conflict with this Precambrian age. The effect of Tertiary and Laramide intrusive activities is discussed, and it is suggested that the Precambrian lead ratios could remain unchanged if the lead of previously existing ore deposits was remobilized during the Laramide and moved rapidly through the crust along pronounced structures to its present position. If the absolute age of mineralization may be determined independently, and geological relations are clearly understood, these data provide a powerful insight into the mechanism of ore deposition and origin of the ore in a given area. — V. S. N.

- 187-17. Karrow, P. V., Clark, J. R., and Terasmae, J. The age of Lake Iroquois and Lake Ontario: *Jour. Geology*, v. 69, no. 6, p. 659-667, 1961.

Recent geological and engineering investigations at Hamilton, Ontario, have resulted in the discovery of buried plant-bearing beds in deposits of Lake Iroquois and Lake Ontario. Fossils in these beds indicate cold, shallow-water conditions of sedimentation for the earlier-deposited beds and warmer conditions for later-deposited layers. Radiocarbon dating of buried wood suggests that Lake Iroquois was formed during the retreat of Port Huron ice. The Valders drift boundary is inferred to the north of Lake Ontario. Lake Ontario probably began over 10,000 yr ago. — Authors' abstract

Laroche, A. Application of palaeomagnetism to geological correlation. See *Geophys. Abs.* 187-478.

- 187-18. Craig, B[ruce]G. Surficial geology of Northern District of Keewatin, Northwest Territories: *Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Paper 61-5*, 8 p., 1961.

The area encompassed by this report is bounded on the east by the 90th meridian, on the west by the 102d meridian, on the north by the Arctic coast and the Isthmus of Boothia, and on the south by the 66th parallel. The abundant variety of glacial landforms, the pattern of ice-retreat, and the evidence for post-glacial marine submergence are discussed briefly. Radiocarbon ages determined for marine shells from 5 localities range from $8,370 \pm 175$ to $3,690 \pm 120$ yr before present. Data from the 4 highest localities agree with those of Lee (1960) for the east side of Hudson Bay, which show that uplift took place more rapidly in the initial stage than it did toward the end of the period of readjustment. The rates of emergence in the present area are, however, greater than those suggested by Lee. — V. S. N.

- 187-19. Wilson, N. W., and Marmo, V[ladi]. Radiogenic ages, in *Geology, geomorphology, and mineral resources of the Sula Mountains: Sierra Leone Geol. Survey Bull.*, no. 1, p. 26-30, 1958.

The lead-isotope ages were determined for galena and monazite and the K-Ar age for microcline from pegmatite and sericitic quartz veins and alluvium associated with the granite and schist of the Sula Mountains, north of the Pampana River in Sierra Leone. The ages as determined by analysts in separate laboratories and as calculated by Wilson on the one hand and by Geiss on the other are given in tables. Ages adopted for the Dalakuru galena are $2.26 \pm 0.12 \times 10^9$ yr (Wilson) and 2.98×10^9 yr (Geiss). Geiss dates the Yirisen galena as 3.02×10^9 yr. Wilson's monazite age, $2.93 \pm 0.20 \times 10^9$ yr, agrees closely with the Holmes and Cahen age for the Dalakuru galena. Isotopic lead ratios of galenas from veins cutting the Bulawayan of Southern Rhodesia, the Nanzian of the Kenya-Uganda border, and the Sula Mountains schist agree closely; these formations may be approximately contemporaneous. — V. S. N.

- 187-20. Bloomfield, K. The age of the Chilwa alkaline province: *Nyasaland Geol. Survey Rec.*, v. 1, p. 95-100, 1959 (1961).

Recent lead-alpha age determinations on zircon from a typical large plutonic mass of the Chilwa alkaline province in southern Nyasaland and Mozambique indicate a Late Jurassic age, $138 \pm 14 \times 10^6$ yr, for the main plutonic phase of the province. Indirect stratigraphic and other evidence has previously suggested a Liassic or later age for the rocks of the Chilwa province. — V. S. N.

- 187-21. Dewey, J. F. A note concerning the age of the metamorphism of the Dalradian rocks of Western Ireland: *Geol. Mag.*, v. 98, no. 5, p. 399-405, 1961.

Evidence is presented to relate the published minimum absolute date (see Giletti and others, *Geophys. Abs.* 187-22) of 475 million years for the metamorphism of the Connemara schists to a position in the Lower Paleozoic stratigraphy of western Ireland. A Late Cambrian or Tremadocian age is considered likely for the Dalradian metamorphism, since it predates the Didymograptus extensus zone of the Arenig in Connemara and South Mayo and post-dates the Leny limestone (lower Middle Cambrian), an integral part of the Scottish Dalradian succession. — V. S. N.

- 187-22. Giletti, Bruno J., Moorbath, Stephen, and Lambert, Richard St. John. A geochronological study of the metamorphic complexes of the Scottish Highlands: *Geol. Soc. London Quart. Jour.*, v. 117, pt. 3, no. 467, p. 233-272, 1961.

Rubidium-strontium age determinations are presented for minerals and whole rocks from the Lewisian, Moinian, and Dalradian metamorphic complexes of Scotland and from the Connemara schists of western Ireland. On the basis of the ages so far measured, the following historical sequence has been constructed for events in the metamorphic and tectonic zones of the Scottish Highlands: (1) the Scourian metamorphism of the Lewisian at a time older than $2,460 \times 10^6$ yr; (2) the Laxfordian metamorphism, which affected most of the Lewisian complex, at about $1,600 \times 10^6$ yr ago; (3) intrusion of the Moinian pegmatites in Knoydart and Morar before 740×10^6 yr ago; (4) intrusion of the Ben Vuroch granite between 700 and 500×10^6 yr ago, giving a lower age limit for the Dalradian sediments; (5) metamorphism of part of the Dalradian sediments and Connemara schists $475 \pm 15 \times 10^6$ yr ago during Early or Middle Ordovician; (6) a Silurian-Early Devonian metamorphism at $420 \pm 15 \times 10^6$ yr ago affecting the Moine Series of the Northern Highlands, and also recorded at Ben Vuroch; and (7) intrusion of Caledonian granitic rocks—the Shap, Leinster, Creetown, Aberdeen, and Galway granites. From the above history it follows that the Torridonian sediments are younger than $1,600 \times 10^6$ yr and possibly less than $1,160 \times 10^6$ yr, and the Caledonian orogeny proper occurred in the Silurian. — V. S. N.

187-23. Dodson, Martin Henry. Isotopic ages from the Lizard Peninsula, South Cornwall: Geol. Soc. London Proc., no. 1591, p. 133-136, 1961.

The results of K-Ar age determinations on two samples of mica-schist from the Old Lizard Head Series, one of hornblende-schist from the Landewednack group, and one from the Kennack gneiss in the area of the Lizard Peninsula, Cornwall, England, are reported. The Kennack gneiss was also dated by the Rb-Sr method. The most striking feature of the results is the close grouping of the ages in the range $348-377 \times 10^6$ yr. Not only is there agreement between the K-Ar results on the three varied rock-types but also between the results obtained by the two different methods on the Kennack gneiss. It seems reasonable that the emplacement of the Hercynian granites 270 million years ago had no serious effect on the ages now measured and that the mean value of 360 million years be considered as the approximate date of an important igneous and metamorphic event in the Lizard Peninsula during Middle or Late Devonian time. This event may have been the crystallization of the Kennack gneisses and the Lizard complex as a whole. If the schists of the Old Lizard Head Series are Precambrian their older age was obliterated by this event; if, they are metamorphosed Lower Devonian sediments as suggested by Hendirks (1959), their principal dynamic metamorphism may have been associated with a major event of which the intrusion of the Kennack gneiss was a part. The present isotopic data, however, do not exclude the possibility of a greater age for the intrusive complex. The application of the technique of whole-rock Rb-Sr analysis is suggested for this area. (See also Geophys. Abs. 186-35.)— V. S. N.

187-24. Oeschger, H., and Röthlisberger, H[ans]. Datierung eines ehemaligen Standes des Aletschgletscher durch Radioaktivitätsmessung an Holzproben und Bemerkungen zu Holzfunden an weiteren Gletschern [Dating of a former stand of the Aletsch Glacier by radioactivity measurements on wood samples and remarks concerning wood found on other glaciers (with English and French summaries)]: Zeitschr. Gletscherkunde u. Glazialgeologie, v. 4, no. 3, p. 191-206, 1961.

Carbon-14 dating of two samples from ancient tree stumps and roots in the area recently exposed by retreat of the Aletsch Glacier in Switzerland showed

ages of 720×100 and 700 ± 100 yr, indicating that the forest was buried by the advance of the Great Aletsch Glacier about A. D. 1200.

No dating has been attempted on wood collected at the snouts of the Findeln and Ferpècle-Mont Miné Glaciers, as it has been impossible to determine the original site of the forests involved. — D. B. V.

- 187-25. Higazy, Riad A., and El-Ramly, M. F. Potassium-argon ages of some rocks from the Eastern Desert of Egypt: United Arab Republic Geol. Survey and Mineral Research Dept. Paper, no. 7, 18 p., 1960.

Potassium-argon ages are reported for 20 samples from the crystalline basement complex of the Eastern Desert of Egypt. The absolute ages range from 600 to 40 million years or from Eo-Cambrian (Late Precambrian?) to Tertiary. Igneous intrusions and volcanic activity seem to have occurred at the following times (in millions of years): Late Precambrian or Eo-Cambrian, 600-590; Early Cambrian-Ordovician, 470-420; Ordovician-Silurian, 410-340; Silurian-Devonian, 300-285 (corresponds to Caledonian); Late Cretaceous, 80-75; and Tertiary, 55-40 (corresponds to Alpine). Granites of the Eastern Desert previously assigned to Metarcean and Late Precambrian are now proved to be Late Precambrian and Early Cambrian-Ordovician, respectively. Detailed results are given in tables. — V. S. N.

- 187-26. Brotzen, F. An interstadial (radiocarbon dated) and the substages of the last glaciation in Sweden: Geol. Fören. Stockholm Förh., v. 83, no. 2, p. 144-150, 1961.

Radiocarbon dating of core samples from Ingebäck, 12 km north of Gothenberg, and from the Hisinge tunnel excavation in Gothenberg gave two groups of dates—20,000-30,000 yr and 10,000-16,000 yr; the older is related to a hitherto unknown marine interstadial and the younger to lateglacial and postglacial sediments. The differences between the two groups is always more than 10,000 yr, demonstrating that below about 55 m depth there is a large break in sedimentation. Possible correlations are discussed. — D. B. V.

- 187-27. Semenenko, N. P. Opredele niye vozrasta metamorficheskikh slantsev dokembriya Shvetsii kaliy-argonovym metodom [Age determination on Precambrian schists from Sweden by the potassium-argon method]: Akad. Nauk SSSR, Kom. Opredele niyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 56-58, 1961.

Whole-rock K/Ar age determinations on 9 samples of slate, schist, and gneiss from Sweden are reported and three periods of metamorphism are proposed. (See also Geophys. Abs. 185-47.) — H. F.

- 187-28. Liyva, A. A. Opredele niye absolyutnogo vozrasta radiouglerodnym metodom (v Estonii) [Determination of absolute age by the radiocarbon method (in Estonia)]: Geokhimiya, no. 8, p. 710-712, 1961.

Radiocarbon dating in Estonia began in 1957. The method used, a variant of Pringle's (1957) scintillation method, is described. So far, a series of archeologic samples from the Neolithic settlements at Klyap have been dated; results will be published separately. — D. B. V.

- 187-29. Komlev, L. V., Mikhalevskaya, A. D., and Danilevich, S. I. O vozraste shchelochnykh intruziy Khibinskikh i Lovozerskikh tundr (Kol'skiy poluostrov) [On the age of the alkaline intrusions of the

Khibin and Lovozero tundras (Kola Peninsula): Akad. Nauk SSSR Doklady, v. 136, no. 1, p. 172-174, 1961.

The average age of minerals from two alkaline intrusions in the Khibin and Lovozero tundras in the Kola Peninsula, dated by the lead isotope method, is $290 \pm 10 \times 10^6$ yr; this is in good agreement with the age of 300×10^6 yr obtained by Gerling and others (1949) by the K-Ar method (recalculated using the new constants). — D. B. V.

187-30. Bespalova, I. D., and Semenov, E. I. Ob absolyutnom vozraste Lovozerskogo i drugikh shchelochnykh massivov Kolskogo poluoostrova [Absolute age of the Lovozero and other alkaline massifs of the Kola Peninsula]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 77-80, 1961.

The ages of several minerals of the thorite group from Lovozero, Khibiny, Keyby, and Afrikanda in the Kola Peninsula were determined by the X-ray spectrometric (total lead) method. The results range from 312 to 400×10^6 yr; most are clustered around 380×10^6 yr. A galena from a pegmatite in Khibiny has the lead isotopic composition 1:18.17:15.40:39.0. — H. F.

187-31. Maslenikov, V. A., Bondarenko, L. P., and Dagelayskiy, V. B. Drevneyshiye gornyye porody Kol'skogo poluoostrova [Ancient rocks of the Kola Peninsula]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 133-155, 1961.

A geologic-petrographic description is presented of the ancient rocks of the Kola Peninsula; these are divided into two groups. The first group consists of gneissic granites, granites, migmatites, and pegmatites, and the K-Ar ages range from 3,600 to $3,060 \times 10^6$ yr. The second group consists of gneisses, granites, pegmatites, amphibolites, and pyroxenites, and the K-Ar ages range from 2,880 to $2,700 \times 10^6$ yr. These rocks are referred to the lower and upper divisions, respectively, of the Katarchean. — Authors' abstract, J. W. C.

187-32. Priyatkina, L. A. Ritmichnaya sloistost' v arkhayskikh porodakh Kol'skogo poluoostrova [Rhythmic bedding in the Archean rocks of the Kola Peninsula]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 156-165, 1961.

Rhythmic bedding in Archean conglomerates of the Kola Peninsula is described. The age of the metamorphic unit is 2,600- $2,200 \times 10^6$ yr, but the age of the granite pebbles within the conglomerate is $3,180 \times 10^6$ yr. — J. W. C.

187-33. Dagelayskiy, V. B. Razval'tsovannyekonglomeraty severo-zapadnoy chasti svity polmos (Kol'skiy poluoostrov) [Laminated conglomerates of the northwest part of the Polmos formation (Kola Peninsula)]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 166-175, 1961.

Argon age determinations were made on a laminated conglomerate of the Polmos formation. A biotite granite gneiss (cement of the conglomerate) gives $2,310 \times 10^6$ yr, a two-mica schist— $2,300 \times 10^6$ yr, and biotite plagiogranite pebbles— $2,780 \times 10^6$ yr. — J. W. C.

187-34. Polkanov, A. A., and Li-Zhen', U. O genezise i evolyutsii shchelochnoy magmy Khibinskogo subvulkana [Genesis and evolution of

the alkaline magma of the Khibin subvolcano]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 176-186, 1961.

A physicochemical analysis is presented for the Khibin comagmatic series of the Kola Peninsula, and a new date of $290 \pm 10 \times 10^6$ yr is given. — J. W. C.

- 187-35. Lobach-Zhuchenko, S. B., and Pinayeva, N. I. Ob absolyutnom vozrast i kharaktere kontaktov porod arkheya i nizhnego proterozoya (yuzhnaya Kareliya) [On the absolute age and character of contacts of rocks of the Archean and lower Proterozoic (southern Karelia)]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 187-211, 1961.

Study of the structure, metamorphism, and geochronology of the metamorphic rocks of southern Karelia has demonstrated that a zone of lower Proterozoic rocks contains Archean formations that have not been reworked by later metamorphism. The Archean rocks are $2,200-2,700 \times 10^6$ yr old and are correlated with the Saamides. The lower Proterozoic rocks are $1,700-1,950 \times 10^6$ yr old and are referred to the early Karelides. — J. W. C.

- 187-36. Glebova-Kul'bakh, G. O., and Pinayeva, N. I. Novyye dannyye po geologii i geokhologii rayona Gormozera v yuzhnoy Karelii [New data on the geology and geochronology of the Gormozer region in southern Karelia]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 212-237, 1961.

The Gormozer region of south Karelia A. S. S. R. is underlain by metamorphosed geosynclinal sediments and volcanic rocks and by granites. Two stages of metamorphism are recognized. A regional metamorphism accompanied by folding and intrusion of granite is dated at $1,900-1,870 \times 10^6$ yr. A regressive metamorphism is dated at $1,740 \times 10^6$ yr. Faulting following the second metamorphism took place at $1,670 \times 10^6$ yr on a basis of biotite in the fault breccia. Anomalous figures were obtained on muscovite from pegmatite ($2,400 \times 10^6$ yr), greisen ($2,200 \times 10^6$ yr), and schist ($2,430 \times 10^6$ yr). — J. W. C.

- 187-37. Borisova, K. D., Gorokhov, I. M., and Lobach-Zhuchenko, S. B. Aktsessornyye mineraly metasomaticheski preobrazovannykh arkheyskikh granito-gneysov [Accessory minerals of metasomatically altered Archean granite gneisses]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 238-256, 1961.

Migmatization of Archean plagioclase granitic gneisses accompanied by growth of new accessory minerals in Karelia is described. Determinations of the absolute age of the various minerals yields three groups of figures: $3,050-2,660 \times 10^6$ yr, $2,500-2,200 \times 10^6$ yr, and $1,800-1,400 \times 10^6$ yr. The first group of figures is the age of the formation. The third group corresponds to the time of recrystallization, giving rise to a "rejuvenation" of the age. The second group of figures is intermediate and is not as yet explained satisfactorily. — Authors' abstract, J. W. C.

- 187-38. Polkanov, A. A., and Gerling, E. K. Geokhronologiya i geologicheskaya evolyutsiya Baltiyskogo shchita i yego skladchatogo obramleniya [Geochronology and geologic evolution of the Baltic shield and its folded frame]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 7-102, 1961.

On a basis of about 600 age determinations on Precambrian, Caledonian, and Hercynian rocks of Karelia, the Kola Peninsula, Finland, Norway, and Sweden, a synthesis is presented of the geologic development of the Baltic shield and adjacent areas. The ages range from Katarchean at $3,590 \times 10^6$ yr to Cambrian at $600-400 \times 10^6$ yr. Each geochronological subdivision is discussed, and the pertinent age data are tabulated. — J. W. C.

- 187-39. Polevaya, N. I., and Kazakov, G. A. Vozrastnoye raschleneniye i korrelyatsiya drevnikh nemykh otlozheniy po otnosheniyu Ar^{40}/K^{40} v glaukonitakh [Age differentiation and correlation of ancient unfossiliferous rocks according to the ratio Ar^{40}/K^{40} in glauconites]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 103-122, 1961.

On the basis of absolute age determinations on about 50 specimens of glauconite from unfossiliferous sediments of the Russian and Siberian platforms and the Urals, it is demonstrated that formation of the Sinian sediments (Late Precambrian) lasted at least about 600×10^6 yr. The upper boundary of the Late Precambrian is placed at $600-500 \times 10^6$ yr. The lower boundary is drawn at the base of the Kaverinformation on the Russian platform, along the pre-Zil'merdak break in the Urals, and at the break between the Uchursk and Maysk series on the Siberian platform; it is determined at $1,200-1,100 \times 10^6$ yr. — Authors' abstract, J. W. C.

- 187-40. Starik, I. Yr., Krylov, A. Ya., and Silin, Yu. I. Absolyutnyy vozrast porod fundamenta vostochnoy chasti Russkoy platformy [Absolute age of the basement rocks of the eastern part of the Russian platform]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 64-65, 1961.

Potassium-argon age determinations on cores taken in exploratory boreholes on the Russian platform give the first insight into the chronology and structure of the region. Of 13 samples analyzed, 1 gives an age of $1,030 \times 10^6$ yr and the remaining 12 give ages between 1,400 and $1,800 \times 10^6$ yr. — H. F.

- 187-41. Rubinshteyn, M. M. O vremeni formirovaniya kristallicheskogo substrata Kavkaza [Time of formation of the crystalline basement of the Caucasus]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 59-63, 1961.

Potassium-argon age determinations on whole-rock samples give ages that are approximately 30 percent too low. Considering only K/Ar determinations on micas and referring to the Holmes-Marble time scale, it is concluded that the crystalline basement rocks of the Caucasus formed in Late Caledonian and partly in Hercynian time, about $400-250 \times 10^6$ yr ago. If Precambrian rocks are present at all, they could be only latest Precambrian. — H. F.

- 187-42. Rubinshteyn, M. M. O vozraste kristallicheskogo substrata Kavkaza [On the age of the crystalline substratum of the Caucasus]: Akad. Nauk Gruzin. SSR Soobshch., v. 24, no. 2, p. 181-187, 1960.

The argon ages of mica-bearing metamorphic rocks from the oldest geologic units in the Caucasus lie between 220 and 385 million years. — A. J. S.

- 187-43. Adamiya, Sh. A. O vozraste "molodykh" granitov khramskogo kristallicheskogo massiva [Age of the "young" granites of the Khrami crystalline massif]: Akad. Nauk Gruzin. SSR Soobshch., v. 21, no. 4, p. 439-442, 1958.

The geologic age of the granitic intrusions of the middle course of Khrami River in the Caucasus is in agreement with the absolute age determined for potassium feldspar from the pegmatite fraction. — A. J. S.

- 187-44. Ivanov, A. I., Monich, V. K., and Zamyatin, N. I. Absolyutnyy vozrast granitoidnykh intruziy yuzhnoy chasti tsentral'nogo Kazakhstana [Absolute age of granitic intrusions of the south part of central Kazakhstan]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 30-47, 1961.

Potassium-argon age determinations on 53 micas, potassium feldspars, and whole-rock samples and helium age determinations on 3 garnets and 1 magnetite from the Akzhal-Aksoran belt and the Kounradski, Sayak, and Batystau-Bayanazar regions range from about 200 to 550×10^6 yr. Pre-Hercynian (415 - 550×10^6 yr) intrusions occur in the Akzhal-Aksoran belt as geoanticlinal rises on the border of the Dzhungaro-Balkhash Hercynian province and partly as huge xenoliths included in Hercynian rocks. The largest Early Hercynian (Late Devonian or Early Carboniferous) intrusives occur in the Gul'shad region (380×10^6 yr) and in the Balkhash tonalitic complex (about 400×10^6 yr). The late Early or early Middle Carboniferous granodioritic intrusions of the Sayak and Topar complexes give ages around 350 - 370×10^6 yr in the Shetska and Kounradski regions and 330×10^6 yr in the Akzhal-Aksoran belt. Many large granitic intrusions show similar ages. The many Late Hercynian leucocratic granites of the Akchatau complex give ages around 300×10^6 yr, and the Ortau massif is still younger, about 250 - 260×10^6 yr. — H. F.

- 187-45. Firsov, L. V. O vozraste zolotorudnogo mestorozhdeniya Vostochnoe v svyazi s opredeleniyami absolyutnogo vozrasta izveshennykh porod intruziva Khatynnakh v bassejne Kolymy [Age of the Vostochnoe gold deposit in connection with absolute age determinations on igneous rocks of the Khatynnakh intrusive in the Kolyma Basin]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 48-55, 1961.

The Vostochnoe deposit lies between the Khatynnakh and Mylga Rivers, near the south end of the Khatynnakh granodioritic intrusive in contact-metamorphosed sedimentary rocks of Triassic and Jurassic age. Potassium-argon age determinations on three rock types from the intrusive give 100, 105, and 135×10^6 yr. Potassium was measured by the chloroplatinate method, and argon was determined volumetrically with the background of atmospheric argon determined by blank analyses. — H. F.

- 187-46. Firsov, L. V. Opyt parallelnogo opredeleniya absolyutnogo vozrasta redkometalnoy kvartsevo-polevoshpatovoy zhily po Ar^{40}/K^{40} i He^4/Th^{232} [Experiment at parallel determination of the absolute age of a rare-metal quartz-feldspar vein according to K^{40}/Ar^{40} and He^4/Th^{232}]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 81-86, 1961.

A McLeod system for parallel volumetric determination of argon and helium is described together with details of analytical procedure and calculation of results. A whole-rock sample consisting of quartz, rose-brown feldspar, monazite, chevkinite, and yttrialite from a vein in northeastern Yakutsk A. S. S. R. gives ages of 190×10^6 yr by K/Ar and 174×10^6 yr by Th/He with no correction for air argon. — H. F.

- 187-47. Zykov, S. I., Stupnikova, N. I., Pavlenko, A. S., Tugarinov, A. I., and Orlova, L. P. Absolyutnyy vozrast intruziy Vostochno-Tuvinskogo regiona i Yeniseyskogo kryasha [Absolute age of intrusions in the East Tuva region and the Yenisei Range]: *Geokhimiya*, no. 7, p. 547-560, 1961.

The results of lead isotope age determinations on about 20 uranium-thorium minerals from intrusives in the Agash, Balyktygzhem, and Dugdin massifs and about 20 from other massifs in eastern Tuva are tabulated, together with results obtained on 25 galenas from intrusions in eastern Tuva and 7 monazites from the Tarak intrusion in the Yenisei Range. Thorianite proved to be useful for dating purposes.

The alkaline intrusives of eastern Tuva fall into two age groups, post-Caledonian ($390-430 \times 10^6$ yr) and Variscan (290×10^6 yr). The results on the Tarak massif confirm its Late Archean age ($1,800 \times 10^6$ yr) and also show evidence of intensive hydrothermal metamorphism about $400 \pm 50 \times 10^6$ yr ago. — D. B. V.

- 187-48. Sudovikov, N. G., and Neyelov, A. N. O vozraste stanovogo kompleksa [Age of the Stanovoi complex]: *Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy*, no. 12, p. 257-280, 1961.

The Aldan shield is underlain by Archean (Aldan and Stanovoi complexes), Proterozoic, Paleozoic, and Mesozoic rocks. The absolute age of the Aldan complex is greater than $2,400-2,200 \times 10^6$ yr (U-Th-Pb and K-Ar methods), and that of the Stanovoi complex is $1,900 \pm 100 \times 10^6$ yr (K-Ar, Rb-Sr, and U-Th-Pb methods). The K-Ar ages for the rocks of the Aldan complex indicate a widespread manifestation of the phenomenon of "rejuvenation" during late Archean (Stanovoi) time. Along the margins of the shield the Archean rocks have been rejuvenated locally by diaphoresis of Proterozoic ($1,450-1,300 \times 10^6$ yr) and Mesozoic ($200-170 \times 10^6$ yr) age.

To the south in the Stanovoi Range all Precambrian formations have been subjected to regional rejuvenation during the Mesozoic ($219-123 \times 10^6$ yr). This was not accompanied by mineralogical changes, and the structure of the rocks was preserved. Argon appears to diffuse from mica without disrupting the crystal structure under conditions corresponding to the epidote amphibolite facies (about 300°C). — J. W. C.

- 187-49. Velikoslavinskiy, D. A., Kazakov, A. N., and Gerling, E. K. K voprosu o vozraste geologicheskikh obrazovaniy Severo-Baykalskogo nagor'ya [Problem of the age of geological formations of the north Baikal highlands]: *Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy*, no. 12, p. 281-290, 1961.

Four age groups are recognized in the highlands of north Baikal: (1) Mayskaya and Chuyskaya series invaded by granite at $1,500-1,100 \times 10^6$ yr; (2) Zherbinskaya formation deposited at $550-500 \times 10^6$ yr, and Patomskaya series metamorphosed at $360-350 \times 10^6$ yr; (3) Mamskaya and Teptorginskaya series metamorphosed at $400-300 \times 10^6$ yr; and (4) postorogenic granites and syenites of the Mamskaya field intruded at $250-230 \times 10^6$ yr. Data for each age group are presented in tables and discussed, and a synthesis of the geologic history is compiled. — J. W. C.

- 187-50. Savel'yev, A. A. O vozraste skladchivosti, magmatizma i metamorfizma v proterozoye tsentral'noy chasti Vostochnogo Sayana [Age of the folding, magmatism, and metamorphism in the Proterozoic of the central part of the east Sayan]: *Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy*, no. 12, p. 291-298, 1961.

Geological and geochronological data are presented for geosynclinal and orogenic activity during the Proterozoic and Cambrian in the central part of the east Sayan. Age data are tabulated for gneisses, granites, marbles, and metamorphosed clastic rocks of the east Sayan anticlinorium; they range from 415 to 542×10^6 yr. — J. W. C.

- 187-51. Khil'tova, V. Ya. Metamorfizm Biryusinskoy i Derbinskoy seriy i yego absolyutnyy vozrast [Metamorphism of the Biryusinskiy and Derbinskiy series and its absolute age]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 299-313, 1961.

Regional and retrogressive metamorphisms have been established for the Biryusinskiy series of the Sayan Range. The K-Ar ages range from 460 to 670×10^6 yr and correspond in general to the time of the retrogressive alteration. Only one stage of metamorphism is distinguished in the Derbinskiy series; it is dated at $450-500 \times 10^6$ yr. — J. W. C.

- 187-52. Starik, I. Ye., Baranovskaya, N. V., Zhirova, V. V., and Krylov, A. Ya. Opredeleniye vozrasta magnetitov gelievym metodom [Determination of the age of magnetites by the helium method]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 151-159, 1961.

Radium and thorium are determined radiochemically, and helium is released (by dissolving the magnetite in HCl in a CO₂ atmosphere) and measured in a McLeod gauge. Magnetites from placers of the Khiloksky region (Transbaykal) and samarskite and fergusonite from pegmatite veins, all presumed to be Triassic on geologic grounds, give helium ages of $150-190 \times 10^6$ yr. The total-lead (X-ray spectroscopy) age of the fergusonite is 190×10^6 yr. Magnetite from the Bukhtarminsky deposit (Altay) gives 225 and 255×10^6 yr, magnetite from a placer in the Ubino-Byeloretskiy massif gives 375×10^6 yr, magnetites from placers in the right tributaries of the Byelaya Uba River (Lineyskiy granite) give 275 and 340×10^6 yr (Caledonian), and magnetites from five lake and river placers in the Tien Shan (from the Caledonian granites of the Terskey and Kungey Alatau) give $290-480 \times 10^6$ yr. Placer magnetite offers new possibilities for age determination, but magnetites that have suffered partial martitization, hematitization, or limonitization are not suitable for age work. — H. F.

- 187-53. Starik, I. Ye., and Zharkov, A. P. Skorost' osadkonakopleniya v Indiyском okeane po dannym radiouglerodnogo metoda [Rate of sedimentation in the Indian Ocean according to data of the radiocarbon method]: Akad. Nauk SSSR Doklady, v. 136, no. 1, p. 203-205, 1961.

Ocean floor sediments from two horizons at each of several stations in different parts of the Indian Ocean were dated by the C¹⁴ method. Ages range from $2,900 \pm 200$ to $34,500 \pm 200$ yr, and sedimentation rates, calculated from these values and thicknesses, range from 0.3 to 2.9 cm per 1,000 yr. Rates are different for the upper and lower horizons, in most cases being greater for the lower. The rate of sedimentation evidently depends on distance from the coast and from the mouth of the Ganges River. (See also Geophys. Abs. 184-591.) — D. B. V.

- 187-54. Inoue, Hideo, and Sato, Kazuo. Mode of occurrence and absolute age of uraninite from Ryuen mine, Fukuoka Prefecture [in Japanese with English abstract]: Japanese Assoc. Mineralogists, Petrologists, Econ. Geologists Jour., v. 46, no. 4, p. 133-137, 1961.

The U-Pb age of uraninite from a pegmatite intruding the Middle Cretaceous Masaki granite at the Ryuen mine, Fukuoka Prefecture, was determined previously as 100×10^6 yr by Kimura and Iimori (1937). A recent determination on uraninite from a chlorite vein cutting the pegmatite gives an age of 110×10^6 yr. This suggests that the chlorite vein formed immediately after solidification of the pegmatite. — V. S. N.

187-55. Searle, E. J. The age of the Auckland volcanoes: *New Zealand Geographer*, v. 17, no. 1, p. 52-63, 1961.

Radiocarbon dating of wood, charcoal, and shells associated with volcanic deposits of the Auckland area indicates that volcanic activity dates back more than 40,000 yr. A realistic estimate for the span of intermittent activity would be 60,000-70,000 yr; during that period eruptions occurred from at least 50 centers. The last eruption (Rangitoto A. D. $1,188 \pm 50$) less than 1,000 yr ago suggests that further eruptions may be expected to occur in the area. An age classification based on field evidence as well as C^{14} dates is presented: volcanoes older than 50,000 yr, volcanoes with C^{14} dates $>20,000$ yr, volcanoes $<20,000$ yr, and historic volcanoes (Rangitoto). — V. S. N.

187-56. Deutsch, Sarah, Picciotto, E[dgard] E., and Reinharz, M. Age measurements on Antarctic rocks (Queen Maud Land): *Nature*, v. 191, no. 4795, p. 1286-1287, 1961.

The last major metamorphic episode in Queen Maud Land is dated at approximately 475×10^6 yr by the Rb-Sr method on biotite from igneous and metamorphic rocks. Twelve determinations range from 455 to 506×10^6 yr. A half life of 50×10^9 yr was used. — R. M. G.

COSMOGONY

187-57. Lyttleton, R. A. An accretion hypothesis for the origin of the solar system: *Royal Astron. Soc. Monthly Notices*, v. 122, no. 5, p. 399-407, 1961.

Direct accretion of interstellar matter by the sun is considered as a possible source of material for a solar disk as the initial stage of planet formation. The existing mass and angular momentum require a size and density of the cloud in close agreement with observed values. The hypothesis would allow an origin for the planetary material quite separate from the sun and also would imply that a large proportion of old stars may have attendant planets. A disk so formed would appear quite as suitable a source for planets as one relying on magnetic coupling to the sun for its formation. — D. B. V.

187-58. Gilbert, C. Dirac's cosmology: *Nature*, v. 192, no. 4797, p. 57, 1961.

It is pointed out that the assumptions made in the theories of Egyed (see *Geophys. Abs.* 182-58, -59) and Hédervári are not necessarily associated only with the values of Hubble's constant (H) and the acceleration parameter (q) obtained by Gilbert (see *Geophys. Abs.* 182-281) on the basis of Dirac's cosmology. Other values may be obtained from a different description of the Dirac model in Riemannian space-time. Empirical values of H and q may soon be sufficiently accurate to permit a choice between models. — D. B. V.

187-59. Dicke, R. H. Dirac's cosmology and Mach's principle: *Nature*, v. 192, no. 4801, p. 440-441, 1961.

Dirac, P. A. M. Dirac's cosmology and Mach's principle: *ibid.*, p. 441, 1961.

Dicke considers that there is a fundamental relation between the cosmological number that determines the gravitational constant and the number of particles in the universe, following from Mach's principle, but that the cosmological number which determines the Hubble age of the universe is independent; therefore, the first two may be constant while the third varies with time. He shows that this third number would have roughly its present value when habitable planets exist.

Dirac points out that in Dicke's view habitable planets could exist only for a limited period, whereas with his own assumption that the relationships of the three cosmological numbers correspond to something fundamental in nature (so that when the last varies with time the others would also vary) habitable planets could exist indefinitely. — D. B. V.

187-60. Claus, George, and Nagy, Bartholomew. A microbiological examination of some carbonaceous chondrites: *Nature*, v. 192, no. 4803, p. 594-596, 1961.

Microscopic particles resembling fossil algae were found to be present in relatively large quantities in the Orgeuil and Ivuna carbonaceous meteorites. No such particles were found in two ordinary stone meteorites (Holbrook and Bruderheim). The five types of organized elements observed so far are described. It is suggested that these may be microfossils indigenous to the meteorite. — D. B. V.

187-61. Öpik, Ernst J. Meteorite impact life on earth: *Space Sci.*, v. 10, no. 1, p. 2-7, 1960.

The larger members of the interplanetary host of stray bodies that might possibly collide with the earth, asteroids of the Apollo group and comet nuclei, are discussed. From statistical analysis of observational data and from the mathematical theory of collisions, the expected number of asteroids and comet nuclei that may have hit the earth during its lifetime of 4.5 billion years has been calculated and results are given in a table. It appears that projectiles exceeding 4 km in diameter must have fallen 70 times; each was able to extinguish land life over an area equal to that of the United States. Catastrophes of hemispherical extent could have occurred 4 times, a global one perhaps once. These statistics also apply to the future. The expected frequency of collisions, however, seems to be low enough to permit continuous development of life for several hundred million or even a billion years. The surface of the moon is discussed as an observational check on the calculations. A similar calculation is given for Mars where the development of life would be interrupted roughly every 900 million years. — V. S. N.

187-62. Mason, Brian. Meteorites: *Jour. Geography* [Tokyo], v. 70, no. 4 (723), p. 193-198, 1961.

Current knowledge concerning the composition and texture of the three types of meteorites, the frequency of falls and finds, and the origin of meteorites are reviewed. (See also *Geophys. Abs.* 181-53, 183-52.) — V. S. N.

187-63. Mason, Brian. Reply to Dr. Harold C. Urey's criticism of the paper by Brian Mason, "The origin of meteorites": *Jour. Geophys. Research*, v. 66, no. 11, p. 3979-3980, 1961.

In his criticism of Mason's paper (see *Geophys. Abs.* 183-52, 185-80) Urey postulated a constant composition for the material from which the meteorites were formed, and a closed system throughout. Mason points out that there seems to be no factual evidence for either postulate.

It is difficult to produce decisive evidence for a clear-cut decision whether carbonaceous chondrites were derived from olivine-pyroxene chondrites or vice versa. If the carbonaceous chondrites were formed as suggested by Urey, however, chondrules of serpentine pseudomorphous after olivine or pyroxene should be found; but the chondrules that are found are of olivine or pyroxene and appear to have replaced serpentine of the matrix. The sequence appears to be Type I carbonaceous chondrites (no chondrules) → Type II carbonaceous chondrites (chondrules forming by decomposition of serpentine) → Type III carbonaceous chondrites (serpentine completely converted to olivine and pyroxene). — D. B. V.

187-64. Hayakawa, T., Hintenberger, H., and Wänke, H. Über die Häufigkeiten der durch die kosmische Strahlung in einigen Eisenmeteoriten produzierten Helium- und Neon-Isotope [On the abundances of the helium and neon isotopes produced by cosmic radiation in some iron meteorites]: *Zeitschr. Naturforschung*, v. 16a, no. 8, p. 844, 1961.

The neon helium contents of the Clark County, Thunda, Treysa, Carbo, and Bendego iron meteorites were reported earlier (see *Geophys. Abs.* 175-257). Their isotopic abundances are tabulated here, along with some corrections to values given in the earlier paper.

The $\text{He}^3/\text{Ne}^{21}$ ratio shows a systematic inverse relation to meteorite mass, and is presumably a depth effect of He^3 . — D. B. V.

187-65. Malmqvist, David. Der Meteoritenfall von Hökmark am 9. Juni 1954 [The meteorite fall of Hökmark on June 9, 1954]: *Uppsala Univ. Geol. Inst. Bull.*, v. 40, p. 95-117, 1961.

A meteorite fall on June 9, 1954 at Hökmark, Sweden, is described. Two fragments of stone meteorite were found; one weighs 196.7 g and has a specific gravity of 3.55, and the other weighs 108.8 g and has a specific gravity of 3.57. A man picked up one of the fragments some 10-20 sec after it fell (it nearly struck him), and it felt neither warm nor cold to the touch. — J. W. C.

187-66. L'vov, Yu. A., Vasil'yev, N. V., Osharov, A. B., Trukachev, G. A., and Yeroshkina, A. I. Proverka odnoy gipotezy (Svyazau li vyral lesa v bassejne reki Keti s padeniyem Tungusskogo meteorita?) [Examination of an hypothesis (Is the forest fall in the basin of Ket River related to the fall of Tungus meteorite?): *Priroda*, no. 7, p. 98-99, 1961.

The explanation that the strip of fallen forest 40 km long and up to 4 km wide along the right bank of Ket River was caused by the fall of Tungus meteorite is challenged. By questioning 80 persons who live in the area, it was found that the fall was caused by two storms: one between 1904 and 1912, and the other between 1923 and 1928. — A. J. S.

187-67. Kirova, O. A. O mineralogicheskom izuchenii prob pochv iz rayona padeniya Tungusskogo meteorita, sobrannykh ekspeditsiyey 1958 g. [On the mineralogical study of soil samples from the region of fall of the Tungus meteorite, collected by the expedition of 1958]: *Akad. Nauk SSSR Meteoritika*, no. 20, p. 32-39, 1961.

A mineralogical study was made of soil samples taken from a 1,000 km² area of the fall region of the Tungus meteorite. About 90 soil samples from 5 cm deep were studied. Washed soil samples were investigated for nickel content, traces of which (about 0.1 percent) were found in some particles of the magnetic fraction. No minerals of meteoritic origin were found. (See also Geophys. Abs. 184-106.)—A. J. S.

- 187-68. Alexander, W. M. McCracken, C. W., and LaGow, H. E. Interplanetary dust particles of micro-size probably associated with the Leonid meteor stream: *Jour. Geophys. Research*, v. 66, no. 11, p. 3970-3973, 1961.

The dust-particle sensor on the Vanguard III (1959 η) satellite revealed an interval of unusual interplanetary dust particle activity. The important details of the event are reported. It is suggested that these particles could have come from the Leonid meteor stream. The need for more sophisticated dust particle sensors on oriented satellites in studying such activity (at particle size for which ground-based observations are not possible) is mentioned in conclusion. — D. B. V.

- 187-69. Singer, S. F. Interplanetary dust near the earth: *Nature*, v. 192, no. 4800, p. 321-323, 1961.

Theoretical calculations of gravitational accretion of interplanetary dust lead to the prediction that there is a maximum dust concentration at about 2,000-3,000 km above the earth's surface. This dust forms a modest shell around the earth rather than being characterized by a variation with a factor of 10^3 - 10^5 increasing uniformly without a maximum. Experimental data so far available are too scanty to permit firm conclusions about the presence or absence of such a shell. — D. B. V.

- 187-70. McCracken, C. W., Alexander, W. M., and Dubin, M[aurice]. Direct measurement of interplanetary dust particles in the vicinity of earth: *Nature*, v. 192, no. 4801, p. 441-442, 1961.

A series of corrections have been completed that allow results from seven successful high-altitude rockets to be used in quantitative discussions of interplanetary dust particles. Preliminary results, including a new curve for mass distribution and spatial density, are presented here.

An interesting consequence of the new curve is that the influx rate of interplanetary dust is approximately 10^4 tons per day onto the earth; this means that dust particles in the direct-measurements range of particle size dominate the accretion process. — D. B. V.

- 187-71. Dietz, Robert S. Astroblemes: *Sci. American*, v. 205, no. 2, p. 51-58, 1961.

The record of meteorite bombardment preserved on the face of the moon plainly suggests that the list of scars on the earth's surface should be much longer than the 14 well-certified meteorite craters now known. A few "fossil" craters have shown up on aerial photographs, and geological maps of surface and subsurface rock formations have revealed still other circular features that have been generally attributed to volcanic explosions. It now appears that many of the latter are root structures of ancient meteorite craters, and the term "astrobleme" is proposed for those that prove to be obliterated meteorite craters (see also Geophys. Abs. 182-68). At the site of a

suspected astrobleme, evidence of sudden extremely intense shock waves should be sought. Two conclusive pieces of evidence of shock waves of this kind are: (1) conical fractures in rocks known as shatter cones, and (2) coesite, which is created under extremely high pressure. Shatter cones associated with well-known craters such as Barringer in Arizona and the Vredefort Ring in the Transvaal of South Africa are discussed, and those in other structures such as the Wells Creek Basin, Tenn.; the Sierra Madera, Tex.; and Serpent Mound, Ohio, are described. The five sites where coesite has been sought and found—Barringer Crater, Ries Kessel (Germany), Wabar Craters (Arabia), Ashanti Crater, and the Teapot Ess Crater at the Nevada Proving Grounds where the mineral was created by an atomic blast—are discussed. A history of the development of the Vredefort Ring structure is proposed and illustrated. — V. S. N.

187-72. Cohen, Alvin J., Bunch, Ted E., and Reid, Arch. M. Coesite discoveries establish cryptovolcanics as fossil meteor craters: *Science*, v. 134, no. 3490, p. 1624-1625, 1961.

Discovery of coesite in St. Peter sandstone from the central uplift of the Kentland structure, Newton County, Ind., and in shatter cones of Lilley dolomite of Middle Silurian age from the central uplift of the Serpent Mound structure near Sinking Springs, Ohio, proves that shatter cones are evidence of meteorite impact. — Authors' abstract

187-73. Bjork, R. L. Analysis of the formation of Meteor Crater, Arizona: a preliminary report: *Jour. Geophys. Research*, v. 66, no. 10, p. 3379-3387, 1961.

A theoretical study of the cratering process accompanying the impact of a 12,000-ton iron projectile on a semi-infinite half space of soft rock at a velocity of 30 km/s suggests that the meteorite that formed Meteor Crater in Arizona had a mass between 30,000 and 194,000 tons, the range being due to uncertainty of the impact velocity. — D. B. V.

187-74. Innes, M. J. S. The use of gravity methods to study the underground structure and impact energy of meteorite craters: *Jour. Geophys. Research*, v. 66, no. 7, p. 2225-2239, 1961.

The mass deficiency and hence the amount of shattered rock under the Deep Bay, Brent, and Holleford meteorite craters in the Canadian shield have been computed from gravity data. The results show good agreement with the crater model computed by Rottenberg as combined with the depth/diameter ratios of Baldwin for meteorite impact craters. The zone of complete rupture is shown to extend to a depth of approximately one-third of the crater's diameter, and impact energy values, derived from the energy of crushing, are 6.5×10^{23} ergs, 2.1×10^{24} ergs, and 8.7×10^{25} ergs for Holleford, Brent, and Deep Bay, respectively. — D. B. V.

187-75. Beals, C. S. A probable meteorite crater of Precambrian age at Holleford, Ontario: *Dominion Observatory Ottawa Pubs.*, v. 24, no. 6, p. 117-142, 1960.

A circular feature 1.46 miles in diameter and 100 feet deep located at long 76°38' W. and lat 44°27' N. in southeastern Ontario has been investigated as a possible meteorite crater. Stereoscopic studies of aerial photographs in conjunction with geological and geophysical investigations (magnetic, seismic,

gravimetric) indicated the presence of a circular depression in Precambrian rock filled in and covered over by Paleozoic sediments. Three diamond drill holes were put down at distances of 1,400, 2,500, and 3,750 feet from the center to determine whether the depth of the base of the sediments and the sub-surface structure are consistent with a meteoritic origin. The results show a depth and profile close to those predicted for a meteorite crater of the observed diameter. Below the sediments a thickness of several hundred feet of shattered and pulverized rock was found for which no adequate explanation has yet been found except that of meteorite impact and explosion (see *Geophys. Abs.* 182-295). — V. S. N.

- 187-76. Shoemaker, E[ugene] M., and Chao, E. C. T. New evidence for the impact origin of the Ries basin, Bavaria, Germany: *Jour. Geophys. Research*, v. 66, no. 10, p. 3371-3378, 1961.

The only direct evidence of magmatic activity at the Ries explosion crater in Bavaria is the presence of glass in scattered patches of a breccia called suevite. Some of the glass has long been recognized as sintered fragments of old crystalline rocks. It is found that glasses of various compositions co-exist in a single suevite specimen, and that coesite and lechatelierite occur in the sintered rocks in the suevite. These same phenomena are present at Meteor Crater in Arizona, suggesting that the glassy components of suevite are of impact rather than volcanic origin. — D. B. V.

- 187-77. Baker, George. A perfectly developed hollow australite: *Am. Jour. Sci.*, v. 259, no. 10, p. 791-800, 1961.

A rare hollow australite found as a complete, non-weathered specimen near Horsham, western Victoria, was cut into two equal portions to reveal an internal cavity and described in 1898 by Walcott. A recent re-examination has shown that the australite resulted from ablation of a primary sphere of tektite glass containing a relatively large, eccentrically disposed, elliptical internal cavity. During the high speed unidirectional fall to the earth through the atmosphere, it maintained an aerodynamically stable orientation so that only the thicker surface directed forward was subjected to ablation from aerodynamic frictional heating. This process resulted in a loss of 43.6 percent of tektite glass from the original sphere without penetrating the internal cavity. — V. S. N.

- 187-78. Clarke, Roy S., and Carron, Maxwell K. Comparison of tektite specimens from Empire, Georgia, and Martha's Vineyard, Massachusetts: *Smithsonian Inst. Misc. Colln.*, v. 143, no. 4, 18 p., 1961.

Physical and chemical data and photographs are presented for specimens of tektites from Gay Head, Martha's Vineyard, Mass., and from Empire, Ga. A similarity between the two specimens is suggested by their close agreement in chemical composition, color, density, and magnetic properties, and by the similar lack of evidence in gross shapes or on the surfaces to suggest a history of aerodynamic shaping. From the data determined, it is not possible to report that these two specimens are unequivocally tektites. The chemical compositions separate the specimens from known tektite groups. All of the properties measured have counterparts in natural or artificial glasses. Further information on these tektites, particularly on their field occurrence, is necessary. — V. S. N.

- 187-79. Kopal, Zdeněk. The moon—our nearest celestial neighbour: New York, Academic Press, Inc., 131 p., 1960.

Our present store of knowledge concerning the physical properties and conditions prevailing on the surface of the moon are described for the layman in an easily followed account of telescopic examination and astronomical research. The text includes seven chapters as follows: prologue; facts and figures; strange world of the moon; the story of moonlight; lunar surface; changes on the moon; and destination moon. — V. S. N.

- 187-80. Kuiper, Gerard P. The moon, in *The exploration of space*: New York, MacMillan Company, p. 70-74, 1960.

This is virtually the same as the paper published previously in *Jour. Geophys. Research*, v. 64, no. 11, p. 1713-1719, 1959 (see *Geophys. Abs.* 179-25). — V. S. N.

- 187-81. Öpik, Ernst J. The origin of the moon: *Space Sci.*, v. 10, no. 8, p. 2-7, 1961.

The changes in lunar orbit can be more or less reliably calculated for the past 4 billion years, but for the first 500 million years of the solar system's existence the uncertainty is great, involving the time, place, and mode of origin of both the moon and the earth. Assuming that the tidal friction between the earth and the moon is determined by the present rate of recession of the moon, it is possible to calculate backwards to find the lunar orbit at any time in the past. Gerstenkorn's theory that the moon came from a distant point on the earth's orbit—possibly opposite the earth—is discussed. Öpik believes, however, that the moon was formed in only 80 years from a ring or cloud of fragments circling the earth at a distance of 5 to 8 earth radii or farther. Tidal evolution started only at the time of the moon's formation. New criteria for deciding on the time and place of the birth of the moon is found in a study of the shapes of lunar craters (see *Geophys. Abs.* 186-92). — V. S. N.

- 187-82. Takeuchi, H[itoshi], Saito, M[asanori], and Kobayashi, N[aota]: Free oscillations of the moon: *Jour. Geophys. Research*, v. 66, no. 11, p. 3895-3897, 1961.

The free oscillations of a homogeneous self-gravitating elastic sphere are studied theoretically; numerical results for torsional and spheroidal oscillations are given in two tables that also show the free periods of a model moon having a density of 3.33 g per cm³ and shear wave velocity of 4.7 km/s. For this model, the effect of gravity on the periods of oscillation is shown to be negligible. The effect of curvature on phase velocity dispersion is estimated from the spheroidal oscillations. — D. B. V.

- 187-83. Bolt, Bruce A. Theoretical phase velocities for a lunar seismic experiment: *Jour. Geophys. Research*, v. 66, no. 10, p. 3513-3518, 1961.

Theoretical frequency spectra ${}_0S_{20}$ - ${}_0S_{150}$ of spheroidal eigenvibrations for three models of the moon are presented. The derived phase velocities for Rayleigh waves, with periods between 120 and 20 sec, are compared with phase velocities calculated using a plane-layer approximation. The comparison demonstrates that, for the moon, the latter approximation is inadequate for waves having periods exceeding 25 to 30 sec. The results (a) support a suggestion

that the operation of a single recorder of free lunar vibrations may provide discriminatory information on the interior of the moon and (b) provide data for the construction of such a recorder. — Author's abstract

- 187-84. Barabashov [Barabashev], N. P., Mikhailov, A. A., and Lipsky, Yu. N. Atlas obratnoy storony Lunny [An atlas of the moon's far side]: Moskva, Akad. Nauk SSSR, 1960; English edition—Rodman, Richard B. (translator). An atlas of the moon's far side. The Lunik III reconnaissance: New York and London, Interscience Publishers, 147 p., 20 plates, 1961.

This atlas includes a map of the far side of the moon compiled from the Lunik III photographs, a catalog of physiographic features observed, and reproductions of 30 photographs. In the introductory section a brief discussion is given of the photographs and their transmission, and of the interpretive techniques used, particularly that of the successful photometric cross section method. — V. S. N.

- 187-85. Jeffreys, Harold. On the figure of the moon: Royal Astron. Soc. Monthly Notices, v. 122, no. 5, p. 421-432, 1961.

A rediscussion of the librations of the moon's axis is carried out literally to orders e^2 and i^2 of the main terms, and a solar effect not evaluated by Hayn is taken into account. It appears that solar effects nearly cancel out the corrections for e^2 and i^2 . The observational data are rediscussed, and it appears that $\beta = 0.006279 \pm 0.0000015$ if the discrepancies between the observational determinations can legitimately be treated as random, but if this is not true the uncertainty may well be multiplied by 4.

Recent discussions of the annual libration in longitude appear to give values of γ near to those given by the Yakovkin term. A method is proposed for dealing with the difficulty stated by Banachiewicz.

The data on the secular motions of the moon's node and perigee show no serious discrepancy with the results on its figure. — Author's summary

- 187-86. Hess, Wilmot N., and Nordyke, M. D. Throwout calculations for explosion craters: Jour. Geophys. Research, v. 66, no. 10, p. 3405-3412, 1961.

Using information obtained from a 500-ton high-explosive blast, the apparent crater and lip shape and characteristics have been roughly calculated. By changing the gravity value and crater size, the appearance of lunar craters was calculated. It was found that a crater on the moon from a certain explosive yield should be about the same size as a crater on earth made by the same explosive yield. — D. B. V.

- 187-87. Cohen, A[lvin] J. Megashatter cone hypothesis of the origin of lunar volcanoes: Nature, v. 192, no. 4800, p. 346, 1961.

It is proposed that lunar volcanoes are not volcanoes, but extremely large shatter cones produced by the shock waves resulting from impact of an asteroid. These megacones are composed of smaller groups of shatter cones, like terrestrial shatter cones of the Kentland type (see Dietz, Geophys. Abs. 179-34, 182-68). It is proposed that the roots of a central uplift in a crater that was formed by a large impact explosion produced by a nickel-iron asteroid consist of a megamegacone composed in turn of many concentrically arranged megacones, all originally pointing upwards and inward toward the center of

impact. Most of these will have been almost instantly blown outward, leaving the central region filled with explosion breccia and (or) impact glass. Rebound after impact will lift this root structure a considerable distance, but it will always remain below the original lunar surface. — D. B. V.

- 187-88. Salisbury, John W. The origin of lunar domes: *Astrophys. Jour.*, v. 134, no. 1, p. 126-129, 1961.

This is the same paper as previously published in *Lunar and Planetary Explor. Colloquium Proc.*, v. 11, no. 2, p. 22-26, 1960 (see *Geophys. Abs.* 186-86). — D. B. V.

- 187-89. Space Science. Survival on the moon: *Space Sci.*, v. 10, no. 7, p. 2-4, 1961.

A condensation is given of the paper, "The application of geology to man's survival on the moon", presented by Jack Green before the meeting of the American Association for the Advancement of Science, in December 1960. Geology may provide knowledge of terrain features and their possibilities for concealment and protection—volcanic landforms would be particularly useful in this respect. Geologic mapping will lead to use of surface rock for insulation, building stone, and water content; to the use of minerals of a volcanic terrain to provide critical elements such as sulfur and ice; and may lead to sources of heat and power from local concentrations of radioactive rocks or from fumaroles at ray intersections. The geoscientist may prescribe the tools best suited for lunar exploration such as the density logger, neutron-neutron logger, and the neutron-gamma deuterium-tritium accelerator logger, as well as nuclear spectroscopy techniques. — V. S. N.

EARTH CURRENTS

- 187-90. Rikitake, Tsuneji. Sq and ocean: *Jour. Geophys. Research*, v. 66, no. 10, p. 3245-3254, 1961.

A theory of electromagnetic induction within a hemispherical conducting sheet over a nonconductor and underlain by a concentric sphere of uniform conductivity is described and applied to induction by Sq in a vast ocean. It is concluded that the electrical currents induced in the ocean are considerably smaller than those estimated for a single hemispherical sheet (about 2γ maximum anomaly); therefore, electromagnetic coupling between the ocean and the nonconducting part of the earth's mantle cannot be neglected in a study of this kind. (See also *Geophys. Abs.* 184-133). — D. B. V.

- 187-91. Shuleykin, V. V. Eksperimental'naya proverka gipotezy o prirode magnitnogo skloneniya [Experimental test of the hypothesis concerning the nature of magnetic declination]: *Akad. Nauk SSSR Doklady*, v. 130, no. 5, p. 1015-1018, 1960.

The hypothesis that earth currents in the ocean cause at least part of magnetic declination was tested in the Atlantic Ocean between Africa and South America. The apparatus used consisted essentially of a ship's compass and a wrist watch with second sweep, together with a photographic recording device in a towed container. It was found that declination at 2,000 m depth was 5° less than that at the surface of the ocean. As this depth is negligible compared to the height of the ionosphere, the difference must all be due to earth currents in the ocean. Calculations show that here these currents account for about one-third of the total magnetic declination, the other two-thirds be-

ing due to ionospheric currents, which are also related to the distribution of continents and oceans. — D. B. V.

- 187-92. Shuleykin, V. V., and Sigachev, N. I. Novaya proverka gipotezy o prirode magnitnogo skloneniya [A new test of a hypothesis concerning the nature of magnetic declination]: Akad. Nauk SSSR Doklady, v. 140, no. 1, p. 107-110, 1961.

A new gyroscopic compass apparatus is described. Results obtained with it in the equatorial Atlantic Ocean support the hypothesis advanced by Shuleykin in 1958 (see Geophys. Abs. 174-10) that earth currents in the ocean are concerned in production of the latitudinal component of the direction of the geomagnetic field, or magnetic declination. Earth currents are responsible for about half of the latitudinal component. — D. B. V.

- 187-93. Kalmakov, M. V. Ob odnoy interesnoy osobennosti teoreticheskikh krivykh magnetotelluricheskogo zondirovaniya [An interesting feature of theoretical curves of magnetotelluric sounding]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 583-587, 1961.

In calculating theoretical curves of magnetotelluric sounding (MTS) it is assumed that plane-polarized electromagnetic waves associated with oscillations of the earth's electromagnetic field impinge perpendicularly on a medium consisting of horizontal homogeneous layers. Surface measurements of the electric field E_x and the magnetic field H_y and of the phase angle ϕ between them at various periods of oscillation (T) furnish a basis for a layer analysis of the medium. The symmetry of MTS curves has been proved for specified relations between the parameters of geologic sections. This symmetry is characteristic of $|\rho_k / \rho_1|$ and ϕ curves. The symmetry reduces the work of calculation and the number of curves by one-half. The identical shapes of the symmetrical curves provide a graphic means of comparing MTS resolving power for different types of sections. — J. W. C.

- 187-94. Gugunava, G. E., and Chelidze, T. L. K voprosu primeneniya chastotnogo analiza pri geokartirovani dlinnoperiodnymi variatsiyami telluricheskikh tokov [On the problem of application of frequency analysis in subsurface mapping by means of long period variations of telluric currents]: Akad. Nauk Gruz. SSR Soobshch., v. 25, no. 6, p. 659-664, 1960.

An exploration method using long period variations in earth currents is discussed. The method of the telluroparameter V is used in the treatment of the data obtained. This value is the ratio of the amplitude of variations of the potential gradient at the base point to that at a point that is moved along the profile. According to the theory, the depth h of penetration of a-c is determined by its wave length $\lambda = 10^3(10\rho T)^{1/2}$, where ρ is resistance in ohms, and T is period in sec. In practice, however, the penetration depth was found to be different; it can be calculated by a modified formula. — A. J. S.

Kántás, Karl. Geophysical interpretation problems in the Vienna Basin. See Geophys. Abs. 187-328.

Shuleykin, V. V. Some features of the secular variation of the magnetic field over the oceans. See Geophys. Abs. 187-410.

Rikitake, T[suneji]. The effect of the ocean on rapid geomagnetic changes. See Geophys. Abs. 187-424.

- 187-95. Kataja, Airi. The 1960 Kuusamo-Salla earthquake, II. Macro-seismic data: *Geophysica* [Helsinki], v. 7, no. 3, p. 179-189, 1961.

The macroseismic data from two earthquakes that occurred in Finland on February 2 and February 20, 1960 are tabulated. The strongest intensities felt indicate that the epicenters were at lat 66.92° N., long 31.02° E. and lat 66.59° N., long 28.76° E., respectively. The macroseismic distribution in Finland was about 18,000 and 14,000 km², respectively. The highest intensity for both was 5, but it is possible that the earlier event was of intensity 6 at the epicenter. The nature of the ground exerted some influence on the felt area because intensities diminished more quickly in some directions than in others. — V. S. N.

- 187-96. Central Water and Power Research Station Poona. Earth tremors at Mangalam damsite, January-March 1960: India Ministry of Irrigation and Power Central Water and Power Research Sta. Poona Ann. Research Mem., 1960, p. 221-223, 1961.

Results of a study of the numerous mild tremors in the vicinity of Mangalam damsite, Kerala State, India, of January-March 1960, and of the field examination of any possible damage to the dam structure are reported. It is concluded from the tectonics and seismicity of this and neighboring areas that no severe seismic activity is anticipated in this or other parts of the west coast of India south of Bombay. Acceleration from earthquakes, even at the epicenters, will be very small, and in general no seismic factor need be incorporated in the design of dams in this area. — V. S. N.

- 187-97. Tskhakaya, A. D., and Sikharulidze, D. I. *Zemletryaseniye v verkhney megrelii* 25 XII 55 [Earthquake in the upper Megrel, December 25, 1955]: *Akad. Nauk Gruzin, SSR Soobshch.*, v. 20, no. 1, p. 27-34, 1958.

An earthquake of 6-7 points intensity took place in the Megrel Range, a south spur of the central Caucasus, on December 25, 1955. This was part of a renewed seismic activity in the western and central Caucasus that began in 1955 after a period of calm since 1902. An isoseismic map shows the epicenter and the intensity zones. The epicenter was located on the Megrel fault. — J. W. C.

- 187-98. Bune, V. I. *Posleduyushchiye tolchki Nurekского zemletryaseniya 9/22-1956 i otsenka seysmicheskoy aktivnosti Bol'shogo Stalinabadского rayona* [Aftershocks of the Nurek earthquake of September 22, 1956, and estimation of the seismic activity of the Great Stalinabad region]: *Akad. Nauk Tadzhik SSR Inst. Seysmostoykogo Stroitel'stva i Seysmologii Trudy*, v. 6, p. 109-140, 1960.

The seismicity of the Stalinabad region (38.0°-39.0 N. and 68.0°-69.5° E.) is examined in the light of the number of aftershocks that followed the Nurek earthquake of September 22, 1956. The interference of the aftershocks with determination of the seismic parameters of the region was investigated, and the disturbance of the "normal" seismic regime by the aftershocks was estimated from the 1955-58 records of highly sensitive seismic stations and from records of standard stations for 1929-58. — A. J. S.

- 187-99. Kinyapina, T. A. *Nurekskoye zemletryaseniye 28 yanvarya 1957* [The Nurek earthquake of January 28, 1957]: *Akad. Nauk Tadzhik*

SSR, Inst. Seysmostoykogo Stroitel'stva i Seysmologii Trudy, v. 6, p. 183-196, 1960.

The Nurek earthquake of January 28, 1957 at 21^h01^m G. m. t. in the central part of the Tadzhik S. S. R. between the Ilyak and Vakhsh Rivers is described. Its focal depth was determined to be 5 km, and the intensity estimated at 6-7 points. The epicentral zone lies on the northeastern boundary fault of the Kara Tau anticline. This earthquake is considered to be possibly a strong aftershock of the Nurek earthquake of September 22, 1956 (see Geophys. Abs. 187-98). — A. J. S.

187-100. Vasil'yeva, L. B. Andzhirskoye zemletryaseniye 1953 [The Andzhir earthquake of 1953]: Akad. Nauk Tadzhik SSR, Inst. Seysmostoykogo Stroitel'stva i Seysmologii Trudy, v. 6, p. 171-182, 1960.

The Andzhir earthquake of 7-8 points intensity occurred on July 7, 1953 at 7^h21^m local time and caused destruction in several villages to the south of Stalinabad. The geology of the region is described, and the origin of the earthquake is discussed. — A. J. S.

187-101. Morgan, W. J., Stoner, J. O., and Dicke, R. H. Periodicity of earthquakes and the invariance of the gravitational constant: Jour. Geophys. Research, v. 66, no. 11, p. 3831-3843, 1961.

Times of occurrence for a total of 1,933 earthquakes are analyzed for periodicities. The results show no definite evidence for effects due to earth tides. Small indications of a solar-date periodicity are assumed to be thermal in origin. A strong statistically significant annual period is found, and the phase is substantially the same for northern and southern earthquakes. This periodicity is not wholly accounted for by temperature effects, wind-induced stresses, and observer bias. The occurrence of this periodicity would be understandable if the gravitational constant were to vary as the earth-sun distance changes or as the earth's velocity relative to a preferred coordinate frame changes; however, the observed periodicity cannot be interpreted as conclusive support for such a hypothesis. — Author's abstract

187-102. Puchkov, S. V. Nekotoryye voprosy rascheta elementov seysmicheskikh kolebaniy dlya mikrorayonirovaniya [Certain problems of calculation of the elements of seismic oscillations for micro-regionalization]: Akad. Nauk Tadzhik SSR Inst. Seysmologii Trudy, v. 113, p. 69-83, 1959.

The engineering basis for seismic microregionalization is discussed, and a mathematical analysis is given for ways of expressing seismic oscillations during their passage through an acoustically rigid medium. The problems arising in determination of the maximum force of an earthquake on the surface of the bed rock, resonant oscillations of a layer, displacements on the surface of a thin layer by repeatedly reflected seismic waves, and the affect of the duration of seismic oscillations for various grounds are investigated and discussed. — A. J. S.

187-103. Gutenberg, B[eno]. Earthquakes in North America, in Smithsonian treasury of science, v. 2: New York, Simon and Schuster, Inc., p. 379-397, 1960.

This paper was originally published in the Smithsonian Report for 1950 (also in Science, see Geophys. Abs. 142-12190) and is reprinted here with minor revisions made in 1959. — V. S. N.

- 187-104. Kárník, Vít. Seismicity of Europe. Progress report II: Internat. Union Geodesy and Geophysics Mon., no. 9, 31 p., 1961.

At the meeting of the European Seismological Commission in Helsinki in 1960 it was reported that the first draft of an earthquake catalog and several seismicity maps for Europe, covering the period 1901-55, have been prepared. A list of sources is given by country. The contents of individual columns in the catalog and problems connected with them are discussed. For orientation purposes and for classification of earthquakes, values of magnitude (M) were calculated for various maximum intensities (I_0) on the Mercalli-Sieberg scale by means of the formula $M=0.67 I_0+1.7 \log h-1.4$ (h =focal depth). Seven classes of earthquakes were used. In view of the limited accuracy of the information and for practical treatment of a large number of observations, it is proposed that in future compilations the number of classes be reduced to four: $I_0=6$ ($M=4-4\frac{3}{4}$), $7-8$ ($M=5-6\frac{1}{4}$), $9-10$ ($M=6\frac{1}{2}-7\frac{1}{2}$), and $11-12$ ($M\approx 7\frac{3}{4}$).

Five maps are given, showing the distribution of epicenters in each of the 7 classes for shallow ($h<60$ km) and deep-focus earthquakes in Europe and the Mediterranean area during the period 1901-55. — D. B. V.

- 187-105. Savarenskiy, Ye. F., and Dzhibladze, E. A. Ob energii zemletriyaseniya Bol'shogo Kavkaza [On the energy of earthquakes of the Great Caucasus]: Akad. Nauk Gruzin. SSR Soobshch., v. 18, no. 1, p. 25-29, 1957.

The earthquakes of the Great Caucasus are classified according to their energy and to features of their epicentral areas (see also Geophys. Abs. 166-67, 176-34). — A. J. S.

- 187-106. Gayskiy, V. N., Katok, A. P., and Bil'man, B. M. O seysmichnosti Tadzhikistana v 1957 [On the seismicity of Tadzhikistan in 1957]: Akad. Nauk Tadzhik SSR, Inst. Seysmostoykogo Stroitel'stva i Seismologii Trudy, v. 6, p. 89-108, 1960.

Seismic activity in the Tadzhik S. S. R. during 1957 is analyzed on a basis of 208 earthquakes recorded by the regional network of seismic stations of central Asia. — A. J. S.

- 187-107. Bune, V. I., and Reyman, V. M. K seysmotektonicheskoy kharakteristike tsentral'noy chasti Tadzhikskoy depressii [On the seismotectonic characteristic of the central part of the Tadzhik depression]: Akad. Nauk Tadzhik SSR Inst. Seysmostoykogo Stroitel'stva i Seismologii Trudy, v. 7, p. 3-26, 1960.

A comparison of data on the main faults and on the location of epicenters of earthquakes is given on the basis of seismic and geologic findings in the Vakhsh River area in 1955-58. The epicentral zone in the area is related to Alpine faults. The planes of the faults dip steeply; they are observed seismically to a depth of 30 km. Migrations of epicenters along the faults are observed. The maximum (9 points M. M.) of earthquake intensity is correlated with the Vakhsh regional fault, and seismically dangerous zones with fault junctions. — A. J. S.

- 187-108. Riznichenko, J. [Yu.] V., and Nersesov, I. L. A detailed study of the seismic regime in the Garm epicentral region: *Annali Geofisica*, v. 14, no. 2, p. 173-186, 1961.

A five-year detailed instrumental study of earthquakes in the Garm-Stalinabad seismic region of the Tadzhik S. S. R. has resulted in a method of quantitative determination of the seismic activity (A) of a region. The value A represents the frequency of occurrence of earthquakes in a given area and in a given energy range, where the number of earthquakes is large enough to afford reliable statistical conclusions. Quantitative determination of seismicity cannot be based only on the strongest earthquakes but must also take A into account.

A special study of temporal changes in A after strong earthquakes suggests that in some cases A varies in inverse proportion to the time elapsed since a strong shock. — D. B. V.

- 187-109. Rozova, Ye. A. *Voprosy stroitel'stva v seismicheskikh rayonakh* [Problems of construction in seismic regions]: *Akad. Nauk SSSR Vestnik*, v. 31, no. 9, p. 73-75, 1961.

The growing industry in the Kirgiz S. S. R. has created the necessity for seismicity maps for use in planning industrial construction. This region is classed almost entirely as 8 or 9 intensity zones. Microregionalization studies are now being made to determine the best areas for location of population centers. — J. W. C.

- 187-110. Fedotov, S. A., Averjanova [Aver'yanova], V. N., Bagdasarova, A. M., Kusin, A. P. [Kuzin, I. P.], and Tarkanov [Tarakanov], R. Z. Some results of the detailed study of the south Kurile Islands seismicity: *Annali Geofisica*, v. 14, no. 2, p. 119-136, 1961.

This is essentially the same paper as previously published in *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 5, p. 633-642, 1961 (see *Geophys. Abs.* 186-149). — D. B. V.

- 187-111. Hatherton, T. A note on the seismicity of the Ross Sea region: *Royal Astron. Soc. Geophys. Jour.*, v. 5, no. 3, p. 252-253, 1961.

Although the aseismicity of Antarctica has been confirmed by International Geophysical Year observations, small local disturbances, up to magnitude 3, are almost a daily feature of seismograms at Scott Base. S-P intervals of these shocks range from 3 to 38 sec but half of the shocks recorded have S-P differences of 4-6 sec, values appropriate to the distance of Mount Erebus. An unusual low-velocity phase (V about 0.6 km/s) is present on many seismograms. — Author's summary

- 186-112. Ragimov, Sh. S. *O napravlenii storon treugol'nika stantsiy pri opredelenii azimuta seismicheskikh voln metodom troynykh stantsiy* [On the orientation of the sides of the triangle of stations in determination of the seismic waves azimuth by the three stations method]: *Akad. Nauk Azerbaydzhan. SSR Doklady*, v. 16, no. 6, p. 547-548, 1960.

A suggestion is made to orient the sides of the three-station triangle arrangement, used in determination of propagation direction of seismic waves, in such a way that the equation $\tan A_z = \tau_{13} / \tau_{12}$ (in which A_z is the azimuth angle;

$\tau_{12}=T_1-T_2$; $\tau_{13}=T_1-T_3$; and T_1 , T_2 , and T_3 are the arrival times of the same wave at stations 1, 2, and 3, respectively) is satisfied when the angle α (azimuth of the side 1, 2) equals zero. Such an arrangement shortens the computation work considerably. — A. J. S.

- 187-113. Ayzazov, I. V. Zavisimosti mezhdu ball'nost'yu, intensivnostyu i glubinoi ochaga dlya kavkazskikh zemletryaseniy [Correlation between intensity, magnitude, and focal depth for Caucasus earthquakes]: Akad. Nauk Gruzin. SSR Soobshch., v. 26, no. 2, p. 149-152, 1961.

The correlation between J , M , and h is given in the form $J_0=P+QM-T \log h$, where J_0 is intensity at the epicenter, M is the magnitude, and h is the depth of the earthquake, P , Q , and T being constants. Shebalin's formula $J_0=(3.0\pm 0.3)+(1.52\pm 0.1)M-(3.2\pm 0.3) \log h$ calculated for the U. S. S. R. was modified for earthquakes in the Caucasus as follows: $J_0=(3.22\pm 0.5)+(1.08\pm 0.25)M-(1.23\pm 0.61) \log h$. Comparative values of intensities of 23 earthquakes calculated with this formula are given. — A. J. S.

- 187-114. Balakina, L. M., Savarensky, E. F. [Savarenskiy, Ye. F.], and Vvedenskaya, A. V. On determination of earthquake mechanism, in *Physics and chemistry of the earth*, v. 4: New York, Pergamon Press, p. 211-238, 1961.

Existing methods for the representation of earthquake focuses by equivalent sources are discussed. The review demonstrates that two different points of view exist on the nature of the mechanism at the focus: One group (Byerly, Hodgson, Keylis-Borok) consider the system equivalent to the shear in the fault plane as a double concentrated force with moment; the other group (Honda, Vvedenskaya) consider it to be a distributed system of forces that can be represented as two equal as to value, perpendicular and oppositely directed double forces without moment. The position of the nodal planes relative to each other for the displacement field in longitudinal waves is the same for both mentioned sources; therefore, reliable observations of transverse waves must be made in the future to judge which of them corresponds to the real focus. It is noted that investigations using two different representations of the real focus as equivalent sources lead to different conclusions as to the nature of the forces acting at the focus and to different conclusions as to the relations of the mechanism of earthquakes and the character of tectonic processes. It is impossible, moreover, to describe the process at an earthquake focus within the limits of the theory of elasticity that is used by all authors. A bibliography of 58 items is included. — V. S. N.

- 187-115. Ritsema, A. R. Some 1951 earthquake mechanisms based on P and PKP data: Royal Astron. Soc. Geophys. Jour., v. 5, no. 3, p. 254-258, 1961.

Fault plane solutions are presented for 24 earthquakes that occurred in 1951. Results are summarized in a table that gives for each earthquake the date, time, epicenter, depth, azimuth and plunge of the A-, B-, and C-axes, type of fault motion, and number of consistent and inconsistent data. Only one of the two possible solutions is given; the other may be obtained by interchanging the A- and C-axes and the dextral and sinistral parts of the fault motion. — D. B. V.

- 187-116. Ben-Menahem, Ari. Radiation of seismic surface waves from finite moving sources: Seismol. Soc. America Bull., v. 51, no. 3, p. 401-435, 1961.

A theory is proposed for the propagation of seismic surface waves from finite moving sources. Basic solutions obtained for surface displacements from directional sources are integrated to obtain the effect of a moving fault with arbitrary dip angle. Displacements are evaluated for Rayleigh and Love waves at long ranges. It is shown that the source dimensions and speed of rupture play an important role in the wave pattern and cannot be ignored when source dimensions are of the order of the radiation's dominant wavelength. It is demonstrated how this theory may lead to a derivation of the velocity of rupture and length of faulting from the records of a single station. — D. B. V.

- 187-117. Press, Frank, Ben-Menahem, Ari, and Toksöz, M. Nafi. Experimental determination of earthquake fault length and rupture velocity: *Jour. Geophys. Research*, v. 66, no. 10, p. 3471-3485, 1961.

Three methods of determining the fault parameters of length and rupture velocity are examined with ultrasonic models. The theory behind the methods is shown to have a valid though approximate basis. Oversimplified assumptions and imperfect experimental data restrict initial results to only rough indications of fault parameters. When applied to the great Chilean earthquake of May 1960, a fault length of the order of 1,000 km and a rupture velocity near the speed of shear waves in crustal rock are found. — Authors' abstract

- 187-118. Vvedenskaya, A. V. Osobennosti napryazhennogo sostoyaniya v ochagakh pribaykal'skikh zemletryaseniy [Features of the strain state at the focuses of earthquakes in the Baikal region]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 5, p. 666-669, 1961.

Study of stresses at the focus of the earthquake of August 29, 1959 in the middle Baikal region ($\lambda = 107.1^\circ \text{E}$, $\phi = 52.6^\circ \text{N}$, $M = 6 \frac{1}{2} - 6 \frac{3}{4}$) shows that the principal stress axes correspond to the predominant direction of these axes in the northeastern and southwestern Baikal region. — A. J. S.

- 187-119. Kasahara, Keichi. An attempt to detect azimuth effect on spectral structures of seismic waves (The Alaska earthquake of April 7, 1958): *Tokyo Univ. Earthquake Research Inst. Bull.*, v. 38, pt. 2, p. 207-218, 1960.

A spectral analysis of seismic waves from the Alaskan earthquake of April 7, 1958, was worked out in order to determine whether the "point" or "spherical" origin models explain earthquake mechanism satisfactorily. If they are valid, waves of the same spectral structure should be observed at all azimuths. Records obtained by Press-Ewing seismographs at Tsukuba, Japan, Uppsala, Sweden, Resolute Bay, Canada, Honolulu, Hawaii, and at Palisades, Waynesburg, and Pasadena in continental United States were used; all but Resolute Bay are almost equally distant ($\Delta = 40^\circ - 45^\circ$) from the epicenter.

No special azimuth effect was noted in the spectrums of P-waves, but there were noticeable differences in the S-wave spectrum types observed at three groups of stations. These differences could be due to the mechanism of wave radiation rather than to distortion of spectrums by conditions of wave propagation, but until more data are available it is premature to conclude that a true azimuth effect is present. — D. B. V.

- 187-120. Kuo, Tseng-Chien. Notes on the fault-plane determination by means of initial motions of earthquakes (continued) [in Chinese with English abstract]: *Acta Geophys. Sinica*, v. 7, no. 2, p. 91-97, 1958.

Formulas are given for determination of the nodal line of a fault plane by means of the nodal line of an auxiliary plane and for determination of the epicentral distances Δ_s and Δ'_s of the intersections of the displacement of S-waves at the focus with the earth's surface. From the results of the latter formula a method is proposed for the determination of the direction of motion by means of S-waves recorded at two stations. — V. S. N.

Gougenheim M. André. Confirmation, by observation, of the negligible role of the earth tide in the production of earthquakes. See *Geophys. Abs.* 187-146.

187-121. Chinnery, M. A. The deformation of the ground around surface faults: *Seismol. Soc. America Bull.*, v. 51, no. 3, p. 355-372, 1961.

A rectangular dislocation surface (one across which there is a discontinuity in the displacement vector) is used as a model of a vertical transcurrent fault, and the displacement field throughout a semi-infinite elastic medium due to such a dislocation is derived in analytical form. Displacements of the surface of the medium are calculated in some detail. Methods are then discussed for the determination of depth of a surface fault from measurements of ground deformation, and these are applied to faults associated with the Tango and North Idu earthquakes and to the San Andreas faults. Good agreement between observed deformation and theory suggests that the dislocation theory provides a good description of the effects of fracture in the earth's crust. — D. B. V.

187-122. Tazieff, H[aroun]. Interprétation des glissements de terrain accompagnant le grand séisme du Chili [Interpretation of the landslides accompanying the great Chilean earthquake]: *Soc. Belge Géologie, Paléontologie et Hydrologie Bull.*, v. 69, no. 3, p. 374-384, 1960 (1961)

The Chilean earthquake of May 22, 1960 was felt over an area of 160,000 km² (see *Geophys. Abs.* 184-134, -135; 185-131). In addition to the destruction due directly to the shocks, destruction by the resulting tsunami, and subsidence of a coastal strip some hundreds of kilometers long and tens of kilometers wide, there were numerous landslides in the vicinity of Lakes Rinihue, Panguipulli, Calafquén, and Neltume in the spurs of the Andes. Millions of cubic meters of material were moved; mainly involved were inclined beds of dry, more or less coherent Pliocene or Pleistocene tuffs. These landslides differed considerably from ordinary landslips and from avalanches of mud (lahars), ice, or snow in that the horizontal displacement was 5 to 10 times greater than the vertical.

It is suggested that the horizontal components of S- and L-waves were sufficiently strong to provoke the landslides, and that the long duration (200-210 sec) of the shocks produced a shaking table effect that brought about the unusually great horizontal movement. — D. B. V.

187-123. Nazarov, A. G. Zadachi issledovatel'skoy raboty v oblasti seymostoykogo stroitel'stva v Tadzhijskoy SSR [The tasks of research in the field of seismic resistant construction in the Tadjik SSR]: *Akad. Nauk Tadjik SSR Inst. Seysmologii Trudy*, v. 113, p. 25-36, 1959.

This is a brief statement of engineering problems in improving seismic resistance of buildings and other engineering constructions in the Tadjik

S. S. R. Addition of accelerographs, deformometers, analyzers, and other seismic instruments to the equipment of the seismic stations is recommended. — A. J. S.

187-124. Nishimura, Genrokuro, and Suzuki, Masazi. Aseismic properties of a wooden house (pt. 3): Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 2, p. 329-343, 1960.

The free vibration of a pendulum of simple mass system, in which the restoring force varies at each amplitude, is considered; the relationships between amplitude, period, and damping factor are derived theoretically; and numerical calculations are made using the experimental data obtained for the free vibration of wooden houses when seismic wave amplitude is great (see also Geophys. Abs. 175-43). — D. B. V.

187-125. Kon'no, Enzo, and others. Geological observations of the Sanriku coastal region damaged by the tsunami due to the Chile earthquake in 1960: Tohoku Univ. Inst. Geology and Paleontology Contr., no. 52, 40 p., 1961.

The erosional and depositional effects of the tsunami of May 1960 on the Sanriku coastal area of Honshu Island, Japan, are discussed in detail. This tsunami, caused by the Chilean earthquake of May 1960 is in sharp contrast to those of 1896 and 1933 in this area. The waves were of much longer wavelength and period (40-45 min at Onagawa, Miyagi Prefecture). — V. S. N.

187-126. MacDonald, Gordon J. F. The earth's free oscillations: Science, v. 134, no. 3491, p. 1663-1668, 1961.

The use of free, low-frequency normal modes of vibration of the earth (observed for the first time in the Chilean earthquake of May 1960) supplements observations of arrival times of high-frequency earthquake waves that heretofore provided almost all information on the nature of the earth's interior. The theory of the earth's free oscillations, the attempts to detect them, and the results of the first observations are reviewed (see also Geophys. Abs. 184-183 through 184-190). — D. B. V.

187-127. Buchheim, W[olfgang], and Smith, S. W. The earth's free oscillations observed on earth tide instruments at Tiefenort, East Germany: Jour. Geophys. Research, v. 66, no. 10, p. 3608-3610, 1961.

The Chilean earthquake of May 1960 wrote unusual long-period records on the horizontal pendulum seismographs designed for recording earth tides at Tiefenort, East Germany. In spite of difficulties of frequency resolution, the cross spectrum of the E-W component and of a comparable E-W pendulum at Pasadena leaves no doubt that the spectral peaks observed at Tiefenort represent coherent vibrations of the whole earth. The lowest mode recorded with certainty is ${}_0S_4$ with a period of 25.8 min, and the highest mode is ${}_0S_{16}$ with a period of 6.78 min. Observed periods and tentative mode identifications are tabulated. Although less precise than previously published values (see Geophys. Abs. 184-185, -186), these are at present the only available observations of the free oscillations in the eastern hemisphere. — D. B. V.

187-128. Takeuchi, Hitoshi, and Saito, Masanori. Free oscillations of the earth: Japan Acad. Proc., v. 37, no. 1, p. 33-36, 1961.

The problem of the earth's free spheroidal oscillations is studied by solving three simultaneous differential equations among $U(r)$, $V(r)$, and $P(r)$. It is assumed that the density ρ and elastic constants λ and μ of the earth are given functions of distance r from its center. The (r, θ, ϕ) components of displacement u and an additional potential P due to the earth's deformation are denoted respectively by:

$$u_r = U(r)S_n(\theta, \phi), u_\theta = V(r)\frac{\delta S_n(\theta, \phi)}{\delta \theta}, u_\phi = \frac{V(r)}{\sin \theta} \frac{\delta S_n(\theta, \phi)}{\delta \theta}, P = P(r)S_n(\theta, \phi)$$

where a common time factor $e^{i\sigma T}$ is omitted and $S_n(\theta, \phi)$ is a spherical harmonic of order n . These equations will determine the period $T=2\pi/\sigma$ of its free oscillation as a function of the azimuthal wave number n . Calculations are given for the Jeffreys-Bullen earth model up to $n=5, 6, 8, 10, 16, 24, 38$, and 96 , and for the Gutenberg model up to $n=16, 24, 38$, and 96 . Calculated periods agree well with observed values and thus, the models used are representative of the internal constitution of the earth. — V. S. N.

- 187-129. Cameron, J. B. Earthquakes in the northern California coastal region (pt. 2): *Seismol. Soc. America Bull.*, v. 51, no. 3, p. 337-354, 1961.

The P_F phase (False S) is shown to be a longitudinal wave having a velocity of 5.1 kmps, which arrives at the observing station with an angle of emergence less than that observed for P_n . The epicenter locations of earthquakes in northern California show that this phase arises only from shocks originating on continental structure. The $P_n-\bar{P}$ relationship and the intensity indicate that exceptionally shallow focuses generate the P_F phase. It is concluded that the very thick Franciscan formation in northern California carries considerable energy from these shallow earthquakes, and this energy is identified as the P_F phase. (See also *Geophys. Abs.* 186-135.) — D. B. V.

- 187-130. Green, R. Appearance of the T-phase: *Nature*, v. 191, no. 4792, p. 997-998, 1961.

Phases similar to those reported by Robson and Barr in Dominica (see *Geophys. Abs.* 183-110) have been noted on Tasmanian records. Some have been identified as due to natural earthquakes on the New Zealand side of the Tasman Sea, and some as due to depth charges set off by naval ships. It is suggested that the energy travels as a compressional wave with a velocity of 1.47 kmps down the "Sofar channel," a low-velocity waveguide at 1,500 m depth in the ocean. This channel-wave phase (T-phase) is converted to a P-phase, and presumably an S-phase, at the Continental Shelf; as recorded by a seismic station the P-phase appears to originate from a disturbance on the shelf. Analysis of records of two earthquakes in the Milford Sound region of New Zealand shows that the channel wave arrives 15-20 min after the P-phase, and that the wave front formed at the Continental Shelf travels over the continent as a shallow P-wave.

If Robson and Barr could find evidence of small shocks somewhere in the Caribbean Sea preceding their disturbances, the problem would be unambiguously solved. Suggestions are made as to why such a phase is picked up only on the sediments of the Roseau River and not over the whole island of Dominica. — D. B. V.

- 187-131. Porkka, M. T. Surface wave dispersion for some Eurasian paths, II. Love waves: *Geophysica [Helsinki]*, v. 7, no. 3, p. 151-160, 1961.

The results of an investigation of Love waves from 19 earthquakes are discussed. The dispersion data for seismic wave paths from Japan, Formosa, and the Altay to Helsinki are consistent with one another, but paths that cross the great Asian Tertiary massif show lower group velocities for corresponding periods. The latter effect is interpreted as a result of crustal thickening of about 20 km in this region of young mountain ranges as compared with the average crustal thickness of this continent. — V. S. N.

Hales, A. L. A weak layer in the mantle? See *Geophys. Abs.* 187-371.

Kovach, Robert L., and Press, Frank. Rayleigh wave dispersion and crustal structure in the eastern Pacific and Indian Oceans. See *Geophys. Abs.* 187-367.

Aki, Keiiti. Crustal structure in Japan from the phase velocity of Rayleigh waves. Part 1. Use of the network of seismological station operated by the Japan Meteorological Agency. See *Geophys. Abs.* 187-363.

Santo, Tetsuo A[kima]. Rayleigh wave dispersions across the oceanic basin around Japan (Pt. 3)—On the crust of the south-western Pacific Ocean. See *Geophys. Abs.* 187-366.

Kovach, Robert L., and Press, Frank. Surface wave dispersion and crustal structure in Antarctica and the surrounding oceans. See *Geophys. Abs.* 187-368.

187-132. Ewing, John [I.], and Ewing, Maurice. A telemetering ocean-bottom seismograph: *Jour. Geophys. Research*, v. 66, no. 11, p. 3863-3878, 1961.

Tests on three occasions show that the system of placing a receiving installation on the sea floor and acoustically telemetering the information to a surface ship is feasible. Information was also gained for more advanced instruments and methods of transmittal that will ultimately make up a worldwide system. Such a system could settle the question of the origin and propagation of microseisms; provide detailed information about the sedimentary layer, the crust, and the mantle; and greatly increase the radius over which a single station can monitor small earthquakes or explosions.

Body waves from an earthquake were recorded, indicating that a good signal-to-noise ratio was achieved. Useful data were obtained on background noise in the short-period range. Long refraction profiles have given additional measurements of crustal and mantle P- and S-waves. Variation in the amount of energy propagated along various refraction paths indicates appreciable local and regional differences in the crust-mantle interface. — D. B. V.

187-133. Teupser, C[hristian], and Ullmann, W. Ein neuer Horizontalseismograph mit galvanometrischer Registrierung [A new horizontal seismograph with galvanometer recording (with English abstract)]: *Zeitschr. Geophysik*, v. 25, no. 6, p. 272-279, 1959.

A horizontal-component electromagnetic seismograph that accurately records amplitudes of ground motion in a period range of 0.1-15 sec is described. The apparatus has a magnification of 1,000. The constants of the pendulum and of the galvanometer are given. The pendulum period is 20 sec, and the free period of the heavily damped galvanometer is 1 sec. — D. B. V.

- 187-134. Hiersemann, Lothar. Aufzeichnung langperiodischer Bodendeformationen mit einem Strainseismometer [Registration of long-period ground deformations with a strain seismometer (with English summary)]: *Zeitschr. Geophysik*, v. 27, no. 1, p. 18-34, 1961.

A strain seismometer constructed at Freiberg, German, is described, with emphasis on the differences between this and pendulum instruments, and results of preliminary tests are reported. The records are somewhat affected by meteorological conditions, including thermoelastic deformation, atmospheric pressure variations, wind, and rainfall. — D. B. V.

- 187-135. Lossovskiy, Ye. K. Pro vrakhuvannya chutlyvosti pryymayuchikh kanaliv pri pobudovi amplitudnykh grafikiv seysmichnykh khvil' [Allowing for sensitivity of receiver channels when plotting amplitude graphs of seismic waves]: *Akad. Nauk Ukrain. RSR Doprividi*, no. 7, p. 904-907, 1961.

A graphical method is presented for introducing into amplitude graphs of observed seismic waves corrections allowing for unequal sensitivity of the receiving channels. Such a method can be applied when the amplitude graph of the relative sensitivity of the recording amplifiers is available. — A. J. S.

- 187-136. Matumoto, Hideteru. A transistor amplifier for seismographs (in Japanese with English summary): *Tokyo Univ. Earthquake Research Inst. Bull.*, v. 38, pt. 2, p. 345-354, 1960.

A new portable seismograph has been constructed, making use of a transistor amplifier (see *Geophys. Abs.* 186-217). The amplifier is described, with schematic diagrams, photographs, and graphs of frequency characteristics. The use of transistors rather than vacuum tubes not only increases the sensitivity but also extends the frequency range downward. — D. B. V.

- 187-137. Boletín Sismológico del Servicio Geológico Nacional de El Salvador. Informe sobre la instalación de una nueva estación sísmológica en el occidente de la República de El Salvador [Report on the installation of a new seismological station in the western part of the Republic of El Salvador]: *El Salvador Servicio Geol. Nac. Bol. Sismol.*, v. 7, p. 2, 1961.

The completion of a new seismic station in Ahuachapan, El Salvador, equipped with two seismographs (N-S and E-W components) constructed by the Servicio Geológico Nacional, is reported and the constants of the instruments are given. The station is intended mainly to record local earthquakes. — D. B. V.

- 187-138. Hodgson, [ohn] H., and Langill, F. E. Bibliography of seismology—July-December, 1958: *Dominion Observatory Ottawa Pubs.*, v. 22, no. 4, p. 87-133, 1961.

The regular semiannual issue of the bibliography of seismology is presented. A continuation of the subject index is included. (See also *Geophys. Abs.* 177-33, -34, 180-32.) — V. S. N.

EARTH TIDES AND RELATED PHENOMENA

- 187-139. Vicente, R. O. The theory of nutation and the internal constitution of the earth, in *Physics and chemistry of the earth*, v. 4: New York, Pergamon Press, p. 251-280, 1961.

The classical theory of nutation is explained giving numerical results obtained theoretically and a kinematic description of the motion. The values of nutations obtained from observations are examined and compared with theoretical values, and disagreements between the two are observed. The relationship of earth tides and the internal constitution of the earth are discussed. Modern researches on the theory of nutation that consider existence of a shell and a core and different properties for the two main regions of the interior are reviewed, and the actual theory of nutation proposed by Jeffreys and Vicente is summarized. — V. S. N.

- 187-140. Weissberg [Vaisberg], O. L. O vozmozhnom zamedlenii vrashcheniya Zemli [On a possible retardation of the earth's rotation]: *Astron. Zhur.*, v. 38, no. 3, p. 545-548, 1961.

The mechanisms that could lead to the retardation of rotation of the earth during the solar flares of February 23, 1956 and July 15, 1959 are discussed. As established by Danjon, the length of the day was increased by 1.1×10^{-10} part during the first disturbance and by 0.85×10^{-8} part during the second. A first hypothesis, assuming an increase in density of the upper atmosphere due to an influx of corpuscular radiation from the sun and subsequent increase of the earth's moment of inertia, was found to be insufficient to explain the retardation observed. A second hypothesis explains the effect by emission of magnetohydrodynamic waves due to the rotation of the earth's magnetic dipole whose axis is inclined by 11.5° to the axis of rotation of the earth in interplanetary plasma. Maeda (1957) analyzed the problem of distortion of the earth's dipole magnetic field due to the earth's axial rotation in interplanetary plasma and determined the power of the emitted magnetohydrodynamic waves to be 10^{18} ergs per sec. On this basis, and assuming an exponential relationship between the ratio ω/a (angular momentum of the earth to the speed of magnetohydrodynamic waves) and the power, W , of the waves, an energy influx of the order of 10^{26} ergs coming to the earth during the solar flare is obtained, thus giving values of energy comparable to that needed to change the earth's moment of inertia by the observed retardation. — A. J. S.

- 187-141. Jones, Harold Spencer. Variations of the earth's rotation, in *Physics and chemistry of the earth*, v. 4: New York, Pergamon Press, p. 186-210, 1961.

The three types of departure from uniformity in the rotation of the earth are discussed, the methods to detect and measure them are reviewed, and the causes of the variations are summarized. — V. S. N.

- 187-142. Verbaandert, J., and Melchior, P[aul] [J.]. La station des pendules horizontaux de Sclaigneaux (Province de Namur) [The horizontal pendulum station at Sclaigneaux (Namur Province)]: *Acad. Royale Belgique Bull. Cl. Sci.*, ser. 5, v. 45, no. 11, p. 1084-1086, 1959; v. 46, no. 2, p. 75-78, 1960.

The first paper describes the pendulum apparatus installed in a mine in the dolomite at Sclaigneaux, Belgium, to measure earth tides. The pendulum for measuring the N-S component has been in operation since November 1959,

and that for the E-W component since February 1960. Adjusted to a 60-sec period, the pendulums yield curves with amplitude of 2 cm in the N-S direction and 4 cm in the E-W direction.

The second paper gives the first numerical results; the phases and observations of theoretical amplitudes of the M_2 , S_2 , N_2 , O_1 , K_1 terms and γ of the N-S component are tabulated for 2 epochs. The phases of the semidiurnal components are very weak. The amplitude ratios $\gamma=1+k-h$ are relatively high, probably due to indirect effects of the Atlantic Ocean. This can be separated from the direct effects when data become available for a longer period and for both components. — D. B. V.

- 187-143. Verbaandert, J., and Melchoir, P[aul] [J.]. La station de pendules horizontaux de Warmifontaine (Province de Luxembourg) [The horizontal pendulum station at Warmifontaine (Luxembourg Province)]: Acad. Royale Belgique Bull. Cl. Sci., ser. 5, v. 47, no. 5, p. 427-431, 1961.

The new underground earth tide station at Warmifontaine, near Neufchateau in Luxembourg Province, Belgium, is described and first results are presented. Comparison with those obtained at Sclaigneaux shows that the Warmifontaine installation is more stable; it is favored by its greater depth and by the physical nature of the bedrock. Further, the Sclaigneaux observations are somewhat affected by the level of the nearby Meuse River. — D. B. V.

- 187-144. Verbaandert, J., and Melchior, P[aul] [J.]. Les stations géophysiques souterraines et les pendules horizontaux de l'Observatoire Royal de Belgique [The underground geophysical stations and the horizontal pendulums of the Royal Observatory of Belgium]: Ciel et Terre, v. 76, no. 9-10, p. 249-278, and no. 11-12, p. 329-368, 1960; v. 77, no. 1-3, p. 17-67, and no. 4-6, p. 179-201, 1961.

Complete details are given concerning the earth tide stations in Belgium, particularly that at Sclaigneaux (see Geophys. Abs. 187-142), including a discussion of earth tides, the principles of construction of pendulums in general and of the new Belgian instruments in particular, the setting of the stations at Sclaigneaux (in Namur Province) and Warmifontaine (in Luxembourg Province), results obtained to date, and their interpretation. — D. B. V.

- 187-145. Ozawa, Izuo. On the observations of the earth tide by means of extensometers in horizontal components: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 46, p. 1-15, 1961.

The results of earth tide observations by means of extensometers at Osakayama, Suhara, and Matsushiro Observatories and at the Kishu mine are reported; the tide-constituents (M_2 , O_1 and so forth) of the observed strains were calculated by harmonic analysis. Results are in good agreement with the theoretical values calculated by use of the elastic moduli obtained from study of transmission of seismic waves. However, for analyzing an anomaly in the earth tide produced by anomalous structures in the crust, more precise observations are needed. — V. S. N.

- 187-146. Gougenheim, M. 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 (with English summary)]: Annali Geofisica, v. 14, no. 2, p. 197-210, 1961.

This is virtually the same as the paper published in Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 21, p. 3313-3314, 1961 (see Geophys. Abs. 186-221). — D. B. V.

ELASTICITY

- 187-147. Rosenbaum, J. H. Refraction arrivals along a thin elastic plate surrounded by a fluid medium: Jour. Geophys. Research, v. 66, no. 11, p. 3899-3906, 1961.

An asymptotic solution is derived for the first arrival of significant amplitude and low frequency, which is refracted along a thin high-velocity plate surrounded by a fluid medium. This first arrival travels with approximately the velocity of a longitudinal plate wave in the refracting layer. The shape of the signal depends on the contrast (in density and elastic constants) between the plate and the fluid as well as on the distance (in units of plate thickness) that the signal has been refracted along the plate. Solutions in closed form are given. Cases of moderate contrast or long refraction path, large contrast and moderate refraction path, and intermediate contrast and path are treated. The case of an elastic plate shallowly submerged in a liquid half-space is considered in an appendix. — D. B. V.

- 187-148. Stoneley, Robert [S.]. The oscillations of the earth, in Physics and chemistry of the earth, v. 4: New York, Pergamon Press, p. 239-250, 1961.

The problem of small oscillations of the earth is discussed. Lamb's solution for a uniform and incompressible sphere is summarized; Love's analysis for the statical deformation and the small oscillations of a uniform gravitating compressible sphere is outlined; and, finally, the problem of obtaining numerical values for the free periods of oscillation of the earth is treated. — V. S. N.

- Takeuchi, H[itoshi]. Torsional oscillations of the earth. See Geophys. Abs. 187-374.

- 187-149. Bortfeld, Reinhard. Seismic waves in a mathematical model of the surface layer: Geophys. Prosp., v. 9, no. 3, p. 350-369, 1961.

The surface layer is replaced by a layer in which the velocity changes linearly with the depth, i. e., by a transition layer. A plane irrotational wave of arbitrary shape travels vertically upward and hits this layer. The multiples produced by differential reflections in the layer and by reflections at the free boundary are computed. From the third order on, these multiples look exactly like empirical reflections. The sum of all multiples is the solution of the differential equations of the problem, and has some formal mathematical similarity to diffraction phenomena known from optics. — Author's abstract

- 187-150. Loeb, J. Attenuation des ondes sismiques dans les solides [Attenuation of seismic waves in solids (with English abstract)]: Geophys. Prosp., v. 9, no. 3, p. 370-381, 1961.

The expression for acoustic wave propagation in formations that is yielded by laboratory experiments is not analogous to that of electromagnetic waves because the attenuation coefficient α is not independent of frequency; yet no

noticeable dispersion can be found with present recording technique. It is shown that these results are compatible if energy losses are accounted for by a hysteresis phenomenon, which is analyzed. The attenuation takes place without phase shift and consequently without dispersion.

The superposition principle is held to be inapplicable. It is predicted theoretically that a certain strain can completely cancel α . — D. B. V.

187-151. Thiruvenkatachar, V. R. Stress-wave propagation induced in an infinite slab by an impulse over a circular area of one face-I: India Natl. Inst. Sci. Proc., v. 26, pt. A, supp. 2, p. 31-47, 1960.

Explicit formulas are derived for determination of stress waves induced in an infinite slab of homogeneous, isotropic, perfectly elastic material, if at the instant $t=0$ an impulsive pressure of uniform intensity P is applied over a circular area of one of the faces of the slab. Approximate and simpler expressions for the same are derived also by application of the method of steepest descents. — V. S. N.

187-152. Asano, Shuzo. Reflection and refraction of elastic waves at a corrugated boundary surface. Pt. 1. The case of incidence of SH wave: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 2, p. 177-197, 1960.

The propagation of SH waves normally incident on a corrugated boundary surface that can be expressed by one cosine term ($\xi=c \cos px$) is treated mathematically. The case can be represented by a Fourier series. The results are presented in tables and graphs. At certain values of L/L_S (L =wave length of corrugation, L_S =wave length of the incident SH wave), for example, $L=L_{S1}$ or $L=L_{S2}$, irregularly reflected or refracted waves become either comparable to or negligible in comparison with regular waves. The effect of the amplitude of the corrugation on the amplitude of a regularly reflected wave is opposite to and larger than its effect on a regularly refracted wave.

It is also found that, depending on L/L_S , there are waves that appear to propagate along the boundary surface because their amplitude decreases exponentially as distance from the boundary surface increases. — D. B. V.

187-153. Yoshiyama, Ryoichi. Propagation of surface waves and internal friction: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 3, p. 361-368, 1960.

A discrepancy between theoretical results and those given by Sato (see Geophys. Abs. 174-61) in his paper on G-waves from the Kamchatka and New Guinea earthquakes is investigated mathematically. The internal friction constant $1/Q$ calculated from Sato's results increases remarkably with period T . This paper seeks reasonable unknown factors that disturb the generally used formula $A \propto (1/\sqrt{|\sin \theta|}) \exp(-k\Delta)$, where A is amplitude, θ is epicentral angular distance, Δ is distance traveled over the earth's surface, and $k=\pi/QVT$ (V =phase velocity). The factor $1/\sqrt{|\sin \theta|}$ in the formula is reexamined in an effort to deduce a characteristic friction $1/Q_0$ from the four series of apparent $1/Q$ values derived from Sato's results.

The definition of internal friction of the earth is still ambiguous; further studies of the attenuation constant of seismic waves are necessary. The value obtained in this paper is 4×10^{-3} , somewhat smaller than that expected from an earlier study by Yoshiyama (see Geophys. Abs. 185-139). — D. B. V.

- 187-154. Yoshiyama, Ryoichi. Stability of waves through a heterogeneous medium and apparent internal friction: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 4, p. 467-478, 1960.

The relation of seismic wave attenuation to period is investigated by means of a mathematical treatment of the stability of a wave propagating through a heterogeneous medium. It is tentatively concluded that the effect of the periodic structure on the amplitude A of a progressive wave is represented by $A=1/\cos h\mu z$; therefore, the apparent internal friction $1/Q^1$ caused by the periodic structure should be somewhat smaller than that calculated on the assumption that A is a simple exponential function. — D. B. V.

- 187-155. Shima, Michiyasu. On the diffraction of elastic plane pulses by the crack of a half plane: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 45, p. 1-18, 1961.

A mathematical solution is given for the two-dimensional problem of the diffraction of plane elastic P- and S-pulses of a rectangular type by the crack of a half plane. Jones' (1952) method for the diffraction of a scalar wave in which the shorter pulse width is compared with the distance of the observation point from the edge of the crack is used. It is observed that the phase of a diffracted pulse is reversed at the shadow boundary, and that while the forms of the incident and reflected pulses are of rectangular type those of the diffracted P- and S-pulses are smooth. — V. S. N.

- 187-156. Volarovich, M. P., Levykin, A. I., and Sizov, V. P. Issledovaniye zatukhaniya uprugikh voln v obraztsakh gornyykh porod [Investigation of attenuation of elastic waves in rock samples]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 8, p. 1198-1203, 1960.

A method of investigation of damping of elastic waves in rock samples under high confining pressure is proposed, and tests with a specially constructed generator of impulses of 1,000 cycles per second are reported. The method uses multiple reflections of ultrasonic impulses in cylindrical samples. Damping coefficients were measured for basalt, gabbro, marble, gabbrodiorite, quartz sandstone, syenite, granite, labradorite, aluminum, brass, and plexiglas samples. — A. J. S.

- 187-157. Rapoport, M. B. Kmetodike ul'trazvukovogo seysmicheskogo modelirovaniya [Method of ultrasonic seismic modeling]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 9, p. 1309-1315, 1960.

Problems of ultrasonic seismic modeling involving suppression of Rayleigh waves, preferential reception directions of the pickups, and formation of wave impulses are discussed. Methods for solving the problems are proposed and tested on solid two-dimensional models. It was found that an introduction of filters into the seismoscope suppresses free oscillations of piezocrystals and makes the form of wave impulses independent of their degree of damping, their contact with the model, and other factors. This secures a good reproducibility of the record form. The method proposed can be applied to three-dimensional models. — A. J. S.

- 187-158. Krayev, G. A., and Rel'tov, B. F. Zatukhaniye uprugikh voln na modelyakh treshchin [Attenuation of elastic waves in models of fractures]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 125-129, 1960.

An experimental method of study of fracturing of rocks is discussed, and the attenuation of induced elastic waves passing through models of such rocks is described. An elastic wave impulse apparatus constructed at Leningrad State University was used in the experiments, in which crystals of potassium sodium tartrate were employed as transmitters and pickups of ultrasonic oscillation. Results of the investigation are presented in graphical form. — A. J. S.

Biot, M. A., Odé, H., and Roever, W. L. Experimental verification of the theory of folding of stratified viscoelastic media. See *Geophys. Abs.* 187-252.

Biot, M. A. Theory of folding of stratified viscoelastic media and its implications in tectonics and orogenesis. See *Geophys. Abs.* 187-251.

187-159. Key, F. A., Wright, J. K., Carpenter, E. W., Stott, B. M. H. Possible method for increasing the signal-noise ratio in the detection of the first motion of a refracted P-wave: *Nature*, v. 191, no. 4796, p. 1382-1383, 1961.

A basic problem in differentiating between small earthquakes and underground nuclear explosions is the detection of first motion when the amplitude of the signal is comparable with the microseismic background noise level at the quietest sites. If the noise is predominantly due to surface waves, the signal-noise ratio can be increased by placing the detector deep underground. By using two detectors, one at the surface and the other at a depth of, for example, a wavelength at the peak recording frequency, the signal at the surface detector can be regarded mainly as noise and subtracted from the other to give the required P-wave signal.

This suggestion has been tested by model experiments. Typical records are reproduced; the gain in S-N ratio is readily apparent. — D. B. V.

187-160. Koopmans, L. H. An evaluation of a signal-summing technique for improving the signal-to-noise ratios for seismic events: *Jour. Geophys. Research*, v. 66, no. 11, p. 3879-3893, 1961.

Formulas are derived for evaluating as a function of frequency the improvement in the root mean square signal-to-noise ratio for seismic events obtainable by the technique of summing the trace amplitudes recorded at a number of closely spaced seismometer stations. A modification of this technique whereby the signals are corrected for phase shift before summing is also studied. The theory is applied to noise data from a three-station network for the ranges of periods 6.7-20 sec and 0.25-1 sec. The signals in the short-period range are taken to be P- and S-body waves. Rayleigh waves are used in the long-period range. Improvement comparable to and occasionally in excess of that expected for uncorrelated noise is indicated for the modified technique in the short-period range, whereas little improvement is obtained in the long-period range for the given station spacing and noise conditions. — Author's abstract

187-161. Nakamura, Kohei. Normal mode waves in an elastic plate, pt. 2: *Tohoku Univ. Sci. Repts.*, ser. 5, v. 12, no. 2, p. 139-158, 1960.

Continuing the study of normal mode waves in an elastic plate, Nakamura investigates the structure of the dispersion curves of the normal mode waves formed by P- and Sv-waves in an elastic homogeneous plate with a Poisson's ratio of one-fourth by examining in detail the characteristic equations and by using the dispersion curves of a hypothetical plate that transmits only a single

body wave. Special emphasis is laid on the behavior of the dispersion curves at some particular angles of incidence of S and at the lattice points used by Tolstoy and Usdin (1956) in their study of group velocity of higher modes.

The frequency which makes the group velocity equal to the velocity of S and the maximum group velocity in higher modes, together with its corresponding frequency, are obtained as functions of mode number. For the most part, the lowest modes $\pi_0 \pm$ are not discussed, as their behavior is well known. — D. B. V.

- 187-162. Berg, Joseph W., Jr., and Cook, Kenneth L. Energies, magnitudes, and amplitudes of seismic waves from quarry blasts at Promontory and Lakeside, Utah: *Seismol. Soc. America Bull.*, v. 51, no. 3, p. 389-399, 1961.

The total apparent energy was computed for seismic waves on seismograms obtained at distances of 6.78 and 13.2 km from a blast of 1,221,000 lb of explosives and at 22.0 km from a blast of 2,138,000 lb of explosives at Promontory, Utah. Magnitudes ranging from 4.0 and 3.9 (charge size of 490,500 lb) to 4.6 and 4.4 (charge size of 2,138,000 lb) were computed from the data applicable at zero and 2 km from the large quarry blasts at Promontory and Lakeside between 1956 and 1959.

For charge sizes from 490,500 to 2,138,000 lb, an approximately linear relationship was found to exist between charge size and average record amplitude of the first cycle of the first arrival measured on vertical-component seismograms at Eureka, Nev. — D. B. V.

- 187-163. Kisslinger, C[arl], Mateker, E. J., Jr., and McEvelly, T. V. SH motion from explosions in soil: *Jour. Geophys. Research*, v. 66, no. 10, p. 3487-3496, 1961.

The fact that tangential horizontal motion that is not predicted by simple theory is prominent in almost all cases from both chemical and nuclear explosions was investigated experimentally. Seismograms recorded at small distances show asymmetrical radiation of SH motion in the source region, in contrast to the symmetrical pattern for the radial and vertical motion. This radiation pattern is the most useful indicator of the nature of the generating mechanism. The combined effect of charge size and depth determine which of two wave forms will appear. The most prominent SH motion is in the form of Love waves and is more pronounced for shallow shots that produce cratering or surface cracking than for completely contained shots. An examination of theoretical radiation patterns indicates that crack formation may contribute significantly to the generation of SH motion. — D. B. V.

- 187-164. Nodens, J. A. E. Tectonic leads in the coseismal-line spread of the Nevada underground nuclear detonation "Blanca": *Oklahoma Geology Notes*, v. 21, no. 9, p. 239-244, 1961.

A coseismal-line (equal time of P-arrivals) map of the Blanca detonation is presented, and a study of the pattern of spread of coseismal lines across the United States is discussed. The teleseismic stations selected for mapping of Blanca P-time arrivals are given in a table. The tectonic map of the United States (King, and others, 1944), used to correlate the spread pattern of the coseismal lines with the tectonic features, is also shown. Three distinct channels of seismic energy lead are noted: the axis of Alpidic-Variscan type orogeny of North America as seen in the NNW-SSE elongation of the line pattern over Washington, Oregon, Idaho, Nevada, Utah, California, and Arizona; the line spread from ground zero Blanca toward the Wasatch fault zone and

ENE through major structures to the line of the Champlain-St. Lawrence overthrust; and the line spread from ground zero Blanca eastward through structures in Utah, Colorado, Kansas, Missouri, Kentucky, and finally, tying in with the seismotectonic lead of the Appalachian orogenic belt through the fault system of the Allegheny Mountains. — V. S. N.

- 187-165. Karapetyan, B. K. Issledovaniye massovykh vzyryvov dlya tseyey inzheneney seysmologii [Investigation of massive explosions for the purposes of engineering seismology]: Akad. Nauk Tadzhik SSR Inst. Seismologii Trudy, v. 113, p. 7-13, 1959.

The effect of seismic waves from large explosions (0.35-30 tons) on engineering constructions was studied. The elastic oscillations of the ground were recorded by AIS-2 seismometers, which are described. The maximum reduced seismic accelerations from 0.017 to 16 g produced by the explosions were observed in the ground. Shooting several charges in a rapid sequence, the high frequency (0.01-0.3 sec period) of a single shot seismic wave can be transformed into a lower frequency seismic wave, which is more useful in seismic investigations. — A. J. S.

Research Group for Explosion Seismology. Crustal structure in central Japan as derived from the Miboro explosion-seismic observations. Part 1. Explosions and seismic observations.

Mikumo, Takeshi; Otsuka, Michio; Utsu, Tokuji; Terashima, Tsutomu; and Okada, Atusi. Crustal structure in central Japan as derived from the Miboro explosion-seismic observations. Part 2. On the crustal structure. See Geophys. Abs. 187-364.

ELECTRICAL EXPLORATION

- 187-166. Van'yan, L. L., Terekhin, Ye. I., and Shtimmer, A. I. Metodika rascheta volnovykh krivykh chastotnogo zondirovaniya [Methods of calculation of wave curves of frequency sounding]: Prikladnaya Geofizika, no. 30, p. 92-102, 1961.

The methods of calculation of the wave curves of frequency sounding in an n -layered medium over a basement of resistivities, $\rho_n = \infty$, $\rho_n = 0$, and $\rho_n \neq 0$, $\rho_n \neq \infty$ are worked out for 2-, 3-, and 4-layer profiles. Asymptotic formulas are developed for calculation of the right and left branches of the wave curves of frequency and magnetotelluric sounding. The method proposed requires neither summation of series nor numerical integration. More than 1,000 wave curves of frequency sounding in 2-, 3-, 4-, and 5-layer profiles were calculated by this method during the period from 1956 to 1960. — A. J. S.

- 187-167. Van'yan, L. L., Kaufman, A. A., and Terekhin, Ye. I. Raschet fazovykh krivykh chastotnogo zondirovaniya sposobom transformatsii [Calculation of phase curves of frequency sounding by the method of transformation]: Prikladnaya Geofizika, no. 30, p. 103-114, 1961.

The apparent resistivity, ρ_ω , as determined by the method of frequency sounding is a complex function of circular frequency, ω , according to the equation $\rho_\omega = |\rho_\omega| e^{i\phi_\omega}$, where $|\rho_\omega|$ is the amplitude and ϕ_ω is the phase displacement of the electric or magnetic field. The method of trapezoidal frequency characteristics is suggested when the phase displacement, $\phi_{\omega k}$, for the fre-

quency ω_k sought cannot be determined in elementary integrals. The process of determination of ϕ_{ω_k} by the method proposed is investigated mathematically. — A. J. S.

187-168. Glyuzman, A. M. Resheniye krayevoy zadachi dlya parabolicheskogo tsilindra v elektrorazvedke [Solution of the boundary problem for a parabolic cylinder in electrical prospecting]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 910-914, 1961.

The boundary problem of the spatial distribution of potential due to a point source located inside and outside a parabolic cylinder, whose surface separates two media of different electric conductivity, is treated mathematically. — A. J. S.

187-169. Molochnov, G. V. O vozmozhnosti osushchestvleniya napravlenogo elektromagnitnogo zondirovaniya [On the feasibility of oriented electromagnetic sounding]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 915-916, 1961.

A method of oriented electromagnetic sounding is proposed. An alternating current of a certain frequency is passed through a frame antenna. A second reception frame antenna is installed within the generating antenna in a position where their centers coincide and their planes are perpendicular. The reception antenna is connected to a field recorder. Since no primary field of the generating antenna is received by the reception antenna, no field will be shown by the recorder if no conducting bodies or layers are present. Calculations of the secondary field show that its maximum is directed perpendicularly to the reception frame in the case of a layered medium of plane parallel boundaries. A similar orientation property of the secondary field was found for a spherical conducting body. — A. J. S.

187-170. Samosyuk, G. P., and Veshev, A. V. Pole tochechnogo istochnika toka v prisutstvii sfery [The field of a point-source current in the presence of a sphere]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 3-12, 1960.

This is a mathematical transformation of formulas for the potential of a point source of electric current in the presence of a conducting spherical body. To avoid the usual bulky solutions in the form of infinite series, cases are analysed where the conductivity of the spheres is equal to zero or infinity; this allows a closed solution of the problem. Based on this closed solution, other finite formulas for the potential and its gradient of a point-source current in the presence of a sphere of an arbitrary conductivity are developed. — A. J. S.

187-171. Veshev, A. V. Vliyaniye rel'yefa na rezul'taty rabot dipol'nym o-sevym profilirovaniyem [Effect of relief on the results of work by dipole axial profiling]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 13-35, 1960.

The effect of relief on the results of electrical axial dipole profiling is investigated experimentally and theoretically. Effects of mountain ridges and valleys with infinite and finite slopes and semispherical hollows are investigated, and their experimental curves of apparent resistivity ρ_k of dipole profiling are shown. It is found that relief affects the form of ρ_k curves, producing maximums and minimums similar to those produced by nonhomogeneities

in rocks and ore bodies of different conductivities. Although these two types of effects can generally be differentiated by qualitative considerations, their quantitative evaluation is possible in only a few specific cases. — A. J. S.

- 187-172. Semenov, A. S. Dipol'noye ekvatorial'noye profilirovaniye [Dipole equatorial profiling]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 35-44, 1960.

The method of electrical dipole equatorial profiling is discussed, and apparent resistivity curves obtained experimentally on a model composed of metal and glass plates are shown. These curves are compared with other curves obtained on the same model by the methods of combined and axial dipole profiling. It was found that the equatorial electrical dipole profiling method may be used advantageously in combination with other methods, the axial dipole method in particular, rather than as a basic method of geoelectrical exploration. — A. J. S.

- 187-173. Ryss, Yu. S. Sopostavleniye anomalii yestestvennogo elektricheskogo polya s kharakterom i usloviyami zaleganiya rud po mestorozhdeniyam Rudnogo Altaya [Comparison of anomalies of the natural electric field with the character and the conditions of occurrence of ore deposits of the Rudnyy Altai]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 45-58, 1960.

The intensities of anomalies of the natural geoelectric field at 25 ore deposits in the Rudnyy Altai are compared with (1) mineralogical composition and structural-textural features of the ores, (2) character and thickness of oxidized and supergene zones, (3) thickness of friable deposits, (4) hydrology of the country rock, and (5) salinity of ore-deposit water. It was found that the depth of the mineral deposit and factors (1), (3), and (4) affect the intensity of the anomalies. — A. J. S.

- 187-174. Yakupov, V. S. Metod vertikal'noy sostavlyayushchey plotnosti toka [The method of vertical component of current density]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 59-62, 1960.

A method is proposed for study of e. m. f. in a vertically oriented section of a linear conductor induced by low frequency alternating current impressed into a grounded feeding line. Such a study allows an evaluation of the distribution of the vertical component of current density over the area investigated and therefore the structural nonhomogeneities in its geology. The applicability of the method was verified by field tests over biotite-granite country rock containing a series of chlorite-magnetite-cassiterite lodes. — A. J. S.

- 187-175. Veshev, A. V. Vliyaniye rel'efa na rezul'taty rabot kombinirovannym elektroprofilirovaniyem [The effect of relief on the result of combined electric profiling]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 278, p. 83-108, 1959.

The results of theoretical and experimental studies of the topographic effect on the combined method of electric profiling are reported. The experiments were performed in two tanks containing water and finely ground clay. Direct current and an alternating current of 21 cycles per second were used for obtaining apparent resistivity curves for elongated forms of relief (a mountain range and a valley) and for isometric forms (concave and convex semi-

spheres and semispheroides). The method takes relief into account by applying to the actual relief a simplified experimental model relief based on the determined resistivity curve. The conditions under which the method proposed can be applied have not been investigated, but tests with the field curves indicate that a considerable reduction of the topographic effect can be obtained. — A. J. S.

- 187-176. Umezu, Naganori. Electrical prospecting method by three phase alternating current (Potential due to a uniform overburden) [in Japanese with English abstract]: Kyushu Inst. Technology Bull., no. 11, p. 19-27, 1961.

A new electrode configuration method, the three-phase alternating current method, for use in electrical prospecting is described and illustrated by several numerical calculations for a uniform overburden. By measuring the potential between the potential electrode and the electrical neutral point, and the three phase symmetrical currents between the three current electrodes, the resistivity between the equipotential surface that is in contact with the potential electrode and the electrical neutral point can be measured. A much wider area can be measured with one setup of this new configuration than with one of Wenner configuration. — V. S. N.

- 187-177. Umezu, Naganori. Electrical prospecting method by three phase alternating current (Potential due to a buried sphere) [in Japanese with English abstract]: Kyushu Inst. Technology Bull., no. 11, p. 29-34, 1961.

The three-phase alternating current method (see Geophys. Abs. 187-176) is applied to an approximate solution of the problem of the electrical potential due to a buried conducting sphere. Resistivity curves are plotted in terms of the radius and depth of the buried sphere, and from these the approximate depth and radius of the sphere are predicted. — V. S. N.

- 187-178. Boyd, D., and Roberts, B. C. Model experiments and survey results from a wingtip-mounted electromagnetic prospecting system: Geophys. Prosp., v. 9, no. 3, p. 411-420, 1961.

Model experiments at a scale of 1:200 were carried out in order to assess the performance of an E.M. system which was rigidly mounted on the wingtips of an aircraft. The experiments were performed over model conductors of various sizes, shapes, and resistivities. From the results the detectability of various natural-sized conductors was calculated. The results obtained over an unmined massive sulfide body in Cyprus are shown and a comparison made with the model results. — Authors' abstract

- 187-179. Terekhin, Ye. I., and Faradzhev, A. S. O svyazi rezul'tatov modelirovaniya nad stupen'yu s teoreticheskimi krivymi GVK [On the relationship of modeling results over a step, and the theoretical curves GVK]: Razvedochnaya i Promyslovaya Geofizika, no. 35, p. 48-51, 1960.

The theory of GVK (horizontal-vertical contact) curves in electrical prospecting is discussed and compared with the results of modeling in a tank over a step. The graph presented in the paper shows good agreement between the experimental and theoretical data. — A. J. S.

- 187-180. Hallof, P[hilip] G. Uses of induced polarization in mining exploration: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 59L118, p. 319-327, 1960.

The large polarization effects used in prospecting techniques are a result of the blocking action or polarization of metallic or electronic conductors in a medium of ionic solution conduction; this type of polarization is called the "overvoltage effect." The usefulness of induced polarization as an exploration method is a result of the extreme sensitivity of the measurements to sulfide content in rocks. Methods of measurement and the instruments used are discussed, and actual field applications are described and illustrated. Field results show that induced polarization can be used to locate and outline the large disseminated sulfide zones characterized by the porphyry copper type ore bodies, to locate and extend some massive sulfide bodies that are too deeply buried to be detected by electromagnetic methods, and to evaluate electromagnetic conductors by separating metallic conductors from those due to electrolytic conduction zones. — V. S. N.

- 187-181. Ward, S[tanley]H. AFMAG: A new airborne electromagnetic prospecting method: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 59L119, p. 333-342, 1960.

The application of natural audiofrequency magnetic fields to the investigation of electrical properties of the subsurface has culminated in the development of an airborne prospecting device known as AFMAG (see *Geophys. Abs.* 179-151). The principles of the technique and methods of interpretation of data are discussed. Results of a test survey over the Whistle orebody and vicinity (Sudburybasin) are reviewed to illustrate the advantages of the method, particularly in rugged terrain. — V. S. N.

- 187-182. Breusse, J. J., and Astier, J[ean] L[ouise]. Étude des diapirs en Alsace et Baden-Würtemberg par la méthode du rectangle de résistivité [Study of the diapirs in Alsace and Baden-Würtemberg by the resistivity rectangle method (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 3, p. 444-458, 1961.

The resistivity rectangle method of electrical surveying is described. This technique is a generalization of the fixed AB profile, in which the measuring electrodes MN are moved not only along the line AB, along a segment equal to the central quarter of AB, but also in the interior of a rectangle centered on the zero point of AB; the width of the rectangle is the above-mentioned segment and the length is $AB/2$. Measurements are made along a series of profiles parallel to AB, covering an area $AB^2/8$.

After stating the principles, procedure, and advantages of the technique, three examples of its application to salt domes are discussed. At Hettenschlag-Oberentzen and Blodelsheim on the Alsace Plain and at Weinstetten-Heitersheim in Baden-Würtemberg, Germany, geologic conditions are similar (resistive alluviums, highly conducting marls, and resistive salt); the depth to the salt varies from 100 m to more than 1,000 m. Results are presented in resistivity maps, graphs of a few electrical soundings, and isobath maps to the top of the salt. Four drill holes subsequently confirmed the resistivity results. By increasing the current electrode spacing to 20 km, the effective depth of the method can be increased to 2,000 m or more. — D. B. V.

- 187-183. Šumi, F[ranc]. The induced polarization method in ore investigation: *Geophys. Prosp.*, v. 9, no. 3, p. 459-477, 1961.

It is shown that the decaytime of the polarization curve represents a characteristic property of polarized mediums and consequently of various ores. The decay times for various minerals, determined by laboratory measurements, are tabulated. Although the intervals of the decay times overlap somewhat, the decay time supplements induced polarization data. Interpretation in cases where the effects of bodies with different decaytimes are superposed is discussed. Examples from Sweden and Yugoslavia show that the induced polarization method can best be applied to finely disseminated ores; in some cases, especially on chromite and cinnabar deposits, it was the only geophysical procedure that yielded usable data. — D. B. V.

- 187-184. Porstendorfer, G[ottfried]. Automatische elektrische Drehsondierungen nach dem Wenner- und Dipolverfahren mit direkter Messwertregistrierung [Automatic electric rotating sounding by the Wenner and dipole techniques with direct registration of measured values (with English abstract)]: *Zeitschr. Geophysik*, v. 26, no. 6, p. 276-284, 1960.

Rotating electric sounding can be carried out without exchanging electrodes by means of a crossed Wenner arrangement, in which current electrodes perpendicular to each other are supplied with currents corresponding in values to the sine and cosine of the azimuth of sounding. In this case pertinent voltages over two pairs of crossed electrodes are automatically registered photographically according to direction and amount by a telluric vector recorder. A dipole arrangement with crosscurrent and voltage dipoles can be used to achieve greater depth of penetration. Supply current values are given as a function of azimuth. The coordinate recorder registers the field anisotropy, which can easily be transformed into anisotropy of apparent specific resistance. A few examples are given. — D. B. V.

- 187-185. Kovalenko, V. F. O primenenií metoda registratsii perekhodnykh protsessov na kolchedannykh mestorozhdeniyakh Yuzhnogo Urala [Use of the method of registering of transition processes in pyrite deposits of the south Urals]: *Sovetskaya Geologiya*, no. 6, p. 89-101, 1961.

In order to increase the resolving power of the induction method of electrical prospecting for direct search for highly conductive ores, a study was made of the method using transition processes in a magnetic field. The substance of the method is as follows: Using any source (underground loop, magnetic dipole, or other) a constant magnetic field is created; then the current in the source field is cut off, and at that moment the transition process in the magnetic field is studied at various points of the area being examined. An advantage of this method is that only anomalous components of the field are measured. A schematic diagram is given for the apparatus, and examples with illustrations of use of the method in three commercial pyrite deposits are described. — J. W. C.

- 187-186. Bogdanov, A. Sh. Razvitiye rudnoy elektrorazvedki v blizhayshiyey gody [Development of ore electrical prospecting in the coming years]: *Razvedka i Okhrana Nedr*, no. 7, p. 31-37, 1961.

Methods of electrical prospecting and their applications in the U.S.S.R. are summarized. Information is given on new designs of apparatus specified for electrical prospecting under various conditions and for various objectives. Suggestions for possible developments of methods and their application are given. — A. J. S.

- 187-187. Kochan, L. S. Ustroystvo dlya etalonirovaniya elektrorazvedochnoy apparatury [A device for standardization of electric prospecting apparatus]: Razvedochnaya i Promyslovaya Geofizika, no. 35, p. 52-55, 1960.

An improved device for periodic standardization of electric prospecting apparatus is proposed for use in the field. A circuit diagram is given, and the procedure for standardization of oscillographs is discussed. This improved device economizes operational time and secures an accuracy within 1 percent for the M-45 device, class 1.0. — A. J. S.

- 187-188. Gross, Gerardo Wolfgang. Location of clay deposits by combined self-potential and resistivity surveys: Am. Inst. Mining Metall. Petroleum Engineers Trans., v. 217, Tech. Paper 60L2, p. 124-130, 1960.

A commercial deposit of white kaolinite clay in central Pennsylvania was successfully mapped by combined SP and resistivity methods, and results were checked by drilling. This investigation supports the hypothesis that certain SP phenomena may be ascribed to diffusion and membrane potentials produced by interaction of clay lenses, sandy matrix, and ground waters. Resistivity minimums in the range between 2,000 and 2,500 ohm-m and second-order SP maximums of 50-60 mv contrast characterize this deposit located beneath 30-40 feet of sandy overburden. — V. S. N.

- 187-189. Frischknecht, Frank C., and Ekren, E. B[artlett]. Electromagnetic studies of iron formations in the Lake Superior region: Mining Eng., v. 13, no. 10, p. 1157-1162, 1961.

Experimental electromagnetic studies were made over several of the iron ranges in the Lake Superior region to determine if nonmagnetic oxidized iron formations in the Mesabi and Cuyuna ranges and the magnetic taconite in the eastern Mesabi and western Gogebic ranges could be detected. The oxidized iron ore beneath thick deposits of glacial drift could not be detected directly by the electromagnetic surveys. However, since graphitic or other conducting beds commonly associated with the hanging-wall of the oxidized formations can be readily located by the method, it should prove useful in mapping new ore. The magnetic taconite rocks are conductive over broad areas in the Mesabi and Gogebic ranges even under considerable thicknesses of glacial drift. Anomalies on electromagnetic profiles (slingram method) can be correlated from traverse to traverse, and if the stratigraphy is known on one traverse, it should be possible to trace lithology laterally for considerable distances. (See also Geophys. Abs. 183-222.) — V. S. N.

- 187-190. Melbye, Charles E. Resistivity method in groundwater exploration, city of Gunnison, Colo.: Am. Inst. Mining Metall. Petroleum Engineers Trans., v. 217, Tech. Paper 59L204, p. 328-332, 1960.

A resistivity survey was carried out in the western half of Gunnison, Colo., to investigate bedrock topography below unconsolidated gravels. The bedrock contour map produced was used in the selection of water-well sites. The satisfactory results in the Gunnison water program illustrate the favorable applicability of the resistivity method to similar ground water exploration problems. — V. S. N.

- 187-191. Cheriton, C. G. Anaconda exploration in the Bathurst district of New Brunswick, Canada: Am. Inst. Mining Metall. Petroleum Engineers Trans., v. 217, Tech. Paper 59L103, p. 278-284, 1960.

A successful exploration program for a massive sulfide deposit in the Bathurst district, New Brunswick, Canada, is described. The program was based on the use of geology and aerial photographs followed by airborne and ground electromagnetic surveys supplemented by some geochemical work. — V. S. N.

- 187-192. Fleming, H. W., and Brooks, R. R. Geophysical case history of the Clearwater deposit, Northumberland County, New Brunswick, Canada: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 59L240, p. 131-138, 1960.

Comparative data are presented for the airborne magnetic, airborne electromagnetic, ground magnetic, and ground electromagnetic surveys over the Clearwater deposit, a massive-sulfide mineralization enclosed in an envelope of disseminated-sulfides. The effective penetration of the airborne electromagnetic equipment for deposits of this type is between 100 and 200 feet when flying at 400 feet above ground. It is possible that should a massive-sulfide deposit occur without an envelope of disseminated mineralization and have little or no out-of-phase response, it would either not be detected or would produce a poor anomaly. The airborne magnetic response was equally significant. All ground geophysical methods used could have led to the discovery of the massive-sulfide deposit, and all methods indicated the structural trend. The self-potential method, however, is not considered of great value for ground prospecting in this area. — V. S. N.

- 187-193. Mackay, D. G., and Paterson, N[orman] R. Geophysical discoveries in the Mattagami, Quebec: *Canadian Inst. Mining and Metallurgy Trans.*, v. 63, p. 478-484, 1960.

The geology of the Mattagami mineral camp, Quebec, Canada, is concealed by very thick overburden, and although the area has been prospected since early in the century, the first major sulfide discovery was made in 1956 as a result of a combined aeromagnetic and airborne electromagnetic survey. Since that time other bodies have been located by airborne and ground electromagnetic surveys for a total of five discoveries—the Mattagami, New Hosco, Garon Lake, Orchan, and Radiore. Routine airborne E. M. surveys at 1/4 mile spacing are capable of detecting about 50 percent of the small conductors in this area; surveys at 1/8 mile spacing seem to provide 100 percent detection. In ground surveys the horizontal loop E. M. is considered to provide the most information. All of the deposits are "good" conductors. Ratios of low to high frequency response in the airborne method are mostly over 1.0; the in-phase to out-of-phase ratio in the ground surveys is from 2 to 20 at the points of greatest response. The ore bodies contain significant sphalerite, but the combined pyrite and pyrrhotite content apparently is sufficient to constitute a good conductor. — V. S. N.

- 187-194. Keller, G[eorge] V., and Frischknecht, F[rank] C. Induction and galvanic resistivity studies on the Athabasca Glacier, Alberta, Canada, in *Geology of the Arctic*, v. 2: *Internat. Symposium Arctic Geology*, 1st, Calgary, Alberta, 1960, *Proc.*, p. 809-832, 1961.

A study of the use of electrical methods for measuring ice thickness on Athabasca Glacier, Alberta, Canada, is reported. Two methods for measuring resistivity were tested: (1) a conventional resistivity method in which current was fed galvanically into the glacier through electrodes; and (2) an electromagnetic method in which a wire loop laid on the ice was used to induce current flow. Both techniques were capable of measuring ice thicknesses up to 1,000 feet, the maximum thickness of the glacier. The electromagnetic

method was better for measuring ice thickness and resistivity of the rock underlying the ice, whereas the galvanic method was better for studying differences within the ice. — V. S. N.

- 187-195. Coster, F. M. Prospecting for groundwater, in *Underground water in Tanganyika: Dar Es Salaam, Tanganyika Department of Water Development and Irrigation, Chap. 8, p. 70-83, 1960.*

The field procedures and instruments used in resistivity surveys for ground water in Tanganyika are described, and an interpretation is given for several apparent resistivity curves from surveys in the basement rocks of Northern Province, younger lavas and pyroclastics, basement areas mainly in fault-zones in the Pare-Usambara region, and alluvial areas in the Kilosa-Kimamba region. In Tanganyika the resistivity surveys are found to be most useful in granitic areas, in coastal sedimentary rocks and unconsolidated sediment where salt-water penetration is liable to occur, and in tracing sandy alluvium under clays. Magnetic surveys have been used in Tanganyika to find dikes, kimberlites, and lavas, and to distinguish different rock types of the basement system where the overburden is heavy. On the whole they have not been found to be of great practical help in the location of water. — V. S. N.

- 187-196. Dam, J. C. van, and Rummelen, F. F. F. E. van. Resultaten van het geo-elektrisch onderzoek in vergelijking met de geologische opbouw van Zeeland [Results of the geoelectrical investigation in comparison with the geologic structure of Zeeland (with English summary)]: *Geologie en Mijnbouw*, v. 39, no. 11, p. 587-602, 1960.

As is to be expected in a marine estuarine region, a relationship exists between the lithologic sequence and salinity of the ground water in Zeeland province of the Netherlands. In many cases it is possible to determine sand-clay boundaries by electrical prospecting methods to depths of 200-300 m. Data from many borings show that the depth and configuration of the so-called "base layer" (Rupelian, middle Oligocene) as determined electrically agrees entirely with the actual stratigraphy. The top of the Maassliuss beds of the Icenian also was located accurately. Fresh water deposits, even smaller ones, were also detected electrically. — D. B. V.

- 187-197. Nazarenko, O. V. Opyt primeneniya differentsial'nykh ustanovok pri morskikh elektrorazvedochnykh rabot na banke Makarova [Experience in the use of differential apparatus for marine electrical exploration on the Makarov Bank]: *Geologiya Nefti i Gaza*, no. 10, p. 44-47, 1959.

The Makarov Bank is a submarine mud volcano on the Baku Archipelago in the Caspian Sea. It was mapped by differential electrical exploration using an A_1MNA_2 and an A_1MBNA_2 apparatus. The profiles were 4.5-5.0 km long and 250-300 m apart. The boat moved at 10-12 km per hr. A map constructed on a basis of the profiles shows a clearly defined narrow zone of positive anomaly. This zone outlines an area of mud volcano deposits, which have a higher electrical resistivity than do the surrounding muds. — J. W. C.

- 187-198. Kim, Kyung Sik, and Kim, Young Cheol. Studies of the spontaneous polarization method at the Duckpoong coal field [in Korean with English abstract]: *Korea Geol. Survey Bull.*, no. 4, p. 116-127, 1960.

A spontaneous-polarization survey was made of the area of the Duckpoong coal field, Korea, to trace the alteration of the sediments where intruded by igneous rocks rather than to locate coal seams. The method was useful in delineating the geology of the area. — V. S. N.

Central Water and Power Research Station Poona. Geophysical investigations. See Geophys. Abs. 187-590.

ELECTRICAL LOGGING

- 187-199. Atkins, E. R., Jr., and Smith, G. H. The significance of particle shape in formation resistivity factor-porosity relationships: *Jour. Petroleum Technology*, v. 13, no. 3, p. 285-291, 1961.

Basic relationships that exist between the formation resistivity factor, F , and the porosity, ϕ , for naturally occurring particles in water solutions are reported. Laboratory tests on slurries of clay and sand show that the value m in the Archie expression $1/F = \phi^m$ is determined by the shape of the particles in the system. The value of m , the "shape factor," is constant for a system of particles of a given shape for a range of $F-\phi$ values. Applying this concept, the $F-\phi$ relationship can be predicted for mixtures of particles with different shapes, and these predicted relationships are useful in electric log interpretation. — J. W. C.

- 187-200. Bedcher, A. Z. Opredeleniya effektivnoy poristosti peschano-alevrolitsykh kollektorov po soprotivleniyu zony fil'tratsii [Determination of effective porosity of sandy-silty reservoirs by the resistivity of the zone of filtration]: *Prikladnaya Geofizika*, no. 30, p. 179-191, 1961.

An attempt is made to determine the total porosity, effective porosity, and noneffective porosity of oil and gas reservoirs from the resistivity curve of the zone of filtration. The quantitative interpretation is based on the assumption that saline water remains in the noneffective pores of the stratum instead of being displaced by the drilling mud filtrate. — A. J. S.

- 187-201. Kal'var'skaya, V. P. Sravnitel'nyy analiz odnokatushechnoy i dvukatushechnoy sistem v karotazhe magnitnoy vospriimchivosti i elektroprovodnosti [Comparative analysis of single-coil and double-coil systems in logging for magnetic susceptibility and electric conductivity]: *Prikladnaya Geofizika*, no. 30, p. 198-205, 1961.

A comparison is made between one- and two-coil systems of pickups used in magnetic susceptibility (κ) and electrical conductivity (σ) logging by the induction method. The one-coil system has several advantages over the two-coil system in κ -logging while the two-coil system performs better in σ -logging. — A. J. S.

- 187-202. Makarov, A. N. Method KS i yego mesto v komplekse karotaznykh rabot na ugol'nykh mestorozhdeniyakh [The KS method and its place in the complex of logging for coal deposits]: *Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki*, no. 286, p. 63-86, 1960.

The resistivity logging method employed for determining the geologic-electrical profiles in coal-bearing areas is discussed in detail, and different procedures for application of the method to various coal deposits are evaluated.

Resistivity logging is recommended for specific coals such as brown, bituminous, subbituminous, lean, and common coals, and the various grades of anthracite. A number of borehole logs from coal-producing areas are given. — A. J. S.

187-203. Khanin, A. A. Sravnitel'nyye dannyye opredeleniya koeffitsiyenta gazonasyshchennosti porod metodami izucheniya kerna i promyslovo-geofizicheskimi issledovaniyami [Comparative data of determination of the coefficient of gas saturation of rocks by the methods of study of core and of geophysical logging]: Razvedka i Okhrana Nedr, no. 9, p. 21-25, 1961.

The gas saturation of reservoirs in the Gazly gas field was determined using laboratory study of cores and electrical logging. The results obtained by these two methods are approximately the same for uniform sandy-silty rocks. Where sandy and clayey rocks are interbedded, however, the values obtained by electrical logging are always lower than those determined on cores. — J. W. C.

187-204. Per'kov, N. A. Okomplekse i metodike promyslovo-geofizicheskikh issledovaniy karbonatnykh kollektorov [Combination and method of geophysical logging investigations of carbonate reservoirs]: Geologiya Nefti i Gaza, no. 6, p. 45-47, 1959.

Although electrical logging is suitable for determining porosity of sandy and shaly sections, it is inadequate for carbonate reservoirs. In limestone sections, SP anomalies occur opposite both porous and massive beds. Highly porous oil-bearing limestone commonly shows a lower resistivity than does massive, water-bearing sandstone or dolomite. Therefore, standard electrical logs must be supplemented by radiation logs and neutron-gamma logs. If a fractured limestone is shaly, a microlog must be made in addition. — J. W. C.

187-205. Vilkov, N. V. Opredeleniye pronitsayemosti neftenosnykh i vodonosnykh plastov po PS [Determination of permeability of oil-bearing and water-bearing strata according to SP]: Geologiya Nefti i Gaza, no. 7, p. 45-47, 1959.

Data on the average permeability of oil- and water-bearing strata of Devonian age in western Bashkir A. S. S. R. and southeastern Tatar A. S. S. R. are compared with data on porosity determined by SP opposite these rocks. A satisfactory relationship is found between the two sets of values; this relationship is illustrated in graphs. The accuracy of the method is found to be higher than that of other methods. — J. W. C.

187-206. Aksel'rod, S. M. Analiz raboty zonda induktsionnogo karotazha pri nastroyke v rezonans tsepey priyemnykh i generatornykh katushek [Performance analysis of an induction logging sounding device when the receiver and generator coil circuits are tuned in resonance]: Prikladnaya Geofizika, no. 30, p. 206-214, 1961.

By an approximate method of mathematical analysis the character and the order of the effect due to the system of coils being installed in resonance in the apparatus for induction logging are determined. The resonance tuning of the circuits of the generator and pickup coils in the apparatus increases sensitivity in proportion to the square of the quality factors of the circuits and does not introduce distortion of signals that are dependent on the specific conductivity of the medium. — A. J. S.

- 187-207. Kinshakov, A. I., Sokhranov, N. N., and Solodunov, A. I. O che-tyrekhelektrodnykh zondakh, primenyayemykh v elektricheskom karotazhe [On four-electrode sondes used in electrical logging]: Prikladnaya Geofizika, no. 30, p. 215-228, 1961.

A discussion is presented on the positioning of the electrodes A, M, N(B, A, M), and B(N) when the latter electrode is not removed to "infinity," but is placed near the borehole in which the electric logging is carried out. The optimum distance of the B(N) electrode is found to be not less than 140 d. — A. J. S.

- 187-208. Fatt, Irving. An electrodeless system for measuring electric logging parameters on core and mud samples: Jour. Petroleum Technology, v. 13, no. 3, p. 292-294, 1961.

A system for measuring electrical resistivity of liquids without use of electrodes offers interesting possibilities for electric logging technology. The apparatus is based on the principle that the solution being measured can form a loop coupling two transformer coils. For a fixed a-c voltage applied across one coil, the voltage appearing across the other is a function of the resistance of the liquid-filled loop. This electrodeless resistivity unit gives an accurate and instantaneous reading of drilling-mud resistivity. It can also be used in the laboratory for measuring the resistivity of cores. — J. W. C.

- 187-209. Knutson, C. F., Conley, F. R., Bohor, B. F., and Timko, D. J. Characterization of the San Miguel sandstone by a coordinated logging and coring program: Jour. Petroleum Technology, v. 13, no. 5, p. 425-432, 1961.

On a basis of induction electrical, microlog-caliper, and some velocity logs in conjunction with core study, a hydrocarbon-volume map was prepared of a portion of the San Miguel-1 reservoir, Sacatosa field, Texas. The producing sandstones prove to be very uniform throughout the drainage area of individual wells. Impervious zones generally disappear within a horizontal distance of 50 feet. — J. W. C.

- 187-210. Jordan, Louise. Salt in Wellington formation, Grant County, Oklahoma: Oklahoma Geology Notes, v. 21, no. 10, p. 272-274, 1961.

An investigation was made of the subsurface salt deposits in the Wellington formation near Medford, Okla., by examination of electric logs of wildcat tests drilled at an earlier time in the area and by a gamma ray-sonic-caliper and laterology survey of a new test hole drilled in Grant County in 1961. The total major salt section is from 812 to 928 feet below the surface; the thickest collective section is 42 feet and contains 69 percent salt. Correlation of the sonic log with the laterolog curves distinguishes clearly between the anhydrite and salt beds. — V. S. N.

- 187-211. Gorbenko, V. F. Detal'noye stratigraficheskoye razlicheneniye verkhnemelovykh otlozheniy severo-zapadnoy okrainy Donbassa i uvyazka mikrofaunisticheskikh kompleksov s diagrammami standartnogo elektrokartotazha [Detailed stratigraphic subdivision of the Upper Cretaceous deposits of the northwest margin of the Donets Basin and correlation of the microfaunal assemblages with standard electric logs]: Akad. Nauk SSSR Doklady, v. 128, no. 3, p. 578-581, 1960.

A clear correlation between stratigraphic horizons established on the basis of microfaunal assemblages in the Upper Cretaceous of the northwest margin of the Donets Basin with those based on electric logging data suggests that the stratigraphic column established for that region can be used in petroleum prospecting and surveying. — D. B. V.

- 187-212. Adylov, F. T., and Mavlyanov, A. V. Geologo-geofizicheskaya kharakteristika produktivnykh plastov paleogena mestorozhdeniya Zapadnyy Izbaskent [Geological-geophysical characteristics of productive strata of the Paleogene of the Zapadnyy Izbaskent field]: *Uzbek. Geol. Zhur.*, no. 4, p. 41-45, 1961.

Resistivity and self-potential data are given for several stratigraphic units of the Zapadnyy Izbaskent oilfield of the Uzbek S. S. R. as determined from electrical logging. — J. W. C.

- 187-213. Mikaelyan, Sh. S. Zavisimost' parametra poristosti ot koeffitsiyenta poristosti [Dependence of the porosity parameter on the coefficient of porosity]: *Geologiya Nefti i Gaza*, no. 7, p. 39-44, 1959.

The porosity parameter is the ratio of the resistivity of the water-saturated reservoir to the resistivity of the water saturating the reservoir at formation pressure. The porosity parameter is related to the coefficient of porosity by a formula which must be determined for each field. A study of this relationship in the Berezoovo oilfield is presented. The average value of the error in determining porosity according to the porosity parameter in this area is 7 percent. Greater accuracy can be obtained by improving the logging methods of resistivity measurement. — J. W. C.

- 187-214. Aliyev, A. G., Minzberg, L. V., and Nikolayeva, L. A. Kollektorskiye svoystva porod Kirmakinskoy svity Apsheronского poluoostrova [Reservoir properties of the rocks of the Kirmaki formation of the Apsheron Peninsula]: [Baku] Akad. Nauk Azerbaydzhan. SSR, 119 p., 1956.

This book provides data on the grain size, content of CaCO_3 , porosity, permeability, effective porosity, and hydraulic coefficients of rocks of the Kirmaki formation in the Apsheron Peninsula. The investigation was made on 2,311 cores and 678 specimens from outcrops. Tables of these parameters are given for various areas in the Kirmaki valley. — A. J. S.

EXPLORATION SUMMARIES AND STATISTICS

- 187-215. Cook, Douglas R. Bonanza project, Bear Creek Mining Company: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 59I18, p. 285-295, 1960.

A case history of exploration for base metals in the Southern Bonanza mining district, Colorado, is presented. The exploration was based on the thesis (Burbank, 1947) that commercial deposits of metals might occur in Paleozoic sediments beneath the hydrothermally altered volcanic rocks of the Southern Bonanza district. Geological, geophysical (magnetic, gravity, scintillation), and geochemical studies were followed by the diamond drilling of 3 holes totaling 6,220 feet. The unusual thickness of the lava flows, possibly in a caldera structure, prevented exploration of the sediments beneath the flows and it

seems unlikely that Paleozoic sediments and major orebodies will be found at economic depths in the district. Ground magnetometer traverses were unsuccessful, probably because the extreme variations in magnetic susceptibility in the lava flows mask the subtle anomalies expected. The gravity survey results show no relation to any conceivable geologic or structural feature. A widespread radioactivity anomaly of low intensity is probably due to K^{40} because of the close correspondence of the anomaly to an area of intense sericitic alteration. — V. S. N.

- 187-216. Chapman, Robert M., and Sable, Edward G. Geophysical exploration, in *Geology of the Utukok-Corwin region, northwestern Alaska*. Part 3, Areal geology: U. S. Geol. Survey Prof. Paper 303-C, p. 145-151, 1960.

The Utukok-Corwin region includes about 7,500 sq mi in the western part of northern Alaska north of the De Long Mountains and east of the Chukchi Sea. Geophysical investigations consisting of seismic, gravimetric, and airborne magnetic surveys were included in the intensive exploration program of this area conducted from 1944-53 in and near the Naval Petroleum Reserve No. 4. Seismic reflection work north of the Utukok River at the headwaters of the Kaolak River and southward along the Utukok River into the southern foothills delineated two structurally distinct areas separated by the major south-dipping and west-trending Carbon Creek thrust fault. Two subsurface closed anticlines were mapped by the seismic method in the shallow Cretaceous system to the north. The Kaolak test well 1 was drilled on one of these. A gravity low lies northwest of Carbon Creek and north of the Utukok River; a gravity high coincides with the Carbon Creek fault zone. Magnetic intensity shows a general southwestward decrease. — V. S. N.

- 187-217. Sawatzky, H. B., Agarwal, R. G., and Wilson, W. Helium prospects in southwest Saskatchewan: Saskatchewan Dept. Mineral Resources Rept., no. 49, 26 p., 1960.

This is a longer version of the paper published in *Oil in Canada*, v. 12, no. 23, p. 54-76, 1960 (see *Geophys. Abs.* 182-224). Gravity, magnetic, and structural maps are included under separate cover in this report. — V. S. N.

- 187-218. Wdowiarz, Stanisław, Depowski, Stanisław, and Śliwiński, Zygmunt. *Badania geologiczne we fliszu Karpat i Bałkanów* [Geological investigations in the flysch of the Carpathians and Balkans]: *Przeгляд Geol.*, v. 9, no. 5, p. 259-261, 1961.

A general geological discussion is presented of existing and desirable investigations of the flysch which extends over the territories of Czechoslovakia, Poland, and the U. S. S. R. in a belt tens of kilometers wide. The advantages of the gravimetric, magnetic, electrical, seismic, radiometric, and borehole logging methods of exploration of flysch and the possibility of discovery of new oil and gas fields by one or several combined geophysical methods are considered. — A. J. S.

- 187-219. Dąbrowski, Adam. *Zastosowanie metod geofizycznych w poszukiwaniu złóż rud żelaza w Polsce* [Application of geophysical methods in exploration for iron-ore deposits in Poland]: *Przeгляд Geol.*, v. 9, no. 7, p. 371-374, 1961.

The history of exploration for iron deposits in Poland is reviewed. Various geophysical methods have been used in the areas of Niż Polski, Góry

Świętokrzyskie, and Dolny Śląsk. These explorations indicate that few iron deposits of economic significance are present in Poland. — A. J. S.

187-220. Vasil'yeva, V. G., ed. *Geologicheskoye stroyeniye i neftegazonosnost' Yakutskoy ASSR* [Geology and oil-gas capability of the Yakutsk ASSR]: Moscow, Gostoptekhizdat, 478 p., 1960.

One chapter of this book (p. 315-400) is devoted to the results of geophysical investigations in the Yakutsk A. S. S. R. Density, magnetic susceptibility, and gamma activity are tabulated for more than 2,000 specimens; these comprise a great variety of sedimentary rocks and some igneous and metamorphic rocks.

Negative gravity anomalies predominate in the central part of the Yakutsk A. S. S. R. Six zones are distinguished, each of which is characterized by definite types of gravity anomalies. Gravity surveying has been very valuable in tectonic regionalization and in evaluating the structure of the crystalline basement.

The magnetic field of the eastern part of the Siberian platform is very inhomogeneous and is characterized by a large number of anomalies of different intensity, form, size, and trend. The character of the magnetic field changes considerably not only from one large structural element to another but also within individual regions.

Seismic reflection surveying has been successful in mapping third and fourth order structures where the amplitude is 250 m or more and the dips are sufficiently steep. Refraction surveying can be used to trace carbonate rocks where their depth does not exceed 5,000 m.

Several geoelectrical sections are described. Vertical electrical sounding has shown that permafrost is present nearly everywhere in the Yakutsk A. S. S. R. — J. W. C.

187-221. Boniwell, J. B., and McKenzie, A. M. Case history of the Corridor orebody, Mount Lyell, Tasmania; *Australasian Inst. Mining and Metallurgy Proc.*, no. 198, p. 281-297, 1961.

The Corridor copper sulfide deposit was discovered after a combination of geophysical prospecting methods had defined a target zone for diamond drilling. Anomalies outlined by Turam and self-potential surveys formed the basis for successful drilling. Vertical force variometer, vertical loop electromagnetometer, airborne magnetometer and scintillometer, AFMAG, gravimeter, induced polarization, and geochemical surveys also were tested over the area. This multipronged geophysical approach demonstrates that, although no one tool is versatile enough to meet the demands of every mineral setting, a combination of geophysical methods can be selected for a program that will attain optimum discrimination with speed and economy. — V. S. N.

187-222. Crary, A. P., and Van der Hoeven, F. G. Sub-ice topography of Antarctica, Long 60° W. to 130° E.: *Internat. Assoc. Sci. Hydrology*, Pub. No. 55 (Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology), p. 125-131, 1961.

Results of three traverses in interior Antarctica south and west of the Ross Sea are presented. For the most part the traverses were of exploratory nature and the main contributions came from the determinations of surface elevations, general snow character and annual accumulation, and ice thickness values; these last were measured by means of seismic, gravity, and magnetic

methods. Most of the area covered was found to have bedrock below sea level. Combining these results with those of other expeditions gives a clearer picture of the Atlantic horst, which rises 2,000-3,000 m above the land surface on either side. — D. B. V.

187-223. Carsey, J. Ben. Exploratory drilling in 1960: Am. Assoc. Petroleum Geologists Bull., v. 45, no. 6, p. 701-727, 1961.

During 1960, a total of 11,704 exploratory holes were drilled in the United States; 2,189 of these, or 18.70 percent, produced some oil or gas. Of 7,320 new-field wildcats, 745 or 10.18 percent produced some oil or gas; of 1,953 new-pool tests 616 or 31.54 percent produced some oil or gas; and of 2,431 outposts, 828 or 34.06 percent produced some oil or gas. Total exploratory footage in 1960 was 55,830,684 feet, an average of 4,770 feet per hole. In 1959, a total of 63,252,521 feet were drilled in 13,191 holes, with an average depth of 4,795 feet.

Although 11-12 percent of all new-field wildcats are "successful," only about 2 percent discover a profitable field. Data on Canada and Mexico are also given in this report. — D. B. V.

GENERAL

187-224. Helliwell, R. A., and Martin, L. H. The international geophysical month: Science, v. 134, no. 3492, p. 1737-1738, 1961.

The concept of International Geophysical Months is suggested. These would consist of three to four weeks of very intensive observations of geophysical phenomena, followed by detailed analysis of the data. The advantages of such concentrated short-term programs, supplementing the long synoptic programs characteristic of the International Geophysical Year, are discussed. — D. B. V.

187-225. Piskunov, L. I. Issledovaniye yavleniy relaksatii [Investigation of relaxation phenomena]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 905-909, 1961.

This paper analyzes a set of n homogeneous exponential processes of relaxation, such as decay of radioactive elements and isotopes, attenuation of elastic waves, and nuclear relaxation in magnetic nuclear resonance, which in the absence of interaction and intensity drop can be represented as

$$F(t) = \sum_{i=1}^n A_{oi} \exp(-k_i t)$$

where A_{oi} is the greatest intensity value of individual components of the process, $k_i = 1/\tau_i$ is a parameter which characterizes velocities, and τ is the relaxation time. The analysis is directed toward determination of A_{oi} and τ_i values of rocks, and subsequent evaluation of their physical parameters. — A. J. S.

187-226. Shaub, Yu. B. Vydeleniye geofizicheskikh anomalii na fone intensivnykh pomekh [Distinguishing geophysical anomalies on a background of intensive interferences]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 898-904, 1961.

A new method is proposed for distinguishing geophysical anomalies from background noise when the anomalies are smaller than the mean error of observation. Based on the summation of the total signal by the alternate sign

process, this method increases the ratio of the total signal amplitude to the interference signal by n^2 , where n is the number of readings in the summation. A simple electronic apparatus is proposed for automatic processing of the alternate sign signal summation. — A. J. S.

- 187-227. Paarma, Heikki, and Marmo, Vladi. Eräistä suurrakenteista Suomen geologiaan sovellettuina [On some large structures with application to the geology of Finland (with English abstract)]: *Terra*, v. 73, no. 2, p. 78-86, 1961.

Recent theories on global structural problems proposed by Belousov, Khain, Peive, and others are reviewed briefly and compared with the results of geologic and geophysical studies (seismic, gravity, and aeromagnetic) in Finland. Attention is called to the orientation of the eskers in Finland that obviously reflect the tectonic structure. Possible application of the tectonic data for ore exploration is also discussed. — V. S. N.

- 187-228. Moody, Graham B., ed. *Petroleum exploration handbook*: New York, McGraw-Hill Book Company, Inc. 829 p., 1961.

The purpose of this handbook is to summarize and to correlate all the activities involved in petroleum exploration. The twenty-five chapters, each by different authors, discuss fundamental concepts of exploration, the application of earth sciences and various techniques to petroleum exploration, and the implementation of an exploratory project from the original planning to the drilling and logging of an exploratory well. Finally, the extremely important complementary activities, such as laboratory procedures, in exploration are covered. In chapter 11, seismic, gravimetric, and magnetic methods of exploration for petroleum are discussed. Chapters 19, 20, and 21 discuss electrical logging, radioactivity well logging, and miscellaneous well logs, respectively. A six page bibliography and four appendixes of tabulated geological, mapping and surveying, and mathematical information are included. — V. S. N.

- 187-229. Gratsianova, O. P., ed. *Spravochnik geofizika. Stratigrafiya, litologiya, tektonika i fizicheskiye svoystva gornyx porod* [Reference book of geophysics. Stratigraphy, lithology, tectonics, and physical properties of rocks]: Moscow, Gostoptekhizdat, 636 p., 1961.

This is the first of four planned volumes devoted to stratigraphic, lithologic, and tectonic data, and to information on the forms and physical properties of oil and gas pools. The handbook contains data needed for planned geophysical investigations in various regions of the U. S. S. R., preparation of geological reports on geophysical exploration in these regions, and interpretation of the geophysical data obtained. Tectonic and morphologic characteristics favorable for accumulation of natural gas and oil are given for specific regions. The last chapter is devoted to methods of determination of specific gravity, porosity, permeability, apparent electrical resistivity, salinity of formation water, coefficient of membrane potential, grain size, and magnetic and elastic properties of minerals and rocks. — A. J. S.

- 187-230. Pemberton, Roger H. Combined geophysical prospecting system by helicopter: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 59L33, p. 388-393, 1960.

The helicopter, outfitted with magnetic, electromagnetic, and radioactivity recording equipment, is an advanced and efficient aerial geophysical tool. This equipment has overcome a large number of the problems that were encountered in other airborne geophysical surveys and provides (1) responses across the entire conductivity-size band, (2) coincident and simultaneous recordings of both the magnetic and electromagnetic responses on the same record, (3) better resolution of electromagnetic and magnetic results, and (4) greater control of the positioning of data so that subsequent ground follow-up work will be at a minimum. The greatest limitation of the system is that it is still capable of exploring only to a finite depth. — V. S. N.

187-231. Marmo, V[ladi]. Nykyaikaisesta malminetsinnästä [On modern prospecting]: Terra, v. 73, no. 3, p. 123-132, 1961.

Methods of prospecting for mineral deposits as practiced in Finland are described briefly in the following order: airborne magnetic and radioactivity, diamond drilling, geochemical, ground electromagnetic (slingram), drill hole (three-component magnetometry), radioactivity, and other methods. — V. S. N.

187-232. Buyalov, N. I., and Zabarinskiy, P. P. Poiski i razvedka neftyanykh i gazovykh mestorozhdeniy [Exploration and prospecting for oil and gas fields]: Moscow, Gostoptekhizdat, 450 p., 1960.

This book on oil and gas exploration contains a section devoted to geophysical methods. Gravity, magnetic, electrical, seismic, and radiometric surveying are discussed separately, and then their combined and coordinated use is treated. — J. W. C.

187-233. Shmidt, O. Yu. Izbrannyye trudy [Collected works]: Moscow, Akad. Nauk SSSR, 210 p., 1960.

This volume contains collected works on geophysics and planetary cosmogony. The papers are devoted to the origin of the earth and its magnetic field, the age of the earth, the core of the earth, and variometer surveying. — J. W. C.

GEODESY

187-234. Kivioja, Lassi. Some expected results caused by the melting of land-supported ice caps, in Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 137-139, 1961.

The effect on the continental shorelines of total melting of present land-supported ice masses is calculated, assuming that the earth is plastic. It is found that with complete isostatic compensation the surface of the oceans would be 28.4 m higher and the continents 29.6 m higher so that shorelines would be 1.2 m lower. The ground under the former ice would be 471 m higher. The geoid would be 28.4 m higher on the oceans and would rise at the continental shore lines; it would sink in icecap areas when the ice is removed but would start to rise as isostatic uplift took place. Gravity on the oceans would change by -7.5 mgal (taking only Bouguer and free air anomalies into account).

The pear-shaped earth may be caused by accumulation of material under the M-discontinuity around areas pressed down by continental ice masses. If Antarctica started to rise after removal of its ice load, this accumulated subcrustal material would be the first to flow back; the surrounding ocean floor would sink faster than in the rest of the world, making room for part of the melt waters, and the continental area would thus increase.

Perfect isostatic compensation is not claimed, but for large masses such as oceans and continents it is only a question of time when perfect equilibrium is approached. — D. B. V.

- 187-235. Baussus, Hans G. Some new aspects regarding the estimation of field variables in meteorology and physical geodesy, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 140-147, 1961.

The first part of this paper discusses the use of dynamic equations including eddy viscosity terms in attacking problems of dynamic weather forecasting. Then it is shown that it is possible to derive the basic structures of an estimation theory through the use of a flow model for the earth's interior. Equations are given that refer to the cogeoid for which the topographic influences have been correlated out so that the flow model extends to the surface. — D. B. V.

- 187-236. Tengström, Erik. A comparison between the methods of Stokes, Molodenskij, and Hirvonen in physical geodesy, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 148-151, 1961.

Results obtained with the Stokes, Molodenskij, and Hirvonen methods of computing the geoid from gravity anomalies have been compared by using models with constant density but different shape. The use of high speed computers has made it possible to give the internal and external potentials of rather complicated models. The solutions obtained for a circular cone having a height of 4 km and a radius of 12 km suggest that both the Stokes method, using Rudzki anomalies and restoring the topography, and the Molodenskij method, starting from the Stokes and Vening Meinesz formulas, seem to agree very well with the true values. There is still some doubt as to the degree of approximation of Hirvonen's expressions; computations for steeper models should throw light on their degree of accuracy. — D. B. V.

- 187-237. Lambert, Walter D. The significance of the geoid, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 151-154, 1961.

Gravimetric geodesy has introduced new and valuable ideas and has caused modification of some earlier ideas, but among the ideas worth keeping is the concept of the geoid. This concept has three advantages: (1) the advantage of thinking in small numbers; (2) the fact that we know or can know directly the form of the geoid as a physical reality over most of the earth's surface; and (3) the geophysical implications of a knowledge of the geoid. — D. B. V.

- 187-238. Heiskanen, W. A. Achievements of physical geodesy, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 154-159, 1961.

The activity of the Columbus group, which has worked continuously for a decade with the problems of physical geodesy, is reviewed. Work has proceeded in four main fields: collecting and analyzing gravity material; computing the quantities N , ξ , and η at the geoid; computing the corresponding quantities N_h , ξ_h , and η_h at different elevations; and performing theoretical studies. The main problem of physical geodesy at present is to fill the big gaps in the gravity anomaly field. The method itself is perfect; that the present accuracy is not yet as high as desired is due to the incompleteness of gravity data. — D. B. V.

- 187-239. Iszak, Imre J. A determination of the ellipticity of the earth's equator from the motion of two satellites, in Research in space science: Smithsonian Inst. Astrophys. Observatory Spec. Rept., no. 6, p. 11-24, 1961; abstract and discussion, in Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 166-167, 1961.

On the basis of the Baker-Nunn observations of the satellites 1959 α 1 and 1959 η , the coefficient β , interpreted as the ellipticity of the earth's equator, and the phase constant λ_0 , which gives the geographic longitude of the long equatorial axis, are calculated as $\beta = (3.21 \pm 0.29) \times 10^{-5}$ and $\lambda_0 = 33.15^\circ \pm 0.53^\circ$ W. The difference between the long and short semi-axes is $a_1 - a_2 = 408$ m. — D. B. V.

- 187-240. Kaula, W[illiam]M. The interaction between geodesy and the space sciences, in Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 168-173, 1961.

Exploitation of satellites and their orbits yields an improved description of the gravitational and geometrical variations of the earth's exterior, and theories of planetary interiors and their evolution are assisted by knowledge of possible mass distributions within the earth. Discussion of these interactions of geodesy and space science leads to the conclusion that the source of the long wave components of the observed gravity field is probably in the lower mantle. If so, a plausible theory is needed to explain the variability of wavelengths of the gravity field too short to have such a deep source. Many geodetic considerations bear immediately on what is plausible. — D. B. V.

- 187-241. Thomas, Paul D. The dual role for geodesy in the space age, in Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 176-183, 1961.

New tools, such as artificial satellites, are being used for research in the fundamental problems of geodesy. The new microwave distance measuring equipment, in combinations with classical instruments and ingenious new observing techniques, provides the very accurate ground control required for many space projects. — D. B. V.

- 187-242. Hirvonen, R. A. New theory of the gravimetric geodesy: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 9, 50 p., 1960.

This is a reprint of the paper originally published in Acad. Sci. Fennicae Annales, ser. A-3, no. 56, 50 p., 1960 (see Geophys. Abs. 183-311). — V. S. N.

- 187-243. Zabek, Z. Problème de l'introduction du système des déviations gravimétriques de la verticale à la compensation du réseau astronomique et géodésique du pays [Problem of introducing the system of gravimetric deflections of the vertical into the compensation of the astrogeodetic network of the country]: Bull. Géod., no. 61, p. 213-243, 1961.

Mathematical treatment of the problem stated in the title of this paper leads to the following conclusions: (1) In some European countries the available gravimetric data, together with suitable choice of parameters of geodetic and

gravimetric references, permit simultaneous compensation of the astrogeodetic network and of the system of plumbline deflections by means of equations which are given. (2) The gravimetric determination of deflections of the vertical for n Laplace points gives rise to $(2n-m)$ superabundant observations, where m is the number of unknowns in the equations; introduction of these observations into compensation of the base network increases the precision of the compensated values of astronomic and gravimetric geodetic elements. (3) As astronomically observed latitudes are not compensated during compensation of the astrogeodetic network, the north-south components of deflections of the vertical are affected by observational errors in astronomical determinations of latitude. (4) The corrections obtained by compensation are valuable in analyzing the accuracy of astronomical determinations of latitude and longitude and of gravimetric deflection of the vertical. (5) The unknowns x and y with indices of 0 to 3 or 5, obtained by the compensation, constitute a basis for transforming the gravimetric deflection of the vertical at any point in the region studied into the geodetic coordinate system, thus providing a convenient way of obtaining a uniform system of deflections of the vertical over every expanse covered by the astrogeodetic network. — D. B. V.

187-244. Fischer, Irene. The present extent of the astro-geodetic geoid and the geodetic world datum derived from it: *Bull. Géod.*, no. 61, p. 245-264, 1961.

Since presentation of the Hough ellipsoid in 1957 (see *Geophys. Abs.* 180-188), the astrogeodetic geoid has been extended into the Caribbean, India, and Japan. The two hemispheres have been tentatively connected across the North Atlantic by a reasonable assumption about the unknown geoid profile there. A series of solutions has been made for a world ellipsoid and world datum, with and without enforcing the flattening of $1/298.3$ and with and without gravimetric orientation. The resulting ellipsoids are very small, with an equatorial radius of about 6,378,160 m. The agreement between astrogeodetic and gravimetric geoid profiles is greatly improved by the small ellipsoid (see also *Geophys. Abs.* 182-250). — D. B. V.

187-245. Modrinskiy, N. I. *Geodeziya* [Geodesy]: Leningrad, Hydrometeoizdat, 449 p., 1960.

This is a textbook on geodesy for students of hydrometeorology. The emphasis is put on the use of topographic maps, ability to level and survey medium-sized areas, and theoretical problems of phototopography and photogrammetry. Instructions on practical training are reserved for special manuals on geodetic field work. — A. J. S.

Woollard, George P[ryor]. The status of gravimetric control for global geodetic studies. See *Geophys. Abs.* 187-309.

Uotila, Urho A. [K.]. Existing gravity material. See *Geophys. Abs.* 187-308.

Kozai, Yoshihide. The motion of a close earth satellite. See *Geophys. Abs.* 187-284.

GEOTECTONICS

- 187-246. Bernal, J. D., Dietz, Robert S., and Wilson, J. Tuzo. Continental and oceanic differentiation: *Nature*, v. 192, no. 4798, p. 123-128, 1961.

This is a discussion provoked by Dietz's recent paper on spreading ocean floors (see *Geophys. Abs.* 186-352). Bernal draws attention to two difficulties that are still unexplained: the first concerns the depth of the asthenosphere, and the second the mechanism of geochemical differentiation between sima and sial. Dietz answers the second objection to Bernal's satisfaction by suggesting that the sima rising from the deep mantle contains some juvenile sialic material; by spreading, this material is eventually slid under the continents, where the sialic fraction is squeezed out (gravitationally differentiated) and plastered to the underside of the continent. Concerning the first, however, Bernal insists that deep-focus earthquakes cannot represent merely temporary accumulations of stress in a long-term easy creep material, but must mean that not only the lower crust but also the rigid upper mantle down to about 900 km must move with the continents.

Wilson comments that paleomagnetic results confirm the flow of mantle currents inferred in Dietz's theory and also in that of Hess, and that certain puzzling features of island arcs and differences in length between older and recent mountain systems are accounted for in the new theories. Movements of continents would cause a change in the principal moments of inertia of the earth and thus produce polar wandering. Collision of continents might produce migrating waves of uplift that could explain some isolated and far-reaching overthrusts. Neither Dietz nor Hess, however, satisfactorily accounts for the thickening and uplift necessary to prevent drowning of the crust beneath the sea; it is suggested that slow expansion of the earth (a few mm per yr) not only would not interfere with, but indeed would assist the other orogenic processes. — D. B. V.

- 187-247. Hamilton, Warren [B.]. Origin of the Gulf of California: *Geol. Soc. America Bull.*, v. 72, no. 9, p. 1307-1318, 1961.

Crustal structure of most of the Gulf of California is of oceanic type, so that an origin by structural depression of continental rocks is not possible. Examination of the structural features north and south of Los Angeles suggests that Baja California originally lay 300 miles to the southeast, against the continental-margin bulge of Jalisco; the Gulf of California may be a pull-apart feature caused by strike-slip displacement plus up to 100 miles of cross-strike separation of the continental plate, subcontinental materials having welled up into the rift gap. The strike-slip motion has a tensional component across the continental margin south of Los Angeles but a compressional component to the north. — D. B. V.

- 187-248. Cook, Melvin A., and Eardley, A[rm]and J. Energy requirements in terrestrial expansion: *Jour. Geophys. Research*, v. 66, no. 11, p. 3907-3912, 1961.

The gravitational energy requirements of terrestrial expansion are calculated to be 6×10^{37} ergs over 225 million years in Egyed's model and 5×10^{38} ergs in Carey's model (see *Geophys. Abs.* 167-165, 178-217, respectively). Chemical energy is shown to be inadequate to produce expansion in either model. Uniform radioactive heating is too low for Carey's model but might fit Egyed's requirements. Phase changes likewise are shown to be inadequate for appreciable expansion. Upward and downward propagation of phase bound-

aries due to glacial loading and unloading, and consequent isostatic adjustments, are shown to be improbable. It is concluded that the earth could not have expanded to the extent proposed by some of the advocates of continental separation. — D. B. V.

- 187-249. Lyustikh, E. [Ye.] N. The energy of gravitational differentiation of the earth's mantle: *Annali Geofisica*, v. 14, no. 2, p. 169-172, 1961.

The crust has formed as a result of gravitational rise of sialic material differentiated from the mantle. The resulting mean supply of energy for tectonic forces might be as much as 10^{23} - 10^{27} ergs per yr. The energy of all tectonic processes is estimated at 10^{24} - 10^{31} ergs per yr. Therefore, the mechanism of differentiation could be the source of tectonic energy. — D. B. V.

- 187-250. Halushko [Galushko], P. Ya. Pro mozhlyvosti vyvchennya vertykal'nykh rukhiv zemnoyi kory za anomal'yamy syla tyazhinnya [On the possibility of studying vertical movements of the earth's crust by means of gravity anomalies (in Ukrainian)]: *Akad. Nauk Ukrainy. RSR Heol. Zhur.*, v. 20, no. 3, p. 96-101, 1960.

This is essentially a review of Russian work pertaining to the determination of vertical crustal movements from regional gravity anomalies, particularly that of Lyustikh and Subbotin (see *Geophys. Abs.* 136-10753, 163-1, respectively). Crustal structure should be ascertained first; then the nature and cause of vertical movements can be interpreted from the gravity data. — D. B. V.

- 187-251. Biot, M. A. Theory of folding of stratified viscoelastic media and its implications in tectonics and orogenesis: *Geol. Soc. America Bull.*, v. 72, no. 11, p. 1595-1620, 1961.

This paper presents an introduction to the theory of folding of stratified viscoelastic mediums under compression and discusses its significance in the context of tectonics and orogenesis. After a discussion of the buckling of an elastic rock that is under axial compression and is restrained laterally by viscous dashpots, the analysis proceeds to the analogous problem for an elastic and a viscous plate surrounded by a viscous medium. Results of some more complex problems previously analyzed by Biot are also applied and discussed.

A new feature of this approach is the emphasis on rate phenomena and time histories in tectonic folding. The theory leads to the concept of dominant wavelength and band width selectivity in analogy with the theory of electric wave filters. The theory is applied to specific examples of geologic interest. Using accepted values of rock viscosity and elastic moduli, the time required for significant folding to take place agrees very well with the geologic time scale.

It is concluded that the viscous mechanism tends to predominate in tectonic folding. Theoretically the wavelength of the folds will not be sensitive to the magnitude of the tectonic stresses unless gravity forces become important. The calculated wavelengths are in good agreement with the range of observed values. — D. B. V.

- 187-252. Biot, M. A., Odé, H., and Roever, W. L. Experimental verification of the theory of folding of stratified viscoelastic media: *Geol. Soc. America Bull.*, v. 72, no. 11, p. 1621-1632, 1961.

An experimental check has been obtained for the theory presented in the companion paper (see Geophys. Abs. 187-251). Model tests have been conducted for both an elastic layer and a viscous layer embedded in a viscous medium and subject to a compression parallel with the layer. The appearance of the folds and measured wavelengths are in good agreement with the theoretical predictions. A theoretical evaluation of the time history of deformation for a layer whose folding develops from a given initial departure from perfect flatness is given. — D. B. V.

- 187-253. Belousov [Belousov], V. V., and Ruditch [Rudich], E. [Ye.] M. Island arcs in the development of the earth's structure (especially in the region of Japan and the Sea of Okhotsk): *Jour. Geology*, v. 69, no. 6, p. 647-658, 1961.

This is an English version of the paper published previously in *Sovetskaya Geologiya*, no. 10, p. 3-23, 1960 (see Geophys. Abs. 184-346). — V. S. N.

- 187-254. Belousov [Belousov], V. V. Development of the earth and tectogenesis: *Philippine Geologist*, v. 15, no. 1, p. 27-58, 1961.

This is a reprint of the paper published in *Jour. Geophys. Research*, v. 65, no. 12, p. 4127-4146, 1960 (see Geophys. Abs. 184-345). — V. S. N.

- 187-255. Brunn, Jan Houghton. Origine et localisation de l'énergie de la granitisation [Origin and localization of the energy of granitization]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 22, p. 3470-3472, 1961.

It is suggested that the energy transfer from deep to more superficial layers required for granitization of sediments, generally attributed to geosynclinal subsidence, is governed by updoming of the crystalline crust. The resulting decompression of underlying layers would permit the release of their volatile elements, which could then rise toward the surface. This concept agrees better with the observed facts (anticlinal batholiths, for instance) than does the subsidence concept. The relaying of subcrustal internal pressure by orogenic compression accounts for the liberation of the latent energy of magma and its transfer to shallow zones. — D. B. V.

- 187-256. Gorshkov, G. S. Petrochemistry of volcanic rocks in relation to the formation of island arcs: *Annali Geofisica*, v. 14, no. 2, p. 137-144, 1961.

Lavas of oceanic islands are alkalic, and those of continental areas and island arcs are calc-alkalic; each is related genetically as well as spatially to its corresponding crustal type. Oceanic magma of hawaiian type is ancestral to all other types; in the course of normal evolution it becomes progressively more alkalic, and on contamination by sialic material it becomes calc-alkalic. Island arcs mark regions where differentiation is taking place at depth and sialic material is rising from the mantle to the surface. This process leads to crustal thickening and abruptly changes the petrochemistry and whole character of volcanism. Volcanism is not a purely surface or intracrustal process, but represents the surface expression of primary subcrustal processes that govern the whole course of the earth's evolution. The formation of island arcs is one of the most important steps in the process. — D. B. V.

- 187-257. Lyustikh, Ye. N. Gipoteza differentsiatsii zemnoy obolochki i geotektonicheskoye obobshcheniya [Hypothesis of differentiation of

the mantle and geotectonic generalizations (with English abstract)]; *Sovetskaya Geologiya*, no. 6, p. 28-52, 1961.

The main factor accounting for vertical movements in geosynclinal belts is interpreted as density inversion, a phenomenon wherein a flexible heavier layer is supported by a fluid lighter one. During the first half of an orogenic cycle, tension in the crust due to thermal expansion of the earth leads to formation of a deep fracture and to downwarping of a geosyncline above this fracture. Granitic magma then flows out of the mantle along the deep fracture and ascends toward the crust or granitic layer. As a result during the second half of the cycle mountains form at the site of the geosyncline, and density inversions control regional and local movements. — J. W. C.

187-258. Wang, Kuang-Yen. Problems of the mechanical energy in earth's crust movement [in Chinese]; *Ti Chih Lun P'ing* [Geological Review], v. 18, no. 1, p. 69-73, 1958.

The thermodynamics and compressive forces involved with cooling of magmas, and the types of forces generated by rotation of the earth are discussed. — J. W. C.

187-259. Yen, Tung-Lu. On the fundamental properties of earth's crust movement [in Chinese]; *Ti Chih Lun P'ing* [Geological Review], v. 18, no. 1, p. 57-68, 1958.

The causes of earth movements and of the evolution of geosynclines into mountains are discussed. — J. W. C.

187-260. Markov, K. K. Mouvements glacioisostatiques de l'écorce terrestre [Glacioisostatic movements of the earth's crust, in Symposium on Antarctic Geology (with English summary)]; *Internat. Assoc. Sci. Hydrology*, Pub. no. 55, (Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960), p. 24-28, 1961.

There are two proofs of the magnitude of glacioisostatic movements of the earth's surface. (1) Comparison of the mean altitude (2,350 m) with gravimetric data shows that Antarctica is in isostatic equilibrium; the continent, twice as high as other continents before glaciation, has been depressed under the ice load while maintaining a bedrock altitude close to the mean altitude of the other continents. (2) Comparison of Pleistocene shorelines shows that deformation of the Baltic shield has been 25-50 times greater than that of the relatively stable Caspian area; this difference can be explained only by vertical movement activated by the removal of the ice. — D. B. V.

187-261. Vening Meinesz, F. A. Orogeny in the New Guinea, Palao, Halmahera area; geophysical conclusions: *Koninkl. Nederlandse Akad. Wetensch. Proc.*, ser. B, v. 64, no. 2, p. 240-244, 1961.

A recent expedition to New Guinea found that the high mountain range of that island is not essentially folded, as believed, but is a huge block that was overthrust from the north with some eastward displacement. An azimuth of N. 45° W. is calculated for the direction of uniaxial stress that caused the crustal shear. The deforming stress is believed to be due to drag on the crust by a mantle convection current rising under Asia. Below the western half of the Indonesian Archipelago the direction of this current must be about N. 160° E., gradually changing toward N. 150° E. below the eastern half. In the New Guinea area the current should diverge to about N. 135° E. A drag

direction of N. 135° E. compares favorably with the results of soundings in the ocean between Waigeo and the Helen-Tobi Islands, where two parallel ridges were found. If the first ridge is the middle part of an island arc, as suggested by an earlier gravity profile (1929), then the second is the accompanying volcanic arc, inside it with respect to the border of the Asiatic continent. Both arcs probably belong to the Marianas-Bonin system. Deformation in the Bismarck Archipelago fits well with this concept.

There appears to be no current radiating from the Australian continent; if there is one it is completely dominated by the Asiatic current, which continues under Australia via Indonesia and the Philippines and plays the principal part in fashioning the tectonic features of Australia. The difference in relative strength of the currents originating below Australia and Asia may be due to the difference in their size, or to the fact that whereas Asia is part of the ur-continent, Australia now occupies a different location with respect to the mantle and there has not been time for heat to accumulate beneath it. — D. B. V.

- 187-262. Ahmad, R. A brief comparative study of the geological formations of western Australia and peninsular India and its bearing on the drift hypothesis: *India Geol. Survey Recs.*, v. 86, pt. 4, p. 621-636, 1960.

The geologic formations on the west coast of Australia and on the east coast of peninsular India are compared, and it is shown that although information is meager wherever it is reliable close parallels are found between the two areas from Archean to Cretaceous time. These similarities are in rock types, mineral occurrences, climate and glaciation, structure, and fauna and flora. The late Precambrian and the Permian glaciations are cited as examples of similarities that cannot be explained unless drift has taken place. The well known reconstructions of Gondwanaland are discussed, and it is concluded that none is totally satisfactory. Carey's 1951 attempt may be a close approach; the major Cretaceous faulting on this assembly is significant in that all faults from western Australia into India appear to run into one another and then into the Baluchistan orocline. It is concluded that in any future Gondwanaland assembly India and Australia should be regarded as inseparables. India should slide further "southward" than is shown in the 1951 assembly, east Australia should fit close to south Africa, and, if necessary, Ceylon shifted to the west of India. — V. S. N.

- 187-263. Ahmad, F. Glaciation and Gondwanaland: *India Geol. Survey Recs.*, v. 86, pt. 4, p. 637-674, 1960.

The records of glaciation in Gondwanaland from the earliest known to the Tertiary are reviewed. Available faunal and floral evidence does not support the generally held opinion that glaciation was contemporaneous over the whole globe or even in one hemisphere, nor is there evidence that refrigeration occurred at a regular interval. Evidence does suggest that glaciation shifted from one continent to another, and the known features can be explained only if the continents were closer together at that time. The known glacial records from Devonian to Triassic time are placed on a reconstruction of Gondwanaland by Carey, and it is demonstrated that glaciation was undoubtedly continuous throughout this long period. The preservation of the glacial record is the result of negative epeirogeny and drift. It is possible that the drifting of the two continents, Laurasia and Gondwanaland, occasionally brought them closer together and resulted in a cosmopolitan flora and fauna. — V. S. N.

- 187-264. Havemann, Hans. Polwanderung und Epeirophorese als Faktoren des Erdevolution [Polar wandering and epeirophoresis as factors

in the earth's evolution (with English and Russian summaries):
Geologie, v. 10, no. 2, p. 185-213, 1961.

The problem of the origin of the present oceans, continental drift toward the Pacific, and polar wandering is reviewed. There can hardly be any doubt that both epeirophoresis (continental drift) of the southern continents and rather large polar wandering took place during the Mesozoic, preceded by similar but smaller movements in the Paleozoic. Polar wandering and continental drift have a common origin—convection currents in the mantle—and take place simultaneously. A two-page bibliography is given. — D. B. V.

Vacquier, Victor, Duff, Arthur D., and Warren, Robert E. Horizontal displacements in the floor of the northeastern Pacific Ocean. See *Geophys. Abs.* 187-515.

187-265. Mooser, F., and Maldonado-Koerdell, M. Tectonica penecontemporanea a lo largo de la costa Mexicana de Oceano Pacifico [Pene-contemporaneous tectonics along the Mexican Pacific Ocean coast [in Spanish and English]: *Geofísica Internat.*, v. 1, no. 1, p. 3-20, 1961.

Mexico's southern and western portions were subjected during Tertiary time to the formation of several large arches by deep-seated subcrustal forces; onset of volcanism released the pressure and led to collapse of the centers causing the zones to expand into increasingly broad fracture zones that now reflect the slightest surface movement. The dominant crustal pressure now exerted in Mexico comes from the northeast and is causing the gradual encroachment of the continental mass over the Pacific basin in a southwestern direction. The San Andreas fault system, the San Andreas-Chapala line, and the Clarion fracture zone with its continental prolongation are now yielding to lateral stresses of the same tectonic force and producing transcurrent movements. The individual rotations of the different fracture zones exhibit a pattern of movement that is conformable with similar patterns postulated for the whole of North America. — V. S. N.

187-266. Okada, Atsushi. Land deformation of the southern part of the Kii Peninsula, southwestern Japan [in Japanese with English summary]: *Tokyo Univ. Earthquake Research Inst. Bull.*, v. 38, pt. 1, p. 113-124, 1960.

Recent deformation in the southern part of the Kii Peninsula was investigated by comparing the results of a precise leveling resurvey with mean sea level variations. Ground tilt along a straight line from Uragami to Kushimoto is shown in a graph. There appears to have been southwesterly tilt, representing continuous subsidence of the southern part of the peninsula in recent years. — D. B. V.

GLACIERS

187-267. Shumskiy, P. A. On the theory of glacier motion: *Internat. Assoc. Sci. Hydrology Pub.*, no. 55 (*Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology*), p. 142-149, 1961.

Existing dynamic theories of glacier motion are all based on calculation of laminar flow and fail to take into account the most important type of move-

ment, block sliding along the bed or along bottom thrust faults. The calculation of uniaxial longitudinal stresses and deformations, supplemented by the calculation of laminar flow, should serve as a first approximation of glacier motion.

Solutions are given for the moving force in a glacier of arbitrary shape under conditions of a plane problem, for normal and tangential stresses, for rates of ice deformation, and for average velocity.

From these solutions it is possible to determine friction against a glacier bed from measurements of its shape and movement. Dependence of equilibrium shape and dimensions of a stationary glacier on rates of accumulation and ablation, bedrock relief, and external friction is more complicated than in previous theories. With the proposed theory, the values of run-off and spreading, stresses, deformations, and movement can be established separately, so that the role of relief and climate in glacier dynamics can be analyzed. — D. B. V.

- 187-268. Shumskiy, P. A. The dynamics and morphology of glaciers: Internat. Assoc. Sci. Hydrology Pub., no. 55 (Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology), p. 152-161, 1961.

This paper is devoted to analysis of certain relationships between the conditions of existence of glaciers and their dynamics and morphology, on the basis of Shumskiy's proposed theory (see Geophys. Abs. 187-267). A differential equation of the state of a glacier is given; then friction against the bed, inclination of the surface, the steady state of a glacier, the role of subglacial relief and climate in glacier dynamics, a morphologic-dynamic classification of glaciers (run-off, mountain-sheet, sheet, and out-flow), intensity of geologic activity of glaciers, and the evolution of glaciers are discussed. — D. B. V.

- 187-269. Weertman, J. Stability of ice-age ice sheets: Jour. Geophys. Research, v. 66, no. 11, p. 3783-3792, 1961.

Application of the present-day theory of ice flow in glaciers and ice sheets leads to the conclusion that a small Arctic icecap can become unstable and expand into a large ice age sheet as a result of moderate changes in the regime of the icecap, and that a large continental ice sheet can become unstable and disappear if snow accumulation is reduced or the ablation rate increased. The results fit well with the Ewing-Donn theory of ice ages. — D. B. V.

- 187-270. Haefeli, R[obert]. Contribution to the movement and the form of ice sheets in the Arctic and Antarctic: Jour. Glaciology, v. 3, no. 30, p. 1133-1151, 1961.

Starting from Glen's flow law for ice and from a series of assumptions based in part on observations in Greenland and in the Jungfrauoch, the velocity distribution (horizontal velocity component) and surface configuration is derived for a strip-shaped ice sheet in a stationary state. For the choice $n=3-4$ of the exponent in the power-law flow relation, there is extensive agreement between the theoretically calculated surface profile and the east-west profile measured through "Station Centrale" by Expéditions Polaires Françaises. The corresponding theoretical solution for a circular ice sheet is also given. As a first application of this theory, an attempt is made to calculate the average rate of accumulation in Antarctica from its surface profile (assumed circular in plan) and from the flow-law parameters derived from the Greenland Ice Sheet. It is also shown that a change in accumulation has only a small influence on the

total ice thickness of an ice sheet. A method of calculating approximately the age of ice in an ice sheet, based on the foregoing theory, is illustrated by applying it to the Greenland Ice Sheet. After comparing the present theory with that of Nye, a general expression for the surface profile of an ice sheet with constant accumulation is set up and discussed by means of comparison with two profiles through Antarctica. — Author's abstract

- 187-271. Haefeli, R[obert]. Eine Parallele zwischen der Eiskalotte Jungfrauoch und der Eisschildern der Arktis und Antarktis [A parallel between the icecap of the Jungfrauoch and the inland ice of the Arctic and Antarctic]: *Geologie u. Bauwesen*, v. 26, no. 4, p. 191-213, 1961.

Continual measurements were made inside an ice tunnel during the period 1950-60 in the icecap of the Jungfrauoch. This icecap can be considered in many ways to be a scale model of a large ice sheet. The experience from its study and that from the French Greenland expedition are a basis for developing a theory of the steady state motion of ice sheets within the firn region where simple assumptions are made as to the general validity for the flow law of polycrystalline ice in a more or less horizontal bed on which the ice is fixed (no sliding). The parameters of the ice are determined in such a way that the difference between the calculated surface profile on the central part of the Greenland ice sheet and the profile measured by the French expedition becomes insignificant. Thus, the steady motion of an ice sheet in equilibrium can be considered as a state of continuous creep under the influence of only gravity (see also *Geophys. Abs.* 187-270). — J. W. C.

- 187-272. Glen, J. W., and Lewis, W. V. Measurements of slide-slip at Austerdalsbreen, 1959: *Jour. Glaciology*, v. 3, no. 30, p. 1109-1122, 1961.

Measurements of the rate at which Austerdalsbreen Glacier is slipping past its side wall were made at four different sites. The rate is less than the slip previously measured up-glacier at the foot of an icefall, and is also about one-sixth the rate found in the center of the glacier. Velocities of the last meter of ice are more erratic than those a few meters from the edge. This suggests that protuberances of rock and boulders between the ice and rock wall cause local variations in flow which smooth out within a few meters. The results are discussed in connection with the process of glacial erosion. — V. S. N.

- 187-273. Carter, Adams, and Atherton, David. Milton Mt. McKinley Range expedition, 1960: *Jour. Glaciology*, v. 3, no. 30, p. 1123-1132, 1961.

Results of a reconnaissance expedition during the summer of 1958 on the north fork of the Eldridge Glacier, Mount McKinley National Park, Alaska, are reported. Velocity profiles were made to determine the type of glacier flow; the movement to width ratio is high (1:6) and thus Block-Schollen type of movement is likely. The velocity profiles also show both slip at the glacier's edge and shear in the adjacent layers. It is concluded that glaciers in this region are near their recent maximum because the high altitude accumulation offsets the shrinking of the lower tributary glaciers. — V. S. N.

- 187-274. Cameron, R. L., and Goldthwait, R. P. The US-IGY contribution to Antarctic glaciology: *Internat. Assoc. Sci. Hydrology Pub.*, no. 55 (*Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology*), p. 7-13, 1961.

A snow accumulation map of Antarctica is presented, compiled from data from Little America, Marie Byrd, South Pole, and Wilkes stations as well as data collected by other countries. The largest accumulation is on the east side of the Weddell Sea, the smallest in the vicinity of the Pole of Inaccessibility. A map of mean annual air temperature shows that the "cold pole" (-57°C to -59°C) lies near Vostok II Station.

Relative motion networks showed that there was no appreciable glacier expansion in 1958-59. Measurements of absolute movement show that the glaciers along the coast of east Antarctica may be discharging ice faster than previously postulated; Vanderford Glacier moves 2.1 m per day, whereas Skelton Glacier moves into the Ross Ice Shelf at a rate of 0.28 m per day. — D. B. V.

- 187-275. Yevteyev, S. A. The geological activity of the ice cover in eastern Antarctica: *Internat. Assoc. Sci. Hydrology Pub.*, no. 55 (*Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology*), p. 14-17, 1961.

In the area studied by the Soviet Antarctic Expedition (long 78°-110° E.) the icecap reaches a thickness of 3,000 m and, flowing at a rate of nearly 1,000 m per yr in its most mobile parts, exerts an intensive effect on the underlying bedrock. The thickness of the moraine-bearing layer at the base of the ice sheet reaches 100 m in the fast-flowing glacial currents and varies between 10 and 40 m in slower-moving parts. A combination of mechanisms within the moraine-bearing ice (visco-plastic flow and gliding along internal shear surfaces) causes boulders in the debris to become oriented lengthwise in the direction of movement, and erratics to acquire a "flatiron" shape. It is calculated that about 0.05 mm is removed annually from the bedrock surface of east Antarctica; this is comparable to stream erosion in plains regions. — D. B. V.

- 187-276. Bauer, A. Nouvelle estimation du volume de la glace de l'inlandsis antarctique [New estimate of the volume of ice in the Antarctic icecap]: *Internat. Assoc. Sci. Hydrology Pub.*, no. 55 (*Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology*), p. 19-23, 1961.

On the basis of International Geophysical Year data, the volume of the Antarctic icecap is calculated to be 33×10^7 km³. — D. B. V.

- 187-277. McLeod, I. R., and Jesson, E. E. Inland ice movement in MacRobertson Land, Antarctica: *Internat. Assoc. Sci. Hydrology Pub.*, no. 55 (*Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology*), p. 57-62, 1961.

Details are given of the ice thickness and surface velocity measurements along an east-west line 12 km inland from the coast of MacRobertson Land. Approximately 68×10^5 kg of water equivalent of ice flows across each meter of this line annually, and 38×10^5 kg of water equivalent of ice reaches each meter of this part of the coastline each year. — Authors' abstract

- 187-278. Bender, J. A., and Gow, A. J. Deep drilling in Antarctica: *Internat. Assoc. Sci. Hydrology Pub.*, no. 55 (*Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology*), p. 132-141, 1961.

Using a modified rotary well drilling rig with compressed air as the drilling fluid, excellent cores were obtained down to 308 m at Byrd Station and down to 254 m on shelf ice at Little America. Detailed analysis of the cores indicates an annual accumulation of 15 and 21 cm of water equivalent at these two stations, respectively. Depth-density and depth-temperature curves are given. Continuation of measurements at the Byrd Station hole indicates that in 2 years there was no change in temperature with depth or in inclination, and that the hole was closing very rapidly with depth and nonlinearly with time. — D. B. V.

187-279. Stuart, A. W., and Heine, A. J. Glaciological work of the 1959-60 U.S. Victoria Land traverse: *Jour. Glaciology*, v. 3, no. 30, p. 997-1002, 1961.

Observations were made of snow accumulation, sastrugi, as indicators of wind direction, and movement of the Ross Ice Shelf as a part of a seismic-glaciological reconnaissance of Victoria Land, Antarctica, from October 1959 to February 1960. Movement and accumulation data were determined from remeasurement of stakes emplaced by a previous traverse. Movement points on the Ross Ice Shelf show a maximum rate of about 844 m per yr with lesser rates in the more marginal areas. — V. S. N.

187-280. Crary, A. P., and Wilson, Charles R. Formation of "blue" glacier ice by horizontal compressive forces: *Jour. Glaciology*, v. 3, no. 30, p. 1045-1050, 1961.

Data are supplied to show that the "blue" ice area with high surface densities encountered in the Skelton Glacier, Antarctica, results from horizontal compressive forces and the absence of accumulation due to strong katabatic winds. Examples of the densification of surface snows of the Ross Ice Shelf by this means are also given. Such density changes should be expected in any area where either of the principal horizontal strain-rates is negative. — V. S. N.

187-281. Wexler, H. Growth and thermal structure of the deep ice in Byrd Land, Antarctica: *Jour. Glaciology*, v. 3, no. 30, p. 1075-1087, 1961.

Times of growth of the ice shelf in the channel connecting the Ross and Bellingshausen Seas by combined freezing from below and accumulation above at the rate of 10 and 20 cm per yr, respectively, are determined for the case of a linear temperature profile in the ice. After the ice shelf becomes grounded, further growth is by accumulation only. Steady-state temperature profiles for ice sheets 2,300 and 4,300 m thick are computed under assumption of a constant geothermal heat flux of 10^{-6} cal $\text{cm}^{-2}\text{sec}^{-1}$ and compared with observed temperatures in the 300 m drill hole at Byrd Station (see *Geophys. Abs.* 177-185). The effect of down-slope motion and sinking of ice strata on the vertical temperature profile of the surface layer is studied with aid of the Benfield-Radok formula. Assuming no climatic temperature change and an initial temperature gradient at the ice crest 1°C increase per 100 m increase in depth, the curve of best fit of all those tried is for a sinking rate of 20 cm per yr and a down-slope speed of 85 m per yr. Calculations are given to show that for the thickness of 4,300 m found 200 km east of Byrd Station a total of 40,390 and 20,720 yr of accumulation at the rates of 10 and 20 cm per yr, respectively, are required. — V. S. N.

Kamb, W. Barclay. The glide direction in ice. See *Geophys. Abs.* 187-598.

Krausz, A. S. Etching technique to study plastic deformation of ice. See Geophys. Abs. 187-597.

GRAVITY

- 187-282. Newton, R. R., Hopfield, H. S., and Kline, R. C. Odd harmonics in the earth's gravitational field: *Nature*, v. 190, no. 4776, p. 617-618, 1961.

The odd harmonics J_3 , J_5 , and J_7 of the earth's gravitational field are calculated from satellite data (1958 β , 1960 γ , and 1960 η) as $(-2.36 \pm 0.14) \times 10^{-6}$, $(-0.19 \pm 0.10) \times 10^{-6}$, and $(-0.28 \pm 0.11) \times 10^{-6}$, respectively. It is interesting that the value of J_7 obtained here is larger than that of J_5 , although the difference is less than the probable error. It may be that the values of the harmonics beginning with the fifth will be determined principally by the topography and will thus tend to decrease slowly but erratically with increasing order. — D. B. V.

- 187-283. Kozai, Yoshihide. The gravitational field of the earth derived from motions of three satellites: *Astron. Jour.*, v. 66, no. 1, p. 8-10, 1961.

Coefficients of the second, third, fourth, and fifth harmonics of the gravitational field of the earth are determined from analysis of motions of the satellites 1958 β 2 (Vanguard I), 1959 η (Vanguard III), and 1959 ι 1 (Explorer VII) to be: $A_2/a_e^2 = (1.62329 \pm 0.00004) \times 10^{-3}$, $A_3/a_e^3 = (2.29 \pm 0.02) \times 10^{-6}$, $A_4/a_e^4 = (9.3 \pm 0.2) \times 10^{-6}$, and $A_5/a_e^5 = (2.3 \pm 0.2) \times 10^{-7}$. — D. B. V.

- 187-284. Kozai, Yoshihide. The motion of a close earth satellite: *Astron. Jour.*, v. 64, no. 9, p. 367-377, 1959.

Perturbations of six orbital elements of a close earth satellite moving in the gravitational field of the earth without air-resistance are derived as functions of mean orbital elements and time. It is assumed that the density distribution of the earth is symmetrical with respect to the axis of rotation, that the coefficient of the second harmonic of the potential is a small quantity of the first order, and that the coefficients of the third and fourth harmonics are of the second order. It is shown that there are no long-periodic terms of the first order in the expression of the semimajor axis. — D. B. V.

- 187-285. Kozai, Yoshihide. Potential field of the earth derived from motions of artificial satellites, in *Geodesy in the space age* (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 174-176, 1961.

The advantages of the satellite-tracking method of determining the coefficients of the zonal harmonics of the earth's gravitational field are outlined, and present and future accuracy of the method is discussed. — D. B. V.

- 187-286. Lambert, Walter [D.]. The gravity field of an ellipsoid of revolution as a level surface: *Acad. Sci. Fennicae Annales*, ser. A-III, no. 57, 42 p., 1961; reprinted as Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 14, 1961.

The reference ellipsoid on which the official gravity formula is based may differ somewhat from the best-fitting ellipsoid without detracting from the ul-

timate accuracy of conclusions from gravimetric data, because the geoid is the same geoid even though the reference surface may change. There are two methods of determining the gravity field of the reference ellipsoid. The method using curvilinear coordinates, not yet found in standard treatises on geodesy, is summarized and developed here both for its own sake and for comparison purposes.

The second method is based on the fact that the figure of equilibrium for a homogeneous earth is an exact ellipsoid; by assuming a thin "coating" of high negative density, a perfectly general expression can be found for the potential and for the components of gravitational attraction or of gravity in terms of powers of $1/r$ (r =radius vector) multiplied by the appropriate zonal harmonics. Both methods yield the same closed formula for gravity on the surface of the ellipsoid and equivalent formulas for outer space. The second is much simpler mathematically.

The two main parts of this paper are mathematical treatments of the special ellipsoidal coordinates and their properties, and of gravity and gravitational attraction in terms of ordinary spherical coordinates. — D. B. V.

187-287. Parasnis, D. S. Exact expressions for the gravitational attraction of a circular lamina at all points of space and of a right circular vertical cylinder at points external to it: *Geophys. Prosp.*, v. 9, no. 3, p. 382-398, 1961.

The gravitational attraction of a circular lamina and a right circular vertical cylinder at any axial point can be found by elementary methods. The usual method of estimating the attraction at a point P off the axis is valid only if P is a distant point. As a step towards calculating exactly the attraction of the cylinder at all points of the space external to it, the corresponding problem for the lamina is treated first. It is shown that the anomaly can be expressed as an infinite series in even powers of the horizontal distance P . The coefficients of the powers consist of exact algebraic expressions containing simple terms of the form $(1+x^2)^{-n-\frac{1}{2}}$. These coefficients are determined by exactly summing certain infinite series involving the derivatives of the Legendre polynomials of odd order. The method of summation is believed to be of interest also in other problems where Legendre polynomials are encountered. The attraction of the cylinder is calculated by approximately integrating the expression for the attraction of the lamina.

Numerical calculations show that the approximate method everywhere underestimates the gravity anomaly of the lamina as well as that of the cylinder. The error at distances one or two times the radius is up to 20 percent for the lamina and 8.5 percent for an infinitely long cylinder. — D. B. V.

187-288. Andreyev, B. A. Gravitatsionnyye anomalii Faya i izostaziya [Faye gravity anomalies and isostasy]: *Akad. Nauk SSSR Doklady*, v. 139, no. 1, p. 91-93, 1961.

The difference between the Faye anomaly (Δg_F) and the isostatic anomaly (Δg_I) is investigated and found to depend closely on h (altitude of the observation point, if on a continent, or depth to bottom, if at sea). The relationship appears to be linear for continental stations with $h > 1.3$ km and for all oceanic stations; $\Delta g_F - \Delta g_I$ increases with altitude and decreases with depth. The maximum positive average values of $\Delta g_F - \Delta g_I$ are observed when altitude is maximum (up to 275 mgal for $h = +4$ km) and the lowest negative values when ocean depth is maximum (to -130 mgal for $h = -8$ km). For almost all continental stations between 0 and 1.3 km high, $\Delta g_F - \Delta g_I$ has small negative values.

For regions in which the height of the relief varies in a relatively narrow interval, it should be possible to predict the mean value of $\Delta g_F - \Delta g_I$, or knowing Δg_F , to predict Δg_I . As an example, the isostatic anomaly for central East Antarctica is calculated as -80 mgal. — D. B. V.

- 187-289. Troshkov, G. A., and Shalayev, S. V. *Primeneniye preobrazovaniya Fur'ye dlya resheniya obratnoy zadachi gravirazvedki i magnitorazvedki* [Application of Fourier transformation to solutions of the inverse problem of gravity and magnetic prospecting]: *Prikladnaya Geofizika*, no. 30, p. 162-178, 1961.

A pair of Fourier transformations, $f(x) = (1/2\pi) \int_{-\infty}^{+\infty} S(\omega) e^{-i\omega x} d\omega$, and $S(\omega) = \int_{-\infty}^{+\infty} f(x) e^{i\omega x} dx$ are applied to the problem of determination of the attitude of elements of geologic bodies producing gravity and magnetic anomalies. In the above equations $f(x)$ is a real or complex function that satisfies the conditions of convergence of the integrals; $S(\omega)$ is the Fourier transformation of the function $f(x)$, and ω is a certain real variable. The method is developed and expressions obtained for transformations of $S(\omega)$ for two-dimensional bodies whose vertical cross sections are bounded by an arbitrary broken line of a finite number of links. The method yielded a depth of 800 m to a disturbing body, which was determined by a borehole to be at 750 m. — A. J. S.

- 187-290. Lukavchenko, P. I. *O geologorazvedochnom znachenii tret'ey proivodnoy potentsiala silytyazhesti* [On the geological prospecting significance of the third derivative of gravity potential]: *Prikladnaya Geofizika*, no. 30, p. 115-142, 1961.

An evaluation of applicability to geological prospecting and methods of calculation of the third derivatives U_{zzx} and U_{zzy} of gravity potential is given. Procedures are demonstrated for calculating averaged gravity anomalies at the surface for bodies of known simple geometry (sphere, horizontal infinite circular cylinder, vertical bench, horizontal half-plane, thin vertical cylinder, thin infinite layer, horizontal layer of infinite extension, and thin vertical layer of limited downward extent), and for determination of their elements of attitude according to characteristic points of the anomaly curves. The methods of U_{zzx} and U_{zzy} calculation for two- and three-dimensional cases are given, and preparation of master charts of the derivatives for a given value of Z is worked out. The Kilchling torsional gravimeter (see *Geophys. Abs.* 170-181) is suggested for direct measurement of the derivatives. The accuracy of the balance is 1×10^{-12} cgs, its moment of inertia -4,760 cgs, oscillation period -15 m20^s, and damping period -3 hr. A diagram of the gravimeter is given. — A. J. S.

- 187-291. Yun'kov, A. A. *Obchyslennya anomalii V_{xz} nad tryvymirnymi tilami paletkoyu dvovymirnogo tila* [Calculation of anomalies V_{xz} of three-dimensional bodies with a master chart for a two-dimensional body]: *Akad. Nauk Ukrayin. RSR Dopovidi*, no. 9, p. 1224-1226, 1960.

A new method of interpretation of anomalies of V_{xz} produced by three-dimensional bodies of arbitrary geometry by using a single master chart for a two-dimensional body is proposed, and a mathematical analysis of the method is presented. — A. J. S.

- 187-292. Yun'kov, A. A. Obchyslennyya anomalii V_{Δ} nad tryvymyrmynmytilami paletkoyu dvovymyrmynogo tila [Calculation of anomalies V_{Δ} of three-dimensional bodies with a master chart for a two-dimensional body]: Akad. Nauk Ukrayin. RSR Dopovidi, no. 10, p. 1393-1395, 1960.

The same method as in Yun'kov's preceding paper (see Geophys. Abs. 187-291) is discussed and analyzed mathematically for determination of the potential anomaly V_{Δ} . — A. J. S.

- 187-293. Kartevilishvili, K. M. Kriterii dlya proverki interpretatsii gravitatsionnoy anomalii V_{zz} . [Critical for verification of a V_{zz} gravity anomaly]: Akad. Nauk Gruzin. SSR Soobshch., v. 25, no. 6, p. 655-658, 1960.

This is a mathematical analysis of the second vertical derivative of gravity potential $V_{zz} = a^2 v / az^2$. Criteria for quantitative interpretation of V_{zz} gravity anomalies are developed for two- and three-dimensional disturbing bodies. — A. J. S.

- 187-294. Paul, M. K. On computation of the second derivatives from gravity data: Geofisica Pura e Appl., v. 48, p. 7-15, 1961.

Second derivative formulas of Elkins and Rosenbach (see Geophys. Abs. 144-12620, 155-14811, respectively) are developed from a unified approach, and their merits and demerits are discussed. Some new formulas are presented that theoretically should prove more efficient. — D. B. V.

Morgan, W. J., Stoner, J. O., and Dicke, R. H. Periodicity of earthquakes and the invariance of the gravitational constant. See Geophys. Abs. 187-101.

- 187-295. Tengström, Erik. An approximate method for calculating the depth of a surface-reaching gravitational mass-anomaly, giving a Bouguer-field with radial or axial symmetry: Geofisica Pura e Appl., v. 46, p. 23-25, 1960.

A method for determining the size and shape of a disturbing body in gravity surveying is described. The problem is treated as a surface-reaching vertical cylinder (when the local Bouguer anomaly has radial symmetry) or as an infinite parallelepiped (when the local Bouguer anomaly has axial symmetry). An expression for χ_0 is given that serves to distinguish easily between deep-seated and shallow disturbances. — D. B. V.

- 187-296. Avdulov, M. V. Ob interpretatsii gravitatsionnykh i magnitnykh nablyudenyi metodom teoreticheskikh poley [On interpretation of gravity and magnetic observations by the method of theoretical fields]: Prikladnaya Geofizika, no. 30, p. 143-153, 1961.

The method of interpretation of gravity and magnetic observational data by comparing theoretical curves of anomalies due to bodies of a regular geometrical shape with the curves obtained by observation is discussed. Formulas for the transformation of gravity anomalies into anomalies of their vertical gradient, and for the second derivatives of these gradients are given for a vertical circular cylinder, a horizontal cylindrical segment, a vertical elliptical segment, a horizontal elliptical cylinder, an extended anticline limited by planes, and a body of vertical cross section in the form of a parallel-

ogram inclined at an angle α . Similar calculations for a spheroid of revolution, a parallelepiped, a hyperbolic cupola, and fault scarps are suggested. The preparation of bilogarithmic master charts is considered for a sphere, half-sphere, and a vertical material line. — A. J. S.

- 187-297. Tushkanov, L. Ya. Interpretatsiya gravitatsionnykh anomalii dlya tel peremennoy plotnosti [Interpretation of gravity anomalies for bodies of variable density]: Prikladnaya Geofizika, no. 30, p. 154-161, 1961.

The method of interpretation of gravity anomalies due to salt dome tectonics in the Emba region is discussed. Circular master charts have been designed for the peripheral slopes of the domes and for the zones between the domes. — A. J. S.

- 187-298. Shvank, O. A. Osobennosti razlichnykh proizvodnykh sily tyazhesti v svyazi s interpretatsiy gravimetricheskikh nablyudeniy [Features of various gravity derivatives with regard to interpretation of gravimetric observations]: Razvedochnaya i Promyslovaya Geofizika, no. 35, p. 55-61, 1960.

Tables are given of the first, second, and third derivatives of gravity anomalies over a sphere, horizontal cylinder, and horizontal half-plane expressed in 10^{-9} cgs units as the functions of the coordinate x . For a similar body with coordinate dimensions increased by a factor n , so that $x_n = nx$, $y_n = ny$, and $z_n = nz$, the tabular values of the first, second, and third derivatives can be obtained by multiplying x and the first derivative by n , the third derivative by $1/n$, and leaving the second derivative values unchanged. The first anomaly derivatives can be used in investigations of regional structures, and the second and especially the third anomaly derivatives can be found useful in investigations of local structures. — A. J. S.

- Halushko [Galushko], P. Ya. On the possibility of studying vertical movements of the earth's crust by means of gravity anomalies. See Geophys. Abs. 187-250.

- 187-299. LaCoste, L. J. B., and Harrison, J[ohn] C. Some theoretical considerations in the measurement of gravity at sea: Royal Astron. Soc. Geophys. Jour., v. 5, no. 2, p. 89-101, 1961.

The theory of operation of spring gravimeters on a stabilized platform in the presence of horizontal and vertical accelerations is considered in the first section of the paper. It is shown that leveling errors with the same period as the horizontal accelerations are very important; their amplitude should not exceed about 8 sec of arc when the amplitude of the horizontal accelerations is 50,000 mgal. A second effect, called the "cross-coupling" effect, is present even on a perfectly stabilized platform; it is produced by coupling between the vertical and horizontal accelerations and may cause an error of more than 100 mgal when horizontal and vertical accelerations both have amplitudes of 50,000 mgal. The second part of the paper discusses a gravimeter free to swing in gimbals. An expression for the second-order correction is derived, taking into account free and forced oscillations of the gimbal system. When the gravity sensing element is positioned at the correct distance below the gimbal axis, this expression takes the simple form $1/2 g \theta^2$ (θ = deflection of the gimbal system from true vertical). — D. B. V.

- 187-300. Paterson, Norman R. New methods of elevation control speed reconnaissance gravity surveys in northern areas: Canadian Inst. Mining and Metallurgy Trans., v. 63, p. 407-415, 1960.

Under certain conditions useful gravity information of a reconnaissance nature can be obtained without measuring elevations by spirit level surveys on the ground. The new procedures are most applicable to remote areas, areas where ground transportation is slow and difficult, and areas where station spacing is large in comparison with the distance of the average optimum level shot. Transportation by helicopter or light plane is usually necessary. The methods discussed are the photogrammetric-Airborne Profile Recorder (APR) spot determinations; barometric altimeter surveys; and the measurement of gravity gradients. Test surveys are described and their accuracy compared with that of level surveys. It is concluded that the three methods have particular application to exploration in northern Canada. The barometric altimeter is serving an increasingly useful role in gravity surveys for iron and for regional geological mapping; similar techniques can be valuable in petroleum exploration in the north. — V. S. N.

- 187-301. Steiner, Franz. Zur Frage der Dichtbestimmung an gravimetrisches Profilmessungen [On the problem of density determination in gravimetric profile measurements (with English abstract)]: Gerlands Beitr. Geophysik, v. 70, no. 1, p. 11-17, 1961.

A simpler but even more accurate transformation than Jung's (see Geophys. Abs. 181-253) transformation of a surface method of gravimetric determination of mean density for profile measurements is presented. — D. B. V.

- 187-302. Slepak, Z. M. Ob opredelenii plotnosti porod pri gravimetricheskoy razvedke [On determination of density of rocks in connection with gravity surveying]: Geologiya Nefti i Gaza, no. 8, p. 48-49, 1959.

A method is presented for gravity profiling that takes into account the density of the rocks of the intermediate layer. Measurements are made at 5-7 points on a profile 500-1,500 m in length. Gravity anomalies are calculated along this profile for various values of density of the rocks of the intermediate layer, and the values of these anomalies are plotted on a graph. The resulting curve that is closest to a straight line is the most reliable value of the density. — J. W. C.

- 187-303. Durbin, William P., Jr. Some correlations of gravity and geology (with discussion), in Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 130-137, 1961.

The demand for worldwide gravity coverage has led to the necessity for a quick method of determining an anomaly from physical evidence, as well as for a more accurate method of assigning substitute values to unsurveyed areas. The correlation of gravity with geologic structures and formations is being investigated in a new approach by attempting to establish procedures whereby the gravity anomaly for any area may be easily computed while maintaining a predictable accuracy. The procedure is discussed, and a gravity map of "geological anomalies" is given for the south central United States. These anomalies were computed wherever a predominant structure was in evidence. Accuracy was evaluated by means of profile and mean anomaly

comparisons. Mutual agreement between the free air, isostatic, and geologic anomaly profiles rarely exceeded 10 mgal, and the Bouguer anomaly profile showed very little, if any, agreement. A possible application of this procedure would be the determination of the degree of isostatic equilibrium for a given area. — D. B. V.

187-304. Guha, S. K. A review of gravity method: *Jour. Mines, Metals, and Fuels (India)*, v. 9, no. 7, p. 25-27, 1961.

The principles underlying the gravity method of exploration for oil and the methods of interpretation of results are reviewed. — V. S. N.

Innes, M. J. S. The use of gravity methods to study the underground structure and impact energy of meteorite craters. See *Geophys. Abs.* 187-74.

187-305. Thompson, Lloyd G. D., and Szabo, Bela. The role of the airborne gravity meter in determining the earth's gravity field, in *Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub.*, no. 15, p. 126-130, 1961.

Geodetic and space navigation requirements can be ideally satisfied by airborne gravity observations because: (1) the observations yield the average effect of anomalies over large areas, (2) properly chosen time (or distance) average readings will represent an average gravity value for a given area on the earth's surface, (3) the observations are made outside the earth's topography, (4) the required navigation accuracy can be achieved with existing equipment, (5) airborne observations are possible over otherwise inaccessible terrain, and (6) the reduction and computation procedures are easier to perform from airborne observations than from ground data.

By proper planning of airborne profiles, adequate coverage of $1^{\circ} \times 1^{\circ}$ average values can be obtained to derive the regional and general gravity fields for geodetic requirements; only detailed surveys for specific points should be done by conventional surveys. The $1^{\circ} \times 1^{\circ}$ coverage will also permit determination of the geoid with sufficient accuracy for reduction of extensive geodetic surveys such as Hiran from the geoid to the reference ellipsoid. After orbital coverage is complete, the gravity field of the earth can be computed in any form necessary for satellite orbital computations and space navigation.

So far, only the LaCoste-Romberg gravimeter has been extensively tested for airborne use; some changes and improvements should be made to adapt it to use in military aircraft. Airborne use of the Graf sea gravimeter is currently being investigated. — D. B. V.

187-306. Heifetz, M. E. A high precision pendulum apparatus: *Bull. Géod.*, no. 60, p. 177-182, 1961.

A new pendulum apparatus designed by the Central Research Institute of Geodesy, Aerial Photographic Survey, and Cartography in the U. S. S. R. for the determination of local gravity base stations is described, and the results of preliminary test measurements at four stations are reported. — D. B. V.

187-307. Wolf, H[elmut]. Möglichkeiten für genauere relative Schweremessungen durch Pendel in stationären Anlagen [Possibilities for more accurate relative gravity measurements by means of pendulums in fixed installations]: *Bull. Géod.*, no. 60, p. 183-188, 1961.

It is suggested that the accuracy of relative gravity measurements can be vastly improved by installing fixed pendulums at several points in a gravity

network; Hoffrogge in 1949 achieved an accuracy of 1×10^{-7} with such equipment. The principles and procedure of this type of measurement are outlined. It is shown how the true error and mean error depend on the duration of the observations. — D. B. V.

187-308. Uotila, Urho A. [K.]. Existing gravity material, in Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 91-97, 1961.

The Columbus group has collected gravity data from more than 50 countries and catalogued about 500 publications as sources. This material has been evaluated carefully and all observations have been related to the Potsdam system. Counting all $1^\circ \times 1^\circ$ squares where there is at least one observation, 30.5 percent of the earth is covered; of this, 72 percent is in the northern hemisphere and the distribution is relatively good. The Pacific Ocean is the largest unsurveyed area, with about 50 empty $10^\circ \times 10^\circ$ squares in one continuous block.

Elimination of the largest gaps with a few profiles would considerably improve the accuracy of the orientations of the reference surfaces. Even though this might not reduce the inaccuracies to one half, it may solve other problems of physical geodesy, including the pear-shaped earth and flattening of the equator. — D. B. V.

187-309. Woollard, George P[ryor]. The status of gravimetric control for global geodetic studies, in Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 97-115, 1961.

As the success of position-fixing schemes such as Loran and Sofar depends entirely on the accurate location of shore control and monitoring stations relative to each other, geodesy, and with it gravimetry, suddenly became important in World War II. The reliability of national gravity base values in use was subjected to critical scrutiny, and in 1948 a program of international gravity control measurements was initiated. The method of evaluating the world gravity base network, the problem of calibration of gravimeters, and the world network of secondary airport bases and its reliability are discussed.

Comparison of results obtained in different parts of the world by different observers shows that the use of an international gravity standard for gravimeter calibration would result in a more unified body of data than is now available. Results consistent to ± 0.3 mgal can now be obtained with gravimeters on a global basis; as this equals the reliability of the best pendulums, there seems to be little reason for a new pendulum network except for extending the range of existing standardization measurements and strengthening the standardization base values already established. By making multiple intercontinental ties involving small changes in gravity with exploration type gravimeters reliable to 0.01 mgal or better, the present global reliability could be improved considerably. Extension of present international cooperation could provide, in the next decade, highly reliable gravity data for all of the earth. — D. B. V.

187-310. Kneissl, M[ax]. Das europäische Gravimetereichsystem [The European gravimeter calibration system]: Bull. Géod., no. 60, p. 111-123, 1961.

This is a report on the progress of the European gravimeter calibration network, given before the International Association of Geodesy at Helsinki in 1960. — D. B. V.

- 187-311. Marzahn, K[jurt]. Vorbereitung der gemeinsam Ausgleichung der Pendel-und Gravimetermessungen des europäischen Gravimeter-Eichsystems [Preparation of the common adjustment of the pendulum and gravimeter measurements of the European gravimeter calibration system]: Bull. Géod., no. 60, p. 125-130, 1961.

This report discusses the calculation procedures, the choice of the pendulum and gravimeter measurements, and the fundamentals of adjustment used in connection with the European gravimeter calibration network. — D. B. V.

- 187-312. Cook, A[lan] H[ugh]. Report on absolute measurements of gravity: Bull. Géod., no. 60, p. 131-139, 1961.

Some 12 new absolute determinations of gravity had been made since 1946 or were underway at the time of this report, made to the International Association of Geodesy at Helsinki in 1960. Measurements in progress were using either pendulums or the free fall method. Results to date are tabulated. — D. B. V.

- 187-313. Winter, P. J., Valliant, H. D., and Hamilton, A. C. Pendulum observations at Ottawa, Gander, Teddington, Paris, Rome, and Bad Harzburg: Bull. Géod., no. 60, p. 142-166, 1961.

Observed periods, gravity differences, and standard deviations determined by means of pendulum measurements made during the summer of 1959, using the bronze bipendulum apparatus of the Dominion Observatory of Canada, are listed. Stations were occupied sequentially as follows: Ottawa, Gander, Ottawa, Teddington, Bad Harzburg, Rome, Paris, Teddington, and Ottawa.

The following provisional values of absolute gravity relative to the Potsdam system have been computed: Teddington 981.19638, Ottawa 980.62062, Washington 980.09991, Paris 980.93995, and Rome 980.36267 gal. Error does not exceed 0.5 mgal. The apparatus, procedure, sites, computations, consistency of the observations, and network adjustment are described. — D. B. V.

- 187-314. Mazzon, C[ozzato]. Mesures pendulaires exécutées sur la L. T. E. de Hammerfest à Catane [Pendulum measurements made on the European triangulation network (L. T. E.) from Hammerfest to Catania]: Bull. Géod., no. 60, p. 167-176, 1961.

The results of pendulum measurements made by the Instituto di Geodesia, Topografia e Fotogrammetria of the Milan Polytechnicum from Hammerfest, Norway, to Catania, Sicily, are reported. Gravity values and differences from Potsdam are tabulated for Hammerfest, Bodö, Oslo, Copenhagen, Bad Harzburg, Monaco, Milan, Bologna, Rome, and Catania. Several general conclusions are drawn concerning the execution of modern pendulum measurements. — D. B. V.

- 187-315. Lozano Calvo, Luis. Informe sobre los trabajos de nivelaciones de alta precisión ejecutados por el Instituto Geográfico y Catastral de España en el trienio de 1957-60 [Report on high precision leveling work done by the Instituto Geográfico y Catastral of Spain during the triennium 1957-60]: Madrid, Inst. Geográfico y Catastral, 8 p., 1960.

During the period 1957-60, El Jefe del Servicio de Gravimetria of Spain has accomplished three major works: completion of a fundamental gravity

map for Spain, observation and calculation of a detailed gravity net for the province of Toledo, and collaboration on international projects. The fundamental gravity net for Spain is described, and absolute gravity values for 144 stations are listed in a table. — J. W. C.

187-316. Helbig, K[laus], and Thirlaway, H. I. S. New gravity measurements in West Pakistan: Royal Astron. Soc. Geophys. Jour., v. 5, no. 2, p. 171-178, 1961.

A gravity base network of eight air links connected to Woollard's Karachi airport station (adopted value, $g=978,963.0 \text{ cm/s}^2$) has been established in West Pakistan, using a Worden "Master" gravimeter No. 551. A selection of 21 new values based on these air links is reported and the stations are described. The gravity air links relative to the Karachi value are estimated to have a standard deviation of 0.2 mgal or better. Standard deviations based on repeat observations by road and rail transport reach a maximum of 0.3 mgal.

Comparisons between the 12 Survey of India pendulum stations and gravimeter values are graphed. The pendulum observations lie within ± 2 mgal of the new results over a range of 700 mgal. It may be possible to derive a sway correction for the pre-Cambridge pendulum values from the results. — D. B. V.

187-317. Dooley, J. C., McCarthy, E., Keating, W. D., Maddern, C. A., and Williams, L. W. Pendulum measurements of gravity in Australia 1950-51: Australia Mineral Resources, Geology and Geophysics Bull., no. 46, 76 p., 1961.

Pendulum gravity observations were made at 59 stations throughout Australia during 1950-51 using invar pendulums. A national gravity base station was established at Melbourne. Subsequent comparisons with gravimeter ties suggest that the pendulum value is about 2 mgal low. The mean standard error of gravity differences from Melbourne to the other stations is about 0.6 mgal. Free air, Bouguer, and isostatic anomalies have been calculated for all stations; the latter two are predominantly negative. The isostatic anomalies are for both Airy-Heiskanen and Pratt-Hayford hypotheses, and for four different assumed crustal thicknesses in each case. A degree of isostatic compensation is present, but some large anomalous areas are uncompensated. — V. S. N.

187-318. Mann, Virgil I., and Zablocki, Frank S. Gravity features of the Deep River-Wadesboro Triassic basin of North Carolina: Southeastern Geology, v. 2, no. 4, p. 191-215, 1961.

Gravity studies made over the Deep River-Wadesboro Triassic basin, North Carolina, suggest that this basin is not a significant gravitational feature. The basin is best outlined by gravity profile maps aligned normal to the axis of structure. A study of the profiles suggests that the basin locally reaches a depth of at least 8,000 feet and in places has graben-like features. It may be traced under the Atlantic Coastal Plain overlap by locating the easily recognized discontinuity in the profile that represents the Jonesboro fault. It is hoped that in the future specific rock types in the Piedmont may be outlined by this gravity profile technique. — V. S. N.

187-319. Lum, Daniel. Gravity measurements east of the Black Hills and along a line from Rapid City to Sioux Falls, South Dakota: South Dakota State Geol. Survey Rept. Inv., no. 88, 26 p., 1961.

A simple Bouguer gravity anomaly map compiled from data of more than 500 stations in an area of 2,500 sq mi east of Rapid City, S. Dak., is presented. Results of a gravity traverse from the Black Hills eastward onto the Sioux uplift are shown in profiles that give the regional and residual Bouguer anomalies and outline the relief of the Precambrian basement. The principal facts for each gravity station are tabulated in the appendix. — V. S. N.

- 187-320. Cook, Kenneth L., and Berg, Joseph W., Jr. Regional gravity survey along the central and southern Wasatch Front, Utah: U. S. Geol. Survey Prof. Paper 316-E, p. 75-89, 1961.

The results of a regional gravity survey, made in 1954 in Salt Lake and Utah Counties, Utah, are reported. Gravity measurements were made at 1,100 stations in an area of about 5,000 sq mi, and results are compiled as a Bouguer gravity anomaly map on a regional geologic map. The regional gravity patterns reflect the present contrasts in the crust that are the product of several orogenies. Interpretations of the gravity data characterizing the Laramide and older structures (northern Utah highlands and the Uinta arch) and the Basin and Range structures are discussed. Gravity data indicate that in the valley areas lying between the great fault block comprising the Oquirrh Mountains, Boulter Ridge, and the northern East Tintic Mountains on the one side and the Wasatch fault block on the other, there is an intermontane trough more than 100 miles in length. It consists of a great belt of grabens and smaller fault blocks whose dislocations are varied and more complex than previously realized. From north to south the major grabens are the Farmington, Jordan Valley, Utah Valley, and Juab Valley; the major fault-block spurs are the eastern part of the Traverse Mountains and the spur in the Santaquin area. — V. S. N.

- 187-321. Worzel, J. Lamar, and Talwani, Manik. Latest results of gravity observations at sea from surface ships, *in* Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 116-126, 1961.

The development of the Graf and LaCoste-Romberg sea gravimeters is reviewed. Measurements over some interesting bottom features made with the Graf instrument from the U.S.S. Compass Island in the Atlantic and Mediterranean (see Geophys. Abs. 178-227) are discussed briefly. The results of about 5,000 miles of continuous observations in the Gulf of California with the LaCoste-Romberg instrument are reported. — D. B. V.

- 187-322. Ingall, L. N., and Copeland, R. J. Operational report on a gravity meter survey conducted on the Arctic Coastal Plain, *in* Geology of the Arctic, v. 2: Internat. Symposium on Arctic geology, 1st, Calgary, Alberta, 1960, Proc., p. 1149-1152, 1961.

The personnel, logistics, equipment, mode of operation, and operational statistics are described for a gravimeter survey conducted in 1959 on the Arctic Coastal Plain. For mobility and speed of operation a helicopter and a Beaver aircraft were used. — V. S. N.

- 187-323. Weber, J. R. Comparison of gravitational and seismic depth determinations on the Gilman Glacier and adjoining ice-cap in northern Ellesmere Island, *in* Geology of the Arctic, v. 2: Internat. Symposium on Arctic Geology, 1st, Calgary, Alberta, 1960, Proc., p. 781-790, 1961.

During 1957 and 1958, 12 bedrock profiles were constructed from results of seismic reflection surveys on the Gilman Glacier and on the icecap between the glacier and Mount Oxford; 200 gravity stations were established over the same area. The regional Bouguer anomaly calculated from ice thicknesses at selected stations along the seismic profile was extrapolated for the whole area, and with assumed specific gravities of ice and bedrock the ice thickness was calculated from the gravity measurements. Agreement between bedrock profiles as determined by the two methods was very close. It is concluded that a gravity survey, when supplemented by a few seismic soundings, can give a good indication of the shape of the bedrock and the ice thickness. — V. S. N.

- 187-324. Becker, Alex. Gravity measurements, in Jacobsen-McGill Arctic research expedition to Axel Heiberg Island, Preliminary Report 1959-1960: Montreal, McGill Univ., p. 109-114, 1961.

Measurements of the variation in the vertical component of gravity were made in the glacierized and coastal regions of Axel Heiberg Island, Canada, to investigate the thickness of ice in the White and Thompson Glaciers and in the McGill Icecap. Coastal measurements were taken to detect any spurious gravity gradients which would influence interpretation of measurements on the ice, as well as to check the isostatic equilibrium of the island. Results will be correlated with the seismic reflection observations (see Geophys. Abs. 187-580). Regional coastal gravity values are given in a table. — V. S. N.

- 187-325. Bullerwell, W. Geophysical investigations, in Geology of the country around Dungannon: Northern Ireland Geol. Survey Mem., no. 35, app. 7, p. 237-245, 1961.

The results are reported of gravity and magnetic surveys aimed at investigating broad rather than precise local geological structures in the area of the Dungannon (35) sheet. A Bouguer anomaly map and a vertical force magnetic anomaly map are included. Interpretation of results is handicapped by lack of continuity in the geophysical data across the area of the Lough Neagh and by the absence of reasonably precise knowledge about variation in thickness of the Antrim basalts. Additional geophysical work or drilling is needed. — V. S. N.

- 187-326. Poldini, E., and Inagaki, Morido. Les anomalies gravifiques de Genève et de ses environs [The gravity anomalies of Geneva and its environs]: Archives Sci. (Genève), v. 13, no. 3, p. 311-325, 1960.

The results of a gravity survey in the vicinity of Geneva, Switzerland, are presented in the form of six maps showing Bouguer anomalies, regional gradient, and residual anomalies, calculated on the basis of two different density values (2.4 and 2.6). Buried valleys in the Molasse bedrock can be traced and some idea of the thickness of their Quaternary fill can be deduced from the gravity data. — D. B. V.

- 187-327. Zaccara, Gaetano. Carta gravimetrica-rilievo della Calabria [Gravity-relief map of Calabria (with English abstract)]: [Italy] Servizio Geol. Boll., v. 80, no. 2-3, p. 209-213, 1959.

The first broad gravity survey of Calabria has revealed several significant structural features, some of which are similar to those of adjacent regions.

The area as a whole is characterized by a rise of the deep substratum corresponding to a general rise of the continental shelf; the north end of the Sicilian trough is represented by the south slope of the Aspromonte Range; and the most marked fractures have a northwest trend. — J. W. C.

- 187-328. Kántás, Karl. Geophysikalische Interpretationsfragen im Wiener Becken [Geophysical interpretation problems in the Vienna basin]: *Erdöl u. Kohle*, v. 14, no. 8, p. 600-606, 1961.

After an outline of the geology of the Vienna basin, the geophysical results obtained by telluric measurements and gravity surveys (vertical gradient) in the area, particularly with respect to the relief of the Flysch, the limestone, and the fault zone, are discussed. Where other methods fail to yield positive results or do so only indirectly, the telluric and vertical gradient methods can be used satisfactorily in this area. The Δg anomalies appear to characterize the structure as a whole, whereas the vertical gradient anomalies and the telluric anomalies reflect changes that occurred during or after sedimentation.

Two appendices are given. The first reviews torsion balance measurements made by Eötvös in 1915-16 in the Slovakian extension of the Vienna basin and measurements made by Schumann in Oberlaa, near Vienna, in 1919-21. The second suggests the possibility of direct measurement of gravity derivatives. — D. B. V.

- 187-329. Stoenescu, Scarlat. Asupra semnificației unor raporturi gravimetrice majore în sudul bazinului Transilvaniei [On the significance of some relationships of gravity maximums in the south of the Transylvanian basin (with Russian and French summaries)]: *Acad. Române Studii și Cercetări de Geologie-Geografie*, v. 5, no. 3, p. 539-546, 1960.

A gravity maximum occurs in the south of the Transylvanian basin between the Târnava-Mare and Olt Rivers. This feature appears on the Bouguer map as a 15 mgal high with a gradient of 1.5 mgal per km. The anomaly is due to the juxtaposition of a block of high density on the south and a block of low density on the north. Deep drilling confirms the gravity interpretation. — J. W. C.

- 187-330. Airinei, Ștefan. Studii asupra efectului gravimetric de la limita externă a flișului cretacic din Muntenia orientală (dintre văile Prahova și Teleajen-Drajna [Study of the gravity effect of the outer limit of the Cretaceous flysch of eastern Muntenia (between the valleys of the Prahova and Teleajen-Drajna)(with Russian and French summaries)]: *Acad. Române Studii și Cercetări de Geologie-Geografie*, v. 5, no. 3, p. 547-571, 1960.

A general description is given of the gravity effects in the zone of the outer margin of the Cretaceous flysch of eastern Muntenia as determined from oil exploration in 1953-56. A gravity minimum occurs along this margin, and it in turn is marked by several negative peaks. The minimum value of gravity in some areas is due apparently to the cumulative effect of flexures in the Cretaceous rocks, which are more dense than the overlying Cenozoic deposits. The local minimum gravity anomalies are probably caused by salt masses and oil-gas deposits. — J. W. C.

Ștefănescu, Sabba [S.]; Stoenescu, Scarlat; Airinei, Ștefan; Botezatu, Radu; Popovici, Dorin; and Ionescu, Florian. Geophysical surveying for iron near Constanța (Rumanian People's Republic). See *Geophys. Abs.* 187-521.

- 187-331. Shengelaya, G. Sh. K voprosu kolichestvennoy interpretatsii tbilisskoy gravitatsionnoy anomalii [On the problem of quantitative interpretation of the Tbilisi gravity anomaly]: Akad. Nauk Gruzin. SSR Soobshch., v. 19, no. 6, p. 668-776, 1957.

Gravity measurements were made along two profiles of the Tbilisi gravity anomaly in the Georgian S.S.R. for determination of the depth to basement. In the Dzhavakhet zone of the Artvini-Somkhit block this depth is 8 km, and it varies from 2 to 0 km in the Bolnisi, Borchali, and Asureti zones.—A. J. S.

- Balavadze, B. K., and Shengelaya, G. Sh. Main features of the crustal structure of the Greater Caucasus according to gravimetric data. See Geophys. Abs. 187-361.

- 187-332. Mufti, Irshad. A gravity survey of Quetta and Mastung valleys: Pakistan Jour. Sci. and Indus. Research, v. 4, no. 1, p. 15-20, 1961.

Data from a gravity survey of the Quetta and Mastung valleys support geological evidence that large scale faulting was a primary factor in the origin of the valleys. Of particular interest are cross faults which must have modified the early drainage and have been a major factor in controlling groundwater aquifers.—V. S. N.

- 187-333. Yokoyama, Izumi. Gravity survey on the Aira caldera, Kyushu, Japan: Nature, v. 191, no. 4792, p. 966-967, 1961.

A gravity survey was made in 1960 of the Aira caldera in Kyushu, Japan, using a North American gravimeter. This caldera is one of the largest in the world; the diameter is about 20 km. It occupies the innermost part of Kagoshima Bay and is bounded on the south by the peninsula of Sakurajima, an active volcano. A relatively low Bouguer anomaly coincides with the caldera depression. The active volcano has hardly any effect on the shape of the anomaly.

The anomaly is of the same type and magnitude as that at Kuttyaro caldera (see Geophys. Abs. 179-232). It is concluded that coarse material with a density 0.3-0.5 g per cm^3 less than that of the surrounding rock underlies the caldera to a depth of 3-4 km. The total mass deficit responsible for the anomaly is calculated as 1.6×10^{11} metric tons; the amount of material ejected during formation of the caldera was estimated by Koto (1916) as $1.6 \times 10^{11} \text{ m}^3$.—D. B. V.

- 187-334. McMutrie, I. H. Supplementary gravity traverses over Bungalow aeromagnetic anomaly near Cowell: South Australia Dept. Mines Mining Rev., no. 111, p. 89-93, 1961.

Supplementary gravimeter traverses were run over the Bungalow aeromagnetic anomaly near Cowell, South Australia, to delineate further the anomaly for a planned drilling program. The drilling results suggest that the magnetic anomaly is caused by magnetite and the gravity anomaly by the occurrence of bands of more dense rock (with which the magnetite is associated) within the country-rock. Profiles of gravity values are given, but no further work is recommended.—V. S. N.

- 187-335. Moorcroft, E., and Dowling, D. R. Gravity and magnetic surveys over aeromagnetic anomaly—Hundred of Chandada: South Australia Dept. Mines Mining Rev., no. 111, p. 94-100, 1961.

Vertical magnetometer and gravimeter traverses have been carried out over an anomaly disclosed by aeromagnetic survey near Cungena, Eyre Peninsula. From a study of the results the presence of a large body of rock slightly denser and more magnetic than the surrounding rock has been inferred. The depth below surface is uncertain and a drilling program to test the depth of the cover is recommended. — Authors' abstract

- 187-336. Bilotserkovets', Yu. I. Pro shchil'nost' v ugillya i vmishchaynichkh porid Donbasu [On the density of the coal and country rock of the Donets Basin]: Akad. Nauk Ukrayin. RSR Dopovīdi, no. 7, p. 900-903, 1961.

Throughout the Donets Basin, the density of the coal differs from that of the enclosing rock by 0.5-1.7 g per cm³. Changes in the density of the coal itself are confined to the range of 0.0-0.7 g per cm³ and are due chiefly to difference in ash content and porosity. — A. J. S.

- 187-337. Prozorovich, E. A. K voprosu o faktorakh uplotneniya osadochnykh gornykh porod [On the problem of factors of consolidation of sedimentary rocks]: Azerbaydzhan. Nauchno-Issled. Inst. po Dobyche Nefti Trudy, v. 4, p. 244-270, 1956.

One of the essential factors that determine the validity of interpretation of gravity anomalies is the reliability of data on the density of the rocks in the area investigated. Specific gravity and total porosity of sedimentary rocks in general and of the Tertiary sedimentary rocks of Azerbaijan in particular are discussed. — A. J. S.

HEAT AND HEAT FLOW

- 187-338. Lubimova, H. A. [Lyubimova, Ye. A.]. On processes of heat transfer in the earth's mantle: Jour. Physics of Earth [Tokyo], v. 8, no. 2, p. 11-16, 1960.

Three components of thermal conductivity—radiative, lattice, and exciton—that lead to heat transfer in the earth are analyzed. The patterns of radiative and lattice thermal conductivity that have been discussed previously by Lyubimova and others (see Geophys. Abs. 174-214, 178-249, 181-318) are reviewed, and the process of energy transfer by the excited states of atoms or excitons is discussed. The comparative distribution of the three components in the earth's mantle is given in a graph, and it is shown that at high temperatures exciton thermal conductivity increases, whereas radiative thermal conductivity dies away. When allowance is made for the exciton component, it is seen that the minimum of thermal conductivity in the upper layers of the mantle becomes sharper than previously supposed; thermal conductivity at the base of the mantle exceeds its value at the surface by almost two orders of magnitude. The exciton component, however, does not change the process of thermal history outlined earlier (see Geophys. Abs. 174-214). Calculations of heat flow and temperature distribution for different moments of time are given for the case of infinitely great thermal conductivity in the layer of the mantle lying below the level of the minimum thermal conductivity. The earth began to cool 1.5×10^9 yr ago with a heat flow exceeding by 5 to 8 times that currently observed. This indicates that heat convection on a global scale has stopped and that the earth's interior is heating anew. Convective transfer of heat in the earth's mantle is not denied but is believed to have been local in

character in the form of convection of heat when sialic material was transferred from mantle to surface in the process of crust formation.—V. S. N.

- 187-339. Lubimova, H. A. [Lyubimova, Ye. A.]. On conditions of magmatism origin and role of volcanic activity in the thermal regime of earth's crust: *Jour. Physics of Earth [Tokyo]*, v. 8, no. 2, p. 17-21, 1960.

It has been established that thermal conductivity in the upper mantle decreases to a minimum at about 50-100 km and that this minimum hinders the intensive loss of heat through the surface and leads to a rapid increase of temperature at great depths; conditions for cooling and contraction of the earth as a whole never existed. The temperature at depths from 50-200 to 500-700 km reached the melting point at 2 to 3 billion years after the formation of the earth. A belt was thus formed in the upper mantle in which conditions were favorable for the origin of magma and the differentiation of matter; magmatism did not exist before 3×10^9 yr ago. The melting belt was not continuous but consisted of local melting pockets at points of weakened pressure. The lower boundary of the "differentiation belt" is just at the depth of deep earthquakes—600 to 700 km. The C-layer at 600 to 900 km and the low velocity layer at 150 km may be traces of former molten layers that underwent differentiation resulting in rise of silicic phases and sinking of those richer in iron. Volcanic and intrusive activity were the main processes by which easily fused and volatile fractions were brought to the earth's surface. The geological periods associated with rise of material from the mantle alternate with periods of relative rest.—V. S. N.

- 187-340. Levin, B. J. [B. Yu.], and Majeva [Mayeva], S. V. On the thermal history of the earth: *Annali Geofisica*, v. 14, no. 2, p. 145-155, 1961.

The thermal history of an initially cold earth is calculated for several models. The formation of the crust is considered to be a continuous process that started 3×10^9 yr ago. If radiative conductivity is high, the radioactive element content of the earth need not be as large as formerly believed in order to account for observed heat flow. The calculated difference between heat flow for oceanic and continental regions is only 30-40 percent; this can explain why systematic differences between continental and oceanic heat flow are not observed.—D. B. V.

- 187-341. Sherratt, A. F. C., and Hinsley, F. B. A heating experiment to determine the thermal constants of rocks in situ [with discussion]: *Mining Engineer*, no. 9, p. 700-711, 1961.

An experiment is described in which a length of roadway within a mine was heated by electric tubular heaters with the object of producing data from which the thermal constants of the rocks surrounding the roadway could be determined. The effect of the heating on the temperature of the strata was measured by thermocouples in boreholes, and the thermal constants of the strata in their natural state were determined by comparing the experimental temperatures with theoretical relationships. The results show surprising variations for different directions with respect to the bedding planes and are low in comparison with previously published values; they are illustrated both graphically and in tables.—V. S. N.

- 187-342. Horai, Ki-iti, and Uyeda, Seiya. Studies of the thermal state of the earth. The fifth paper: Relation between thermal conductivity

of sedimentary rocks and water content: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 2, p. 199-206, 1960.

The relation between thermal conductivity of a soft porous shale and water content was studied experimentally. It was found that thermal conductivity increases as water content increases from zero to about 14-16 percent by weight (saturation of pores), then decreases. This is interpreted as follows: Until the pores are saturated the water replaces air, a poor heat conductor; but as the rock becomes oversaturated the percentage of water increases at the expense of solid particles, which have greater thermal conductivity. The variation of thermal conductivity in the oversaturated region agrees with Bullard's model (see Geophys. Abs. 176-207). That model is extended here to account for the features in the undersaturated region as well. (See also Geophys. Abs. 176-210, 179-239, 186-415, -427, -428.)—D. B. V.

- 187-343. Lubimova, H. A. [Lyubimova, Ye. A.], Lusova, L. M., Firsov, F. V., Starikova, G. N., and Shushpanov, A. P. Determination of surface heat flow in Mazesta (USSR): *Annali Geofisica*, v. 14, no. 2, p. 157-167, 1961.

Results of temperature and thermal conductivity measurements made in three boreholes in the Matsesta region of the U. S. S. R. are presented. Heat flow calculated from these measurements is 0.88×10^{-6} cal per cm^2 per sec. (See also Geophys. Abs. 186-423.)—D. B. V.

- 187-344. Khrebtov, A. I. Vnutrenneye teplo neftegazonosnykh ploshchadey [Internal heat of oil and gas areas]: *Akad. Nauk SSSR Doklady*, v. 136, no. 5, p. 1069-1072, 1961.

The results of temperature logging in the lower 200-300 m of the Maykop shales in various oilfields of the Central Ciscaucasus since 1948 show positive anomalies ranging from 1.9°C in the Ipatov research borehole to 4.5°C in the Aleksandrov oilfield, with an average of 3.1°C. These anomalies are due to the generation of gas-forming hydrocarbons in the shales (which contain about 1 percent bitumens). There is no evidence that the anomalies are related to the radioactivity of the Maykop rocks. — D. B. V.

- 187-345. Dzhibuti, S. S. Geotermicheskiye usloviya Zapadno-Turkmenskogo artesianskogo basseyna (primenitel'no k resheniyunekotorykh voprosov gidrogeologii i neftegazonosnosti [Geothermal conditions of the west Turkmen artesian basin (applicable to the solution of some problems of hydrogeology and oil and gas possibilities)]: *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 5, p. 95-100, 1961.

Temperature data measured in springs and boreholes in different oil- and gas-bearing structures in the west Turkmen basin are summarized in a map of geoisotherms at 2,000 m below sea level. This map reflects the geologic structure. The results suggest that the geothermal method can serve as one of the criteria in the prospecting of oil and gas deposits. (See also Geophys. Abs. 186-424.)—D. B. V.

- 187-346. Elizondo, Jesús Ruiz. Prospection of geothermal fields and investigations necessary to evaluate their capacity: United Nations Conf. on new sources of energy, Rome, Italy, 1961, Gen. Rept., 79 p., 1961.

Following an introductory statement on geothermal energy, a generalized description and tabulation of known geothermal fields in Italy, New Zealand, Iceland, United States, Mexico, Japan, U. S. S. R., and El Salvador are given. Methods and techniques used in geothermal prospecting, some views on the origin of the heat and steam in geothermal zones, elements in evaluation of the capacity of geothermal zones, the problem of silica and calcite deposition, and costs and other economic aspects are discussed also. A list of topics proposed for discussion and a list of papers by title and author presented at the conference are included. — V. S. N.

187-347. Ovchinnikov, A. M. Termy Bolgarii [The hot springs of Bulgaria]: Akad. Nauk SSSR Lab. Vulkanologii Trudy, no. 18, p. 133-138, 1960.

There are several hundred hot springs in Bulgaria. The three main types—nitrogenous, carbonic, and methane-bearing—are discussed briefly. Areas worth investigating for possible geothermal energy sources are mentioned. — D. B. V.

187-348. Hu, Ch'ang-lin. Mineral water of the upper reaches of the Sha River in Lu-Shan Hsien, Honan Province [translation from Chinese]: Shui-wen Ti-chih Kung-ch'eng Ti-chih [Hydrogeology and Engineering Geology], no. 12, p. 16-18, 1959; translated by U. S. Joint Publications Research Service, JPRS no. 7853, p. 32-46. 1961.

Hot mineral springs are found in four areas—Han-ch'ang, Hsia-t'ang, Chung-t'ang, and Shang-t'ang—along the upper reaches of the Sha River, Honan Province, China. The area is characterized by pre-Sinian metamorphic and Sinian igneous rocks cut by a major east-west fault zone that is paralleled by the river. The temperature range is from 43°C to 60°C. It is concluded that these thermal waters rise along the fault plane from a depth calculated to be at least 1,500 m on the assumption that the geothermal gradient is 1° per 33 m. Variation in temperatures of individual springs is a result of the admixture with cold surface ground water. — V. S. N.

187-349. Mou, Hung-wei. Hot springs of the fold area of southeast Szechuan Province [translation from Chinese]: Shui-wen Ti-chih Kung-ch'eng Ti-chih [Hydrogeology and Engineering Geology], no. 12, p. 19-21, 1959; translated by U. S. Joint Publications Research Service, JPRS no. 7853, p. 47-64, 1961.

Numerous warm springs flow from the karst area of the Chia-ling-chiang limestone in the anticlines of southeastern Szechuan Province, China. The water is stored in both solution channels and tectonic fractures in the limestone and is held by impervious layers both above and below the formation. The springs appear where the folds have been cut transversely by rivers. The waters are heated as a result of the depth from which they come and not by association with volcanic activity. The geothermal gradient in the Szechuan area is about 1°C per 41.5 m; thus, the water must come from a depth greater than 1,500 m. — V. S. N.

187-350. Hughes, T. D. Thermal Springs, Hastings: Tasmania Dept. Mines Tech. Repts., no. 5 for 1960, p. 44-46, 1961.

The thermal springs at Hastings in southern Tasmania are believed to be due to the effect of temperature gradient on water coming from a great depth;

in this area it is estimated that the temperature rises 1°F for each 66 feet of depth. The waters, originally surface waters descending along synclinal dolomite beds, rise under hydrostatic pressure from a depth of 2,000 feet along a major fault plane to reach the surface. — V. S. N.

- 187-351. Swartz, J[oe]l H., and Raspet, R[udolph]. Thermal shock and its effect on thermistor drift: *Nature*, v. 190, no. 4779, p. 875-878, 1961.

It was found in studies of permafrost problems in Alaska that thermistor calibrations were disturbed by the vulcanization process used to seal the cable slits made for insertion of the thermistors. In order to test the hypothesis that the effect was due to thermal shock rather than to chemical effects, 12 thermistors were placed in a clear mold and raised to vulcanizing temperatures for one hour. All showed the same disturbance as those vulcanized in a cable. Subsequently some 80 thermistors were investigated for the effects of thermal shock, and their subsequent calibration was studied by recalibrations at approximately regular intervals. Results are presented here.

It is concluded that thermistors that have been subjected to thermal shock should be allowed a sufficient rest period to return to a normal drift rate. They should be recalibrated just prior to or just after subsequent measurements, or both if highest accuracy is necessary; if possible they should be kept continuously at the temperature being measured for the entire measurement period. With these precautions drift can be reduced to very small values, which may often be further reduced by properly applied corrections. — D. B. V.

- 187-352. Uyeda, Seiya; Tomoda, Yoshibumi; Horai, Ki-iti; Kanamori, Hiroo; and Futi, Hidetaka. Studies of the thermal state of the earth. The seventh paper: A sea bottom thermogradimeter: *Tokyo Univ. Earthquake Research Inst. Bull.*, v. 39, pt. 2, p. 115-131, 1961.

An apparatus for measuring the geothermal gradient in the sea bottom is described, with photographs and schematic diagrams. It consists of a probe containing two pairs of thermistors and a recorder housed in a pressure-resistant waterproof steel container. It can be attached to a core sampler. The two pairs of thermistors give the temperature differences between the bottom and the top and between the bottom and the middle point of the probe. Probes of different lengths are used for different conditions of sea bottom, the longest being 4.5 m. Temperature differences in the interval 0°C-2°C can be recorded with an accuracy of 0,001°C in about 2.5 hours. Preliminary tests indicate that the apparatus will serve to determine terrestrial heat flow through the ocean bottom. — D. B. V.

- 187-353. Holz, Hans-Werner. Aragonit-Sinter als geologisches Thermometer [Aragonite sinter as a geologic thermometer]: *Deutsch. Geol. Gesell. Zeitschr.*, v. 112, pt. 3, p. 513-514, 1960 (1961).

Different sinters have been deposited in two caves 9 km apart in Middle Devonian coral limestones in the Rhenish Schiefergebirge about 50 km east of Cologne, Germany; in the Wiehl cave the sinter consists only of calcite, whereas in the Runderoth cave it consists only of aragonite. Moore (1956) suggested that aragonite sinter is a paleotemperature indicator, developing instead of calcite when mean annual temperature exceeds 60°F (15.6°C). Such temperatures are unknown in central Europe in postglacial time, and it cannot be determined whether the sinter was deposited during or before the Pleis-

tocene. It is suggested that the deposition of aragonite instead of calcite was governed by the presence of magnesium ions—there are patches of dolomitic limestone at the Ränderoth cave—rather than by temperature control.—D. B. V.

- 187-354. Legget, R. F., Dickens, H. B., and Brown, R. J. E. Permafrost investigations in Canada, in *Geology of the Arctic*, v. 2: Internat. Symposium on Arctic Geology, 1st, Calgary, Alberta, 1960, Proc., p. 956-969, 1961.

A review is given of a program initiated in Canada to study climatic and terrain factors affecting the existence of permafrost at specific locations as a means of improving prediction of permafrost conditions for engineering and geologic purposes. The object is to investigate the thermal characteristics of the terrain components and to seek correlations between these, the climatic factors, and the distribution of perennially frozen ground.—V. S. N.

- 187-355. Scott, Ronald F. Heat transfer in soil involving change of state: *Géotechnique*, v. 11, no. 2, p. 144-153, 1961.

Heat-flow processes in the ground which involve soil-moisture freezing and thawing are discussed with emphasis on methods for estimating or predicting the depths of freeze or thaw in moist soil; data from Alaska and Greenland are used. Previous work on evaluation of soil thermal properties and measurement techniques is reviewed; the effect of soil heat property variation, current methods of computing the depth of thaw in permafrost using air temperature and correction coefficients, and a new method based on heat flow into the ground are considered; and, finally, methods of measurement of heat flow into the soil are discussed.—V. S. N.

INTERNAL CONSTITUTION OF THE EARTH

- 187-356. Bott, M[artin H[arold] P[hillips]. The granitic layer: *Royal Astron. Soc. Geophys. Jour.*, v. 5, no. 3, p. 207-216, 1961.

The negative gravity anomalies observed over granite masses show that the upper part of the "granitic layer" is denser than granite. It is suggested that the denser and more mafic (metasedimentary or dioritic) upper layer is underlain by a truly granitic zone. This hypothesis can be tested seismologically. As it implies that the low-velocity channel is directly connected to the surface by batholiths, a study of the amplitude variation of Lg (particularly Lg₂) on and around a large batholith should be of considerable interest. A seismic refraction study of a large granite mass should determine the depth of the underlying high-velocity rocks. The proposed model of the continental crust is stated in tabular form and illustrated diagrammatically.—D. B. V.

- 187-357. Lyustikh, Ye. N., and Saltykovskiy, A. Ya. O nekotorykh gipotezakh proiskhozhdeniya granitnogo sloya Zemli [On some hypotheses of the origin of the granitic layer of the earth (with English abstract)]: *Geokhimiya*, no. 4, p. 371-373, 1960.

It is calculated that all the silicic and sedimentary rocks of the earth's crust cannot have been formed from basic rocks, because the excess of iron and magnesium that should result (as iron ores and dolomites) would be twice as great as the total mass of the sedimentary rocks.—D. B. V.

- 187-358. Shimazu, Yasuo. Regional metamorphism and physical state of the crust [in Japanese with English abstract]: *Zisin*, ser. 2, v. 14, no. 1, p. 1-17, 1961.

The physical state of the crust and upper mantle are inferred from the results calculated from models of three types of metamorphic reactions and associated variations of temperature and water pressure during regional metamorphism. The flow diffusivity of water within the crust is estimated to be on the order of 10^{-2}cm^2 per sec. It is shown that normal temperature gradient has no significance during metamorphism and that the heat flow from the mantle toward the crust is an essential factor in determining the types of regional metamorphism. An unusual feature of the Sambagawa metamorphic belt in southwestern Japan is discussed briefly in relation to the physical structure of the earth's interior. — V. S. N.

- 187-359. Glangeaud, Louis. Origine profonde des volcans et structure de la croûte terrestre [Deep origin of volcanoes and structure of the crust]: *Géodésie et Géophysique Comptes Rendus*, p. 43-49, 1959 [1960].

According to recent theories the eruptive rocks and volcanoes are supplied by two categories of magmas of different origin: (1) The peridotite and basaltic magmas which are the primary magmas mobilized in the upper mantle and lower crust, and (2) the granitic (sialic) magma which appears under different conditions and indirectly provides the sedimentary rocks transformed by metamorphism and granitization. The emphasis in this paper is on the formation of the granites and of the sialic magmas. Experimental work on temperatures and pressures necessary to produce granite in the laboratory is reviewed briefly, and the theory that heterogeneous sediments may sink to a zone where temperatures and pressures would cause certain elements to fuse to granite is discussed. These liquid phases would gradually separate from the solid phases, crystallize, and reassemble to form a rhyolitic magma. A highly metamorphosed series would be formed eventually at a zone between 10 and 22 km in depth (based on geologic evidence) that is called the mesozone or middle crust. Seismological evidence indicates that the granitic crust extends nearly 20 km in depth. It is suggested that variations in seismic velocities in the crust may be explained by the presence of liquid pockets where new granites are forming. Some volcanoes are shown to be supplied by both basaltic and granitic magmas; Mont-Dore is cited as an example. — V. S. N.

- 187-360. Cisternas, Armando. Crustal structure of the Andes from Rayleigh wave dispersion: *Seismol. Soc. America Bull.*, v. 51, no. 3, p. 381-388, 1961.

When records from a Benioff shortperiod seismograph at Huancayo, Peru, are digitalized and then passed through a low-pass filter to get the long-period waves, the dispersion curves of Rayleigh waves for Andean paths can be computed from seismograms that otherwise would be unusable. Comparison with the empirical curve for a "normal" continental crust and with specially computed theoretical models indicates a crustal thickness of the order of 50 km. For periods between 20 and 25 sec the observed group velocity shows abnormally low values. — D. B. V.

- Porkka, M. T. Surface wave dispersion for some Eurasian paths, II. Love waves. See *Geophys. Abs.* 187-131.

- 187-361. Balavadze, B. K., and Shengelaya, G. Sh. Osnovnyye cherty struktury zemnoy kory Bol'shogo Kavkaza po gravimetricheskim dannym [Main features of the crustal structure of the Greater Caucasus according to gravimetric data]: Akad. Nauk SSSR Doklady, v. 136, no. 6, p. 1328-1334, 1961.

The results of gravity surveys in the Greater Caucasus are interpreted in terms of crustal structure. Maps show contours on the Paleozoic crystalline basement and on the M-discontinuity, together with data from other sources including deep drilling, seismic depth sounding, and earthquakes. From an area of outcrop in the central part of the mountains, the basement descends to depths of 1-8 km in the Peri-Caucasus, 6-8 km and 14-16 km in the Taman and Apsheron Peninsulas, respectively, and 0-14 km in the Rion-Kura depression. The basalt layer, in contrast, is deepest in the central and eastern parts (about 32 km) and rises to 20 km toward the periphery. The M-discontinuity in general follows the basalt layer but is deeper under the central part (64 km) than under the eastern (56 km).

The root under the Greater Caucasus, therefore, is due mainly to thickening of the granitic layer, but the basaltic layer, depressed beneath it, is also somewhat thickened; a root is lacking, however, in the high mountainous Kazbek area between the central and eastern parts. These results agree fully with those of other geophysical investigations. — D. B. V.

- 187-362. Savarenskiy, Ye. F., and Shechkov, B. N. Stroyeniye zemnoy kory Sibiri i Dal'nego Vostoka po dispersii voln Lyava i Releya [Structure of the crust of Siberia and the Far Eastern Region according to the dispersion of Love and Rayleigh waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 700-704, 1961.

The thickness of the earth's crust determined for Siberia and the Far Eastern Region was found to be 25-35 km from the dispersion of Love waves, and 35 km from the dispersion of Rayleigh waves. By comparing the observed dispersion of the group velocities of both types of surface waves, it was found that the granite layer in Siberia and the Far Eastern Region is 1.5-2.00 times thicker than the basaltic layer. — A. J. S.

- Fedotov, S. A., Averjanova [Aver'yanova], V. N., Bagdasarova, A. M., Kuzin, A. P. [Kuzin, I. P.], and Tarkanov [Tarakanov], R. Z. Some results of the detailed study of the south Kurile Islands seismicity. See Geophys. Abs. 187-110.

- 187-363. Aki, Keiiti. Crustal structure in Japan from the phase velocity of Rayleigh waves. Part 1. Use of the network of seismological stations operated by the Japan Meteorological Agency: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 2, p. 255-283, 1961.

The phase velocities of Rayleigh waves with 20-30 sec periods were determined for different parts of Japan using the records of the Samoan earthquake of April 14, 1957, obtained at the network of seismological stations operated by the Japan Meteorological Agency. An accuracy of 1-1.5 percent was attained by means of the least squares method.

The results, together with those of refraction studies in Japan, suggest that Press' standard phase velocity curves (see Geophys. Abs. 168-192) do not apply to Japan. A 5.5 percent reduction from the standard velocities in the crust and upper mantle gives better agreement with values obtained from the refraction studies, and yields crustal thicknesses that agree very well with those

determined in these and other studies. Crustal thicknesses determined for seven regions in Japan are tabulated.

The positive correlation between Rayleigh wave phase velocities and positive Bouguer gravity anomalies found by Ewing and Press in the United States (see Geophys. Abs. 176-230) was also noted here; however, the relationship is slightly different in southwestern Japan from that for central and northeastern Japan, suggesting a relationship to local geologic and geotectonic conditions.

The wave front chart suggests that Rayleigh waves are refracted laterally at the andesite line in Japan. — D. B. V.

- 187-364. Research Group for Explosion Seismology. Crustal structure in central Japan as derived from the Miboro explosion-seismic observations. Part 1. Explosions and seismic observations; Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 2, p. 285-326, 1961; also in Zisin, ser. 2, v. 14, no. 3, p. 150-167, 1961. Mikumo, Takeshi; Otsuka, Michio; Utsu, Tokuji; Terashima, Tsutomu; and Okada, Atusi. Crustal structure in central Japan as derived from the Miboro explosion-seismic observations. Part 2. On the crustal structure: *ibid.*, v. 39, pt. 2, p. 327-349, 1961; also in Zisin, ser. 2, v. 14, no. 3, p. 168-188, 1961.

Six seismic projects were based on the large-scale quarry explosions at a damsite in the Miboro valley near Sirakawa, Gifu Prefecture, Japan. The first paper gives details of the explosions and tabulates the observations at 75 temporary stations. Many seismograms are reproduced.

The second part interprets these results in terms of crustal structure in the Kwanto, Tyubu, Kinki, and Tyugoku districts in central Japan. Two probable models are shown for eastern and western profiles. In the eastern profile the first model shows downwarping of the first and second layers to maximum depths of 9 km and 38 km, respectively; in the second model the mean depth of the second discontinuity (regarded as being the M-discontinuity) is about 36 km. In the two western profiles the maximum depth of the M-discontinuity is about 36 km in the first model, and its mean depth 27-29 km in the second model. This structure corresponds at least qualitatively to the Bouguer gravity anomaly and to the structure deduced from its spectrum. — D. B. V.

- 187-365. Matuzawa, Takeo, Matumoto, Tosimatsu, and Asano, Shuzo. On the crustal structure derived from observations of the second Hokkaido explosion; Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 509-524, 1959.

This is the same as the paper published in Zisin, ser. 2, v. 13, no. 2, p. 78-89, 1960 (see Geophys. Abs. 184-432). — D. B. V.

- 187-366. Santo, Tetsuo A[kima]. Rayleigh wave dispersions across the oceanic basin around Japan (Pt. 3)—On the crust of the south-western Pacific Ocean; Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 1, p. 1-22, 1961.

The physical conditions governing the deviation of Rayleigh wave dispersion from a purely oceanic character, due to the presence of islands or atolls and observed particularly in the western Pacific and around the "andesite line" in the southwestern part, have been investigated. Correlation between Rayleigh wave dispersion and average sea water depth is disturbed around the "ande-

site line"; this anomaly seems to be due to the presence of a volcanic rock layer of variable thickness overlying the basalt layer.

Data are as yet insufficient for complete estimation of local structures by the group velocity method, but there seem to be two small regions of oceanic crust on the continental side of the "andesite line," one in the Marianas Sea and the other in the region bounded by New Caledonia, the Fiji Islands, and New Zealand. — D. B. V.

187-367. Kovach, Robert L., and Press, Frank. Rayleigh wave dispersion and crustal structure in the eastern Pacific and Indian Oceans: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 202-216, 1961.

Rayleigh wave dispersion data, presented for a number of earthquakes having their epicenters in the Easter Island area and recorded at Pasadena, differ in a small but significant way from those obtained for Pacific Ocean basin paths. The discrepancies are resolved by addition to the theoretical model of a modified low velocity zone in the upper mantle; the modification consists of lowering the mean shear velocity in the upper mantle to 4.5 km/s. It is further demonstrated that it is possible to obtain a model compatible with observed compressional velocities and dispersion data which does not require changing Poisson's ratio and consequently reducing the shear velocities in the upper mantle; this is accomplished by reducing the thickness of the 8.2 km/s layer to the minimum required to give a refraction arrival. The mean shear velocity of 4.5 km/s implies a "soft" upper mantle layer along the Easter Island-Pasadena path. Dispersion data also show that the mean thickness of unconsolidated sediments between Easter Island and Peru is 0.57 km.

Rayleigh wave dispersion data for Indian Ocean shocks recorded at Wilkes Station in Antarctica are in agreement in the period range 25-37 sec with the model assumed for the Easter Island-Pasadena data. — D. B. V.

187-368. Kovach, Robert L., and Press, Frank. Surface wave dispersion and crustal structure in Antarctica and the surrounding oceans: *Annali Geofisica*, v. 14, no. 2, p. 211-224, 1961.

Love and Rayleigh wave data of Evison and others (see Geophys. Abs. 185-364) from five earthquakes recorded at Hallett Station, Scott Base, and Mirnyy in Antarctica have been reinterpreted in the light of more recent theoretical calculations on a digital computer. A mean crustal thickness of about 40 km is indicated for East Antarctica; an indication of 30 km for West Antarctica is less certain. Evison's determination of 10 km for crustal thickness in the south Indian Ocean is unproved because Love wave dispersion data for more than 22-sec period cannot distinguish between a 5-km and a 10-km oceanic crust. — D. B. V.

Dohr, G[erhard]. On the observations of deep reflections within the compass of routine seismic reflection surveys. See Geophys. Abs. 187-584.

187-369. Sheynmann, Yu. M. Poverkhnost' Mokhorovichicha, glubina zarochdeniya magm i razmeshcheniye ul'trabazitov [Mohorovičić surface, depth of origin of magmas, and distribution of ultrabasics (with English summary)]: *Sovetskaya Geologiya*, no. 8, p. 31-44, 1961.

The problem of the composition of the subcrust is considered, and preference is given the periodite hypothesis. Geophysical data show that basaltic

magmas form below the M-discontinuity by partial melting of ultramafic material. The rise of such melts into the upper parts of the crust results in a deficiency of the components of basalt in the peridotite immediately below the M-discontinuity. Peridotites that have not lost their light constituents must lie at greater depth. Such a distribution of rock types can account for the low velocity layer at the top of the mantle.

Basaltic magmas appear most frequently within oceans and platforms. If the temperature is raised locally, a complete melting of mantle material occurs; examples are the highly alkaline ultramafic magmas of the Pacific Ocean. Melting of upper mantle material devoid of the constituents of basalt takes place under the conditions of high temperature beneath geosynclines, and the low alkali peridotites of the folded belts are thereby produced. A later and more intensive heating of the deep zones under geosynclines results in melting of mountain roots and generation of granitic magma. — J. W. C.

Lubimova, H. A. [Lyubimova, Ye. A.]. On conditions of magmatism origin and role of volcanic activity in the thermal regime of earth's crust. See Geophys. Abs. 187-339.

187-370. Birch, Francis. Composition of the earth's mantle: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 295-311, 1961.

Measurements of the velocity of compressional waves in silicates and oxides having a range of density from 2.6 to 5 g per cm³ suggest a simple dependence of velocity upon density and mean atomic weight. Consequences of the assumption that this relation remains valid at high pressures are examined with reference to the composition of the mantle, especially of the transition layer. It appears probable that the abnormally high rate of increase of velocity with depth in the transition layer may be accounted for principally in terms of phase change, with little change of composition. Recent studies with strong shock waves are examined in connection with the composition of the core; the evidence is unfavorable to the hypothesis of a metallic core of light elements, but is consistent with a core of iron alloy. — Author's summary

187-371. Hales, A. L. A weak layer in the mantle? Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 312-319, 1961.

The paper discusses the effect of a weak layer in the upper mantle on the deformation of the crust arising from atmospheric loading, and on the isostatic compensation process. It also points out that S-phases with periods of 1 sec are much more strongly damped than S-phases with periods of 10 sec or more, and than P-phases with short periods. The damping arising from a liquid layer is proportional to the square root of the frequency and does not provide a satisfactory explanation. Scattering of the kind suggested by Jeffreys (see Geophys. Abs. 179-250) or any other mechanism leading to the firmoviscous law, gives rise to damping proportional to the square of the frequency and is sufficiently frequency sensitive to be consistent with the observations. The differences between P and S can only be accounted for in terms of different behaviour of the elastic constants for dilatational and distortional movements. — Author's summary

187-372. Vening Meinesz, F. A. Continental and ocean-floor topography: mantle-convection currents; Koninkl. Nederlandse Akad. Wetensch. Proc., ser. B, v. 63, no. 4, p. 410-421, 1960.

From the spherical harmonic development of the land and sea-floor topography it is shown that probably during the beginning of the earth's history the spherical harmonic distribution of mantle convection currents corresponded to that to be expected in a viscous fluid mantle, and that during more recent periods the distribution corresponded to an entirely or at least mostly crystalline mantle. These results support the view that the earth is cooling. — D. B. V.

187-373. Vogel, A[ndreas]. Laufzeitanomalien von am äusseren Erdkern reflektierten Erdbebenwellen und deren Korrelation zum Schwerkraft- und Nicht-Dipol-Magnetfeld der Erde [Traveltime anomalies of earthquake waves reflected from the outer core and their correlation with the gravitational and nondipole magnetic fields of the earth (with English abstract)]: *Zeitschr. Geophysik*, v. 26, no. 6, p. 273-275, 1960.

Lucke's criticism of Vogel's paper that attributed anomalies in traveltimes of PcP, ScS, PcS, and ScP waves, geoid undulations, and the nondipole geomagnetic field to irregularities of the core boundary (see *Geophys. Abs.* 184-442) is answered by assuming convection currents within the core. — D. B. V.

187-374. Takeuchi, H[itoshi]. Torsional oscillations of the earth: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 259-264, 1961.

This is essentially the same paper as previously published in Zisin, ser. 2, v. 13, no. 3, p. 141-149, 1960 (see *Geophys. Abs.* 185-154). — D. B. V.

ISOTOPE GEOLOGY

187-375. Keeling, Charles D. A mechanism for cyclic enrichment of carbon-12 by terrestrial plants: *Geochim. et Cosmochim. Acta*, v. 24, no. 3/4, p. 299-313, 1961.

A model is described that predicts that variations in relative abundance of C^{12} and C^{13} in terrestrial plants may be due in part to varying degrees of local cycling of CO_2 gas. The model emphasizes the effectiveness of transient departures from a steady state in achieving cyclic enrichment, and predicts that cyclic enrichment should be limited by the maximum concentration of CO_2 occurring near the plants during their diurnal cycle.

A number of predictions related to plant ecology based on this hypothesis may also be used to test the hypothesis: (1) Lower plants and branches of the same plant should show greater enrichment than taller plants and branches, and average enrichment should decline as a plant grows taller; (2) plants in topographic basins should be enriched with respect to those on slopes, those on slopes with respect to those on ridges or summits, and those in the lee of prevailing winds with respect to those in windward locations; (3) a dependence of CO_2 concentration on rainfall, temperature, or season may be reflected in the isotopic ratio; and (4) the fractionation factor should set a lower limit for the enrichment between plants and air which should be reflected in the C^{12}/C^{13} ratio, unless depletion of C^{12} occurs after the absorption of CO_2 by plants. Several of these predictions find experimental support. — D. B. V.

187-376. Broecker, W[allace] S., Tucek, C. S., and Olson, E[dwin] A. Radio-carbon analysis of oceanic CO_2 : *Internat. Jour. Appl. Radiation and Isotopes*, v. 7, p. 1-18, 1959.

Variations in the radiocarbon concentration of oceanic bicarbonate offer clues to large-scale ocean circulation patterns as well as to operation of the terrestrial CO_2 cycle. The process aboard ship for stripping CO_2 gas from acidified ocean water, and the laboratory technique for the purification of the CO_2 and direct measurement of C^{14} activity are described in detail. By mass spectrometrically analyzing the $\text{C}^{13}/\text{C}^{12}$ ratio of the CO_2 assayed for radiocarbon, corrections are made for isotopic fractionation during shipboard processing of the samples. — V. S. N.

Hayakawa, T., Hintenberger, H., and Wänke, H. On the abundances of the helium and neon isotopes produced by cosmic radiation in some iron meteorites. See *Geophys. Abs.* 187-64.

187-377. Craig, Harmon, and Lal, Devendra. The production rate of natural tritium: *Tellus*, v. 13, no. 1, p. 85-105, 1961.

The global mean production rate of natural tritium in the prethermonuclear epoch is calculated from the geochemical inventory to be 0.5 ± 0.3 atoms T/cm^2 sec; this is 3 or 4 times smaller than that of previous calculations. Reasons for the difference are discussed. The predicted production rate is calculated from cosmic ray and nuclear cross section data, using the star production rates in the atmosphere. The predicted mean global tritium production rate during an average solar cycle is found to be 0.25 ± 0.08 atoms T/cm^2 sec, with a variation over an average solar cycle of ± 4.5 percent. These values agree within the uncertainties of the data and calculations; thus there is no observational evidence for accretion of tritium from an extraterrestrial source. — D. B. V.

187-378. Tugarinov, A. I., and Zykov, S. I. Ob izotopnom sostave svintsia rudnykh mestorozhdeniy Kavkaza i Srednei Azii [Isotopic composition of leads from the ore deposits of the Caucasus and central Asia]: *Akad. Nauk SSSR, Kom. Opredeleyuy Absolyut. Vozrasta Geol. Formatsiy Byull.*, no. 4, p. 66-76, 1961.

Isotopic analyses of lead from Variscan and Alpine ore deposits in the northern Caucasus, Georgia, Armenia, Azerbaijan, the Nuratin Mountains, the Kara-Mazar and Kuramin Mountains, the Turkestan-Alay Mountains, the Tadzhik depression, and central and eastern Kirgiz S. S. R. are reported. Variscan ore deposits of the Caucasus yield lead of fairly uniform isotopic composition (18.00, 15.73, 38.77), but the deposits of central Asia give a broad range of compositions (Variscan: 17.80-18.52, 15.50-16.10, 38.00-38.80; Alpine: 18.19-19.13, 15.66-16.14, 38.31-39.85). The variations in the isotopic composition of the Alpine ores are the result of redeposition of these ores from various earlier sources. — H. F.

187-379. Starik, I. Ye., Sobotovich, E. V., Lovtysyus, A. V., and Leontyev, V. G. Razdeleniye khimicheskikh form svintsia [Analysis of the chemical forms of lead]: *Akad. Nauk SSSR, Kom. Opredeleyuy Absolyut. Vozrasta Geol. Formatsiy Byull.*, no. 4, p. 128-135, 1961.

The pyrochemical method of releasing lead from rocks and minerals (see *Geophys. Abs.* 187-9) offers the possibility of determining the chemical form of lead present in small amounts. The sublimation of artificially prepared mixtures of Pb, PbO, PbS, PbSO₄, and PbCl₂ was studied in air, nitrogen, hydrogen, and vacuum. With increasing temperature, PbS, Pb, and

PbSO₄ (as PbO) are liberated in that order in nitrogen, and more PbO sublimes when hydrogen is introduced at 1,200°C. A sample of Joachimsthal pitchblende, treated the same way, gave lead progressively richer in radiogenic isotopes. The early lead fractions show a lead already highly radiogenic (in galena), presumably the original lead of the mineralization. The final fractions, about half of the total lead, are heavily enriched in the radiogenic isotopes presumed to have come from metallic Pb disseminated in the uranium mineral. A sample of ferrian thorite, containing 4.7 percent lead, did not show any pronounced fractionation of isotopes. The chemical form of the lead in the thorite is not known. — H. F.

- 187-380. Valentine, James W., and Meade, Robert F. California Pleistocene paleotemperatures: Univ. California Geol. Sci. Pubs., v. 40, no. 1, p. 1-46, 1961.

Estimates of the paleotemperatures of Pleistocene coastal waters off California and northwestern Baja California are made from two lines of evidence: (1) Paleocology, and (2) oxygen isotope ratios. The range of habitats and temperatures represented by 13 Pleistocene fossil assemblages are inferred from the present distributions and habits of the species. Oxygen isotope paleotemperature estimates were obtained for 43 specimens representing 22 species of Mollusca from the 13 assemblages. The isotopic temperatures fall within the thermal limits of most of the species as inferred from zoogeographic evidence. Paleotemperature estimates from both approaches are in close agreement; they favor times of greater temperature range than today for the period of formation of the Upper Pleistocene terrace deposits and the Lower Pleistocene Lomita marl, and times of cooler temperature than today for the period of the Lower Pleistocene Timms Point silt and San Pedro sand. — V. S. N.

- 187-381. Yeremenko, N. A., and Mekhtiyeva, V. L. Rol' mikroorganizmov protsessakh fraktionirovaniya stabil'nykh izotopov sery [The role of micro-organisms in the processes of fractionation of the stable isotopes of sulfur (with English summary)]: Geokhimiya, no. 2, p. 174-180, 1961.

The fractionation of stable sulfur isotopes during bacterial reduction of sulfates in a closed medium has been investigated experimentally. The results show that the S³²/S³⁴ ratio decreases with time in the H₂S formed in the process. The maximum enrichment of the biogenic H₂S in S³² and S³⁴ with respect to the amounts in the original sulfate were 11.4 and 6.5 per mil, respectively. The change in the S³²/S³⁴ ratio in biogenic H₂S depends on the isotopic composition of the original sulfate. In sheets of stagnant waters, the formation of H₂S and sulfides is possible not only with heavier but also with lighter sulfur. — D. B. V.

- 187-382. Starik, I. Ye., Starik, F. Ye., and Yelizarova, A. N. Sravnitel'naya vyshchelachivayemost nekotorykh izotopov [Comparative leachability of some isotopes]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 160-165, 1961.

The relative leachability of radium and thorium isotopes from uraninites and of lead isotopes from uraninites and monazites in 5 N, 0.1 N, and 0.01 N HNO₃ is studied, and the results are tabulated. The leachability of Th²³⁴, the first decay product of U²³⁸, is relatively large, presumably because of the large energy of the decay. The preferential leaching of Th²²⁸ over Th²³² with decreasing acid concentration indicates that Th²²⁸ is in a more mobile

state than Th^{232} , the parent isotope. Common lead has greater leachability than radiogenic lead as shown by Tilton. Pb^{206} and Pb^{207} are leached preferentially over Pb^{208} from monazites, but the opposite is true for uraninites, indicating that uranium and thorium occupy special positions in monazite and uraninite, respectively. — H. F.

187-383. Starik, I. Ye., and Lazarev, K. F. Izucheniye adsorbtsionnykh processov, proiskhodyashchikh pri vyshchelachivanii [Study of adsorption processes that accompany leaching]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 136-143, 1961.

The leaching of various isotopes of the uranium and thorium series from monazite with hydrochloric and nitric acids of various concentrations is analyzed. The distribution law describes the process formally. — H. F.

MAGNETIC FIELD OF THE EARTH

187-384. Hide, R[aymond], and Roberts, P. H. The origin of the main geomagnetic field, in *Physics and chemistry of the earth*, v. 4: New York, Pergamon Press, p. 27-98, 1961.

Current knowledge concerning the nature and origin of the main geomagnetic field of the earth is reviewed in the following chapters: introduction, description of the geomagnetic field, physical analysis of the irregular field, screening in the mantle, induction theories of the main field, theory of the secular variation, and theory of long period changes. Two appendices complete some of the mathematical calculations. A bibliography of 110 entries is included. — V. S. N.

187-385. Hine, A. Some aspects of terrestrial magnetic phenomena: *Research Appl. Industry*, v. 14, no. 4, p. 143-146, 1961.

A brief historical summary of the development of knowledge concerning terrestrial magnetism is presented, the components of the magnetic field are defined, and the method of taking measurements and the magnetometer used at the Admiralty Compass Observatory are described. The characteristics of both systematic and random changes in the observed values of geomagnetic elements and their relation to solar and ionospheric phenomena are discussed. — V. S. N.

187-386. Yukutake, Takesi. Stability and non-steady state of self-exciting dynamos. Pt. 1: *Tokyo Univ. Earthquake Research Inst. Bull.*, v. 38, pt. 1, p. 1-12, 1960.

Study of the time-dependent behavior of Herzenberg's self-exciting dynamo model (two conducting spheres rotating in a large conducting sphere; see *Geophys. Abs.* 183-417) shows that the steady state cannot be stable for small disturbances. If the magnetic field decreases by chance below a certain value, the coupling torque is weakened and the spheres come to rotate with infinite velocity. If the field is increased, the speed of rotation diminishes. It is anticipated that the magnetic field should reach a maximum and begin to decrease; however, in order to obtain such an oscillatory field, which would explain the reversals of the geomagnetic field indicated by paleomagnetic results, it is necessary to have a closer approximation of the electromagnetic coupling between the two spheres. — D. B. V.

- 187-387. Yukutake, Takesi. Stability and non-steady state of self-exciting dynamos: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 3, p. 437-449, 1960.

The variation with time of the magnetic field and angular velocity are treated mathematically for the case of two conducting spheres rotating in an infinitely extended conductor. Induction equations are approximated by those expanded up to the second time-derivatives of the magnetic field. In some special cases the magnetic field is found to change its polarity with decrease of amplitude. For spheres 500 km in radius rotating 1,100 km apart in the earth's core, the periods of the damping oscillation are about 1.3×10^4 yr. If the effect of the external torque is 10^{-9} erg per sec cm^3 , the induced magnetic field and the surface velocity of the spheres become about 1 gauss and 0.7 cm per sec, respectively. (See also Geophys. Abs. 187-386.)— D. B. V.

- 187-388. Lew, John S. Drift rate in a dipole field: Jour. Geophys. Research, v. 66, no. 9, p. 2681-2685, 1961.

Expressions are found for the drift of charged particles in the field of a magnetic dipole. These give, in the guiding center approximation, the longitude drift rate and drift period of relativistic particles with mirror points at any latitude. The results are applied to trapped electrons and protons in the earth's magnetic field and are adapted for further use in such applications. — Author's abstract

- 187-389. Chapman, Sydney. Scale times and scale lengths of variables: with geomagnetic and ionospheric illustrations: Phys. Soc. [London] Proc., v. 77, pt. 2, p. 424-432, 1961.

The conception of the atmospheric scale height (relating to the proportionate variation of barometric pressure) is generalized to apply to any scalar and vector functions of time and (or) position. Examples are given relative to magnetic fields and the ionosphere. The scale length and scale time here defined enable precision to be given to often used terms such as "slow variation," "distance (or time)" "small in relation to the scale of variation" of another quantity. — Author's abstract

- 187-390. de Vuyst, A. Sur les connaissances actuelles du géomagnétisme [On present knowledge of geomagnetism]: Ciel et Terre, v. 76, no. 1-2, p. 1-20, 1960.

This review of the present state of knowledge concerning the magnetic field of the earth discusses the primary field, the residual field and secular variation, paleomagnetism, and the possible origin of the geomagnetic field. — D. B. V.

- Shuleykin, V. V. Experimental test of the hypothesis concerning the nature of magnetic declination. See Geophys. Abs. 187-91.

Shuleykin, V. V., and Sigachev, N. I. A new test of a hypothesis concerning the nature of magnetic declination. See Geophys. Abs. 187-92.

- 187-391. National Bureau of Standards. Antennas for detecting micropulsations: U.S. Natl. Bur. Standards Tech. News Bull., v. 45, no. 5, p. 83, 1961.

Special-purpose antennas for investigating micropulsations in the earth's magnetic field have been designed and constructed. They will be used to collect data on the behavior of micropulsations and to discover their relationship to unusual manifestations of solar or magnetic activity. Permanent micropulsation installations are being established near Boulder, Colo.; College, Alaska; and Huancayo, Peru. Additional antennas will equip two portable stations. — V. S. N.

- 187-392. Lipskaya, N. V., Deniskin, N. A., Yegorov, Yu. M., and Shel'ting, V. F. *Statsionarnaya mikrovariatsionnaya stantsiya s fotoelektronym usileniyem* [Stationary microvariation apparatus with photoelectric amplification]: Akad. Nauk SSSR, 3d Sess. IGY Program, no. 4, Geomagnetic disturbances, p. 42-47, 1960.

A three-component apparatus for continuous recording of geomagnetic field microvariation up to several thousandth of a gamma in amplitude and up to 1 cycle per second frequency is described. This stationary apparatus is based on the magnetostatic principle. The field pickup element is a highly sensitive, low-inertia torsion quartz magnetic balance. This has an oscillating mirror. The beam of light reflected from it is transformed into a photocurrent, which being amplified by a photomultiplier records microvariations on a paper tape at a scale value of 0.005 γ per 1 mm. — A. J. S.

- 187-393. Bullard, E[dward]C., and Mason, R. G. The magnetic field astern of a ship: *Deep-Sea Research*, v. 8, no. 1, p. 20-27, 1961.

In making measurements of the total force of the earth's magnetic field over the oceans by a magnetometer towed behind a ship, it is necessary to measure the disturbance to the magnetic field produced by the ship. The magnetization of a ship may be divided into a permanent and an induced part. If the induced part is a linear function of the field components and the permanent part is independent of them, the disturbance of the total force by the ship contains a term independent of magnetic heading and terms proportional to the sine and cosine of the heading and of twice the heading, the sine terms being less than a tenth of the cosine terms. The variation with distance astern the ship is similar to that due to a pole near the bow and one near the stern plus a line of vertical dipoles. Results are verified by experiment. The disturbance measured for *Discovery II* and for *Sarsia* of less than 10 γ at a distance of 2 ship's lengths astern is believed to hold for most ships. A method for determination of the principal coefficients and their variation with distance is described. — V. S. N.

- 187-394. *International Geophysical Year Bulletin* (No. 51). Survey of the earth's magnetic field. The world magnetic survey: *Am. Geophys. Union Trans.*, v. 42, no. 3, p. 401-410, 1961.

The projected world magnetic survey will use data gathered since 1955 but will heighten its efforts during the period April 1964-December 1965 when a minimum of solar activity is expected. The nature of the geomagnetic field, types of geomagnetic maps, methods of mapping, and general plans for the survey are outlined. — D. B. V.

- 187-395. *International Geophysical Year Bull.* (No. 46). Geomagnetic field studies using earth satellites: *Am. Geophys. Union Trans.*, v. 42, no. 2, p. 244-250, 1961.

Analyses of data collected by the proton-precessional magnetometer carried by the *Vanguard III* (1959 η) satellite are contributing to evaluations of

the accuracy of magnetic charts and computed magnetic fields, determinations of possible discontinuities in the geomagnetic field, and further knowledge of geomagnetic storms and their effects. — D. B. V.

- 187-396. Caner, B., and Loomer, E. I. Record of observations at Victoria magnetic observatory 1957-1958: Dominion Observatory Ottawa Pubs., v. 24, no. 9, p. 223-296, 1961.

Magnetic observations recorded at Victoria Magnetic Observatory, 10 miles north of Victoria, British Columbia, for the period July 1957 through December 1958 are given in monthly tables that include the mean values for horizontal and vertical intensity, declination, and three-hour range indices. A summary table is given for each year to show the diurnal inequalities of the magnetic elements by month. The site of the observatory, instruments used, and types of observations made are described briefly in the introduction. — V. S. N.

- 187-397. Onhauser, A. A., and Onhauser, M. H. Three-hour range indices of magnetic elements—Agincourt and Meanook 1956-57-58: Dominion Observatory Ottawa Pubs., v. 21, no. 4, p. 181-221, 1959.

The three-hour range indices D, H, and Z for Agincourt and Meanook for the years 1956 to 1958 inclusive are given in tables. The K-indices supplied on a routine basis to De Bilt and Göttingen are also included. — V. S. N.

- 187-398. Miliayev, N. A. Magnetic disturbance in the area of operations of drifting stations North Pole 3 and North Pole 4 [translation from Russian]: Problemy Arktiki, no. 5, p. 73-80, 1958; translated by Canada Directorate Sci. Inf. Services, DBR-T339R, 7 p., 1960.

From April 1954 to April 1955 continuous recording of variations of the D, H, and Z components of the geomagnetic field was carried out on drifting stations North Pole 3 and 4. Mobile magnetic variation equipment was used. It was concluded that in years of minimum magnetic activity (1954-55), the mean level of disturbance in the circumpolar region is lower by 1.5 to 2 times than in the zone of maximum magnetic activity ($\phi=68^\circ$); in the formation of the mean level of magnetic disturbance, the principal role is played by the morning and daytime disturbances; the disturbances are 2-3 times greater in the summer than in the winter; night disturbances play an insignificant role in the general level of disturbance and are smallest during the winter with little variation throughout the 24 hr; and the western part is in the postulated second zone of enhanced magnetic activity and is characterized by a daytime disturbance occurring at 13-14 hr universal time. — V. S. N.

- 187-399. Gjellestad, Guro, and Dalseide, Helge. The magnetic station at Dombås ($\phi=62^\circ 04' .4N$, $\lambda=9^\circ 07' .0E$ Gr). Observations 1958: Norske Inst. Kosmisk Fysikk Pub., no. 49, 17 p., 1960.

Observations made during 1958 at the magnetic observatory at Dombås, Norway, are reported. Tables of absolute hourly mean values in three elements, D, H, and Z, and daily and hourly means for all days and for the 5 international quiet and disturbed days are given. Monthly and annual means for all days and for the 5 international quiet and disturbed days are listed in a separate table, and other tables give the adopted scale and base line values. — V. S. N.

- 187-400. Selzer, E[douard]. Observations magnétiques faites à l'Observatoire de Chambon-la-Forêt en 1956 [Magnetic observations made

at the Chambon-la-Forêt Observatory in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 5-30, 1960.

This tabulates the hourly values of D, H, and Z; the deviation of D, I, H, Z, X, -Y, and F from monthly and annual mean values; the annual hourly values; and the geomagnetic conditions on each day of the year 1956 as observed at Chambon-la-Forêt, France. Annual mean values and secular variations of each component of the total field, calculated from these data, are given in the introduction. — D. B. V.

- 187-401. Noblanc, O. Observations magnétiques faites à l'Observatoire de Nantes en 1956 [Magnetic observations made at the Nantes Observatory in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 31-33, 1960.

Deviations of D, H, and Z observed at Nantes, France, from their mean monthly and mean annual hourly values are tabulated, and the mean annual values and secular variations are given for D, I, H, Z, and F. — D. B. V.

- 187-402. Delpeut, Jean. Observations magnétiques faites à l'Observatoire de Ksare (Liban) en 1956 [Magnetic observations made at the Ksara Observatory (Lebanon) in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 35-37, 1960.

Hourly mean monthly and mean annual values of D, H, and Z observed at Ksara in Lebanon in 1956 are tabulated. — D. B. V.

- 187-403. Duclaux, F[rançoise], Bucher, A., Gilbert, D., Will, R[olland], and Oussarof, G. Observations magnétiques faites à l'Observatoire de Tamanrasset en 1956 [Magnetic observations made at the Tamanrasset Observatory in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 39-57, 1960.

The hourly values of D, H, and Z observed during 1956 at Tamanrasset, Algeria, are tabulated. Mean annual values of D, I, H, Z, X, Y, and F are given in the introduction. — D. B. V.

- 187-404. O. R. S. T. O. M. Observations magnétiques de l'O. R. S. T. O. M. faites à l'Observatoire de M'Bour en 1956 [Magnetic observations of the O. R. S. T. O. M. made at the M'Bour Observatory in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 59-77, 1960.

Hourly values of D, H, and Z during 1956, observed at M'Bour in French West Africa, are tabulated. — D. B. V.

- 187-405. O. R. S. T. O. M. Observations magnétiques de l'O. R. S. T. O. M. faites à l'Observatoire de Bangui en 1956 [Magnetic observations of the O. R. S. T. O. M. made at the Bangui Observatory in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 79-97, 1960.

Hourly values of D, H, and Z during 1956, observed at Bangui in French Equatorial Africa, are tabulated. — D. B. V.

- 187-406. LeBorgne E[ugène]. Réseau magnétique de répétition de la France Métropolitaine. Troisième série de mesures en ces stations, rapportées à l'époque 1958.0 [Magnetic repeat network of Metropolitan France. Third series of measurements at these stations, re-

duced to epoch 1958.0]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 99-115, 1960.

The results of a third series of measurements of D, H, and Z at the 16 stations of the magnetic repeat network in France and Corsica, reduced to epoch 1958.0 and referred to Chambon-la-Forêt standards, are tabulated. Values of I and F deduced from the corresponding H and Z measurements are also given. Secular variations of D, H, Z, I, and F are shown on maps and discussed. — D. B. V.

187-407. Cecchini, A[ndrè], Jobert, N[elly], LeBorgne, E[ugène], and Selzer, È[douard]. Nouveau reseau magnétique de la Corse [New magnetic network of Corsica]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 125-156, 1960.

A revision of the local geomagnetic network of Corsica was undertaken in 1953. A Chasselon magnetic theodolite, and 2 QHM and 2 BMZ magnetometers were used. Instrumental calibration, methods of operation, and reduction of the results are discussed briefly. The values of D, H, Z, I, X, -Y, and F are listed for the 106 stations of the network, and each station is described. Results are presented in the form of maps of D, H, Z, and I, reduced to epoch 1953.0. Finally, secular variations of D, H, Z, and I since 1924 are tabulated for 19 stations. — D. B. V.

187-408. MacDowall, J., and Blackie, A. Geomagnetic observations, in *The Royal Society International Geophysical Year Antarctic Expedition Halley Bay, Coats Land, Falkland Islands Dependencies 1955-1959*, v. 1: London, The Royal Society, p. 61-224, M 1-181, 1960.

Geomagnetic observations made at Halley Bay, Antarctica, by scientists of the Royal Society of London for the International Geophysical Year, 1957-58, are reported. The following are discussed: site of the nonmagnetic hut; instruments for continuous recording; absolute measurements; allocation of base lines; insensitive recorder H, D, and Z scale values and base lines; the diurnal variation of the geomagnetic elements; the incidence of geomagnetic activity; geomagnetic activity as shown by analysis of K-indices; diurnal variations indicated by the Q-index of activity; frequency distribution of absolute daily range R; the diurnal distribution of the times of incidence of the daily maximum and minimum values of the geomagnetic field; the daily Ck-index of local geomagnetic activity; local selection of days at various levels of activity; variation of the geomagnetic elements, vector field changes; data tabulated; and magnetograms reproduced. The report includes 186 tables, 45 figures, and 181 pages of magnetograms. — V. S. N.

187-409. Kakinuma, Seiichi, and Muraishi, Yukihiro. Report on geomagnetic total force observation in the fourth Japanese Antarctic research expedition [in Japanese with English abstract]: *Antarctic Rec.*, no. 11, p. 200-203, 1961.

The results of geomagnetic total force observations made between Cape Town and the Antarctic Ocean by the 4th Japanese Antarctic Expedition (1959-60) are reported, and comparisons are made with results from the second and third expeditions. These results are illustrated. — V. S. N.

187-410. Shuleykin, V. V. Nekotoryye osobennosti vekovykh izmeneniy magnitnogo polya nad okeanom [Some features of the secular variation of the magnetic field over the oceans]: *Akad. Nauk SSSR Doklady*, v. 137, no. 4, p. 848-851, 1961.

Examination of the course of secular magnetic variation suggests that there is a genetic connection between Bullard's drifting convection nuclei and the main geomagnetic field, whose axis coincides with the axis of rotation of the earth. If these "eddies" of the electromagnetic field can interact with the poorly conducting solid mantle to cause the drift of the convection nuclei, they should exert a much greater effect on the well conducting ocean waters. Changes in declination on passing from continents to oceans, shown on a sketch map, are related to telluric current eddies produced when the nuclei pass from land to water. It is possible that interaction of the nuclei with the waters of individual seas produces constant current components on which are superposed eddy currents induced in the sea at the time of magnetic storms. — D. B. V.

- 187-411. Nagata, Takeshi [Takesi]. Geomagnetic secular variation over and near the Antarctic continent [with Japanese abstract]: Antarctic Rec., no. 11, p. 217-224, 1961.

The results of study of geomagnetic secular variation in the vicinity of the Antarctic Continent by the Japanese Antarctic Research Expeditions indicate that variations in the geomagnetic field at Syowa Station and the neighboring areas are extremely large. The average secular variations at Syowa Station for the period of 1957-60 (in γ per year), were as follows: $X=-79$, $Y=-40$, $Z=+181$, $D=-14.1$ (min per year), and $H_2=-28$. Differences between measurements in Lützow-Holm Bay in 1956-57 and those of Vestine's magnetic chart compiled in 1945 amount to about $+5 \times 10^3$ for Z , -2×10^3 for H , and about one degree for D . The reliability of observations of variations for the area of the Antarctic continent as recorded by permanent stations at Macquarie Island and Orcadas del Sur, several Argentinian stations, and a group of temporary stations established for the International Geophysical Year are discussed. Comparison of the southern with the northern hemisphere shows that secular variation in the geomagnetic field is much more active in the southern than in the northern hemisphere with respect to both the number of focuses and their intensity. It is suggested that the origin of two neighboring focuses near the coast of East Antarctica may be attributed to a pair of radial magnetic dipoles on the earth's core; the upward magnetic dipole would have about 3.5×10^{22} emu per yr as the rate of change in moment, while the downward dipole, 15° away would have about 2.3×10^{22} . — V. S. N.

- 187-412. Mansurov, S. M. Vekovyie variatsii geomagnitnogo polya Vostochnoy Antarktity [Secular variation of the geomagnetic field in East Antarctica]: Akad. Nauk SSSR, 3d Sess. IGY Program, no. 4, Geomagnetic disturbances, p. 48-52, 1960.

Secular variations in the earth's magnetic field in the region of the U.S.S.R. Antarctic magnetic observatories Oasis (18 average monthly observations), Mirnyy (44 observations), Pionerskaya (17 observations), and Vostok (26 observations) are determined for 1957-59. Attention is drawn to the two-year periodic variation of the H component and the correspondence of this period to the synodic revolution period of Mars. It is also noted that the observed amplitude of δH long-period variations during 1957-59 was three times greater than the same variation according to earlier data. — A. J. S.

- 187-413. Ellis, G. R. A. Geomagnetic micropulsations: Australian Jour. Physics, v. 13, no. 4, p. 625-632, 1960.

The results of simultaneous observations of geomagnetic micropulsations at three places ranging from 28° S. to 51° S. geomagnetic latitude during the period September 1959 to April 1960 are described. There is no observable

change in the micropulsation period with latitude although there is a monotonic increase in amplitude with latitude for all periods between 10 and 100 sec. These results are discussed in the light of existing theories of the geomagnetic field. — D. B. V.

- 187-414. Campbell, Wallace H. Magnetic field micropulsations and electron bremsstrahlung: *Jour. Geophys. Research*, v. 66, no. 10, p. 3599-3600, 1961.

Observations of enhanced magnetic micropulsation activity in the auroral zone near College, Alaska, simultaneous with increases in intensity of bremsstrahlung from energetic electrons, are reported. — D. B. V.

- 187-415. Oshima, H. Pc-type pulsations and geomagnetic disturbances [with Japanese abstract]: *Kakioka Magnetic Observatory Mem.*, v. 9, no. 2, p. 1-13, 1960.

To analyze the relation between the pc-type pulsations and other phenomena an attempt is made to express quantitatively by an index the activity of pc-type pulsations. A P-index on a scale of 10 grades determined by the amplitude of the pulsation in each 5 min interval is presented and discussed. It is anticipated that an index determined by amplitude alone will express with accuracy the general behavior of pc-type pulsations for the narrow range of periods of 10-40 sec with mushroom growth of occurrence-frequency at about 20 sec. The P-index is utilized in this paper to study the relation between pc-type pulsations and geomagnetic disturbances and some results are described. It is concluded that pc-type pulsations are generally active in the geomagnetically disturbed period. Even at times of no geomagnetic disturbances, the great and typical diurnal variations of ΣP appear; these also appear in times of rather high geomagnetic activity. It was found that ΣP increases suddenly at the time of storm commencement, but that this increase is not due to an increase in its typical diurnal variations. — V. S. N.

- 187-416. Saito, Takao. Period analysis of geomagnetic pulsations by a sonagraph method: *Tohoku Univ. Sci. Repts.*, ser. 5, v. 12, no. 2, p. 105-113, 1960.

An attempt at period analysis of geomagnetic pulsations by means of a sonagraph is described and illustrated. Induction magnetograms obtained at the Onagawa Magnetic Observatory in Japan were reprinted on film and reproduced photomechanically as a sound wave that was then analyzed for period, amplitude, and time by a sonagraph. A daily variation of period, amplitude and other characteristics revealed in the pt, pc, storm time pulsation, and pulsation accompanying ssc is interpreted in terms of differences in apparent heights of hydromagnetic barriers between the sunlit and night hemispheres. — D. B. V.

- 187-417. Nagata, Takesi, and Kokubun, Susumu. Relation between geomagnetic disturbances in the northern and southern polar regions [with Japanese abstract]: *Antarctic Rec.*, no. 11, p. 204-216, 1961.

This is virtually the same paper as previously published in *Rept. Ionosphere and Space Research Japan*, v. 14, no. 3, p. 273-290, 1960 (see *Geophys. Abs.* 186-495). — V. S. N.

- 187-418. Yanagihara, K[azu]. Geomagnetic pulsations in middle latitudes — morphology and its interpretation [with Japanese abstract]: *Kakioka Magnetic Observatory Mem.*, v. 9, no. 2, p. 15-74, 1960.

Data from observations during the International Geophysical Year are used to classify, characterize, and interpret the geomagnetic pulsations observed at middle latitudes. Pt and pc pulsations are the most prominent and typical on the records, although to distinguish them careful consideration must be made of the frequency response of the instruments used in making the observations. Particular attention is given to the difference in character between disturbance-type and calm-type pulsations in their diurnal, annual, or 11-year variations. Behaviors of the variations of activity are found to vary according to the relative efficiency of the primary agency or terrestrial effect near the earth, especially in the variation of the disturbance-type pulsation. The annual variation of occurrence frequency of disturbance-type pt or pc shows equinoxial maximums, whereas the calm-type pt or pc has maximum activity in winter or summer. — V. S. N.

- 187-419. Ol', A. I. Sinopticheskiye karty magnitnoy vozmushchennosti v Arktike [Synoptic charts of magnetic disturbances in the Arctic]: Akad. Nauk SSSR, 3d Sess., IGY Program, no. 4, Geomagnetic disturbances, p. 22-29, 1960.

Synoptic charts of magnetic disturbances r_H^Y made from the data of high latitude geomagnetic observations during 1957-58 are discussed. Two-hour charts and a few examples of successive hourly charts of magnetic disturbances are given. A considerable variation in disturbance distribution with universal time was found. Characteristic of these distributions are their focal, nonzonal concentration. The disturbances are found to change their distribution disorderly from hour to hour, while the focuses of the disturbances remained fixed for several hours at the same locality. — A. J. S.

- 187-420. Zhigalov, L. N. O nekotorykh osobennostyakh variatsiy vertikal'noy sostavlyayushey magnitnogo polya Zemli v Severnom Ledovitom okeane [On some specific features in variations of the vertical component of the earth's magnetic field in the Arctic Ocean]: Akad. Nauk SSSR, 3d Sess. IGY Program, no. 4, Geomagnetic disturbances, p. 30-34, 1960.

A study of geomagnetic variations obtained by the U. S. S. R. SP-6 drifting station in the Arctic in 1957-58 and by U. S. S. R. high latitude Arctic geomagnetic observatories has led to the conclusion that the character of variations in the vertical component of the earth's magnetic field depends on the depth of the ocean where the reading is taken. The amplitude of the short-period part of the variations (5-10 γ) was found to drop sharply with increases in ocean depth and to disappear completely where the depth is greater than 2,500-3,000 m. — A. J. S.

- 187-421. Angenheister, Gustav [H.], and Consbruch, Claus von. Pulsationen des erdmagnetischen Feldes in Göttingen von 1953-1958 [Pulsation of the magnetic field of the earth in Göttingen for 1953-1958 (with English summary)]: Zeitschr. Geophysik, v. 27, no. 1, p. 3-12, 1961.

Records of the H component obtained at Göttingen, Germany, from 1953 to 1958 with a Grenet-type induction magnetograph are analyzed. The index P_z ("Pulsationszahl") is introduced, defined as $P_z(h, d, m, T) = n \cdot a / (3,600/T)$, where n is the number of cycles, a is the mean amplitude of an octave interval with the central period T in the hour h of the day d of the month m ; the octaves are period ranges $T = \overline{7.5-15}$, $\overline{15-30}$, $\overline{30-60}$, $\overline{60-120}$, $\overline{120-240}$, $\overline{240-480}$ sec. The data are divided into three classes: disturbed (D), moderate (M), and quiet

(Q) days. The daily variation of the values of \bar{P}_Z (the values divided by the mean of the day), π_Z (the smoothed values), and $2\pi_Z$ (the doubly smoothed values) are plotted against universal time. — D. B. V.

187-422. Honda, Hirokichi; Kato, Yoshio; and Yamamoto, Giichi, eds. Geomagnetic rapid variations observed at the Onagawa Magnetic Observatory during the International Geophysical Year, Pt. II: Tohoku Univ. Sci. Repts., ser. 5, v. 12 supp., p. 1-75, 1961.

The geomagnetic rapid variations observed at the Onagawa Magnetic Observatory during the International Geophysical Year, January 1 to December 31, 1958 are reported. Storm sudden commencement (ssc or ssc*), sudden impulse (si), geomagnetic bay (b, bp, bs, or bps), and solar flare effect (sfe) were observed by the normal and highly sensitive rapid run magnetometers; the results are tabulated. Tabulated results are also given for geomagnetic rapid pulsation (pc and pt) observed with the induction and highly sensitive rapid run magnetometers; the original induction magnetometer records for ssc, si, pt, and pc are reproduced in plates. — V. S. N.

187-423. Ponomarev, Ye. A. O prirode beregovogo effecta [On the nature of the coast effect]: Akad. Nauk SSSR, 3d Sess. IGY Program no. 4. Geomagnetic disturbances, p. 35-41, 1960.

The geomagnetic coast effect reported by Mansurov (see Geophys. Abs. 187-412) in the region of the Mirnyy Observatory in Antarctica is considered to be a skin-effect, because the electrical conductivity of sea water is at least 4 orders greater than that of ice and crystalline rock, which constitute the shore and the submarine slope. An attempt is made to explain the sudden increase in relative values of variations of the magnetic field along the coast of Antarctica. An analysis of the problem and its solution are given. — A. J. S.

187-424. Rikitake, T[suneji]. The effect of the ocean on rapid geomagnetic changes: Royal Astron. Soc. Geophys. Jour., v. 5, no. 1, p. 1-15, 1961.

Electromagnetic induction in a conductor covered by a conducting sheet has been studied with the aid of two-dimensional experiments and mathematical theory. Application of the results to the effect of the ocean on rapid geomagnetic variations shows that the previous estimate of the ocean effect, based on induction in a single sheet, is too large.

Cox's explanation (unpublished) of the anomalous geomagnetic variations of Japan by the effect of the ocean at its margin is criticized. Rikitake believes the anomaly is caused by induced currents deep beneath Japan (see Geophys. Abs. 180-266). — D. B. V.

187-425. Helliwell, R. A. Exospheric electron density variations deduced from whistlers [with French and Russian abstracts]: Annales Géophysique, v. 17, no. 1, p. 76-81, 1961.

A new model based on whistler dispersion data from the International Geophysical Year shows that the electron density of the equatorial exosphere is approximately proportional to the earth's magnetic field out to five earth radii. The density decreases significantly faster with height than predicted theoretically by Dungey. An annual variation in electron density in which the December value is nearly twice the June value has been discovered. The variation is much larger than can be explained by the annual variation of the earth-sun distance, and it may be intimately connected with the mechanism of solar control of the outer ionosphere. — V. S. N.

- 187-426. Vestine, E. H. Geomagnetism in relation to aeronomy: *Annales Géophysique*, v. 17, no. 2, p. 181-194, 1961.

The geomagnetic field and its time fluctuations, which are of interest to aeronomy, are described. The theories that have been brought forward to explain these fluctuations are reviewed. The role of upper air winds in producing the solar and lunar daily magnetic variations, and that of charged energetic particles in causing geomagnetic disturbance are indicated. The response of geomagnetically trapped radiation in the Van Allen belts and adjacent regions to geomagnetic field changes is discussed. The use of integral invariants in predicting certain auroral effects and especially the explanation of auroral isochasms is also reviewed. Finally, mention is made of the early findings of rocket probes penetrating nearby space. — Author's abstract

- 187-427. Duffus, H. J. A connexion between Pc and the F region: *Nature*, v. 188, no. 4752, p. 719-721, 1960.

Analysis of International Geophysical Year data on geomagnetic micropulsations suggests that there might be a worldwide relationship between Pc and ionospheric electron density that is obscured by local effects. As yet there are only enough data to suggest that the diurnal variation of Pc is inversely related to the diurnal variation of the true electron density at 280 km. It is necessary to postulate a source of Pc in the outer atmosphere that is stronger on the sunlit side of the earth. The present results do not exclude the possibility that localized hydromagnetic resonance in the upper F region is the source of some Pc disturbances. — D. B. V.

- 187-428. Lock, C. M., and Stevens, P. J. Connexion between micropulsations and the ionosphere: *Nature*, v. 191, no. 4788, p. 584-585, 1961.

Results of simultaneous magnetometer observations at Christchurch, England, and Ascension Island, close to the geomagnetic equator, confirm Duffus' conclusions (see also *Geophys. Abs.* 187-427) that the low atmosphere has a modulating control over Pc and also show that this control varies markedly with latitude, in contrast to Pt. The problem is to explain why Pt are nighttime phenomena and are coherent over a great latitude range, being of greater amplitude at high latitude, while Pc are recorded in the daytime and vary with latitude, both classes of pulsation being linked with the ionosphere.

It is suggested that Pt may be oscillations of the outer atmosphere which are coupled with the ionospheric duct at the auroral belt, being propagated only in the low-attenuation nighttime state of the ionosphere, while Pc may have a much more local and resonant transmission system, still originating in an outer atmosphere oscillatory mode. It is possible that part of their oscillatory content is inherent in the arriving corpuscular stream. — D. B. V.

- 187-429. Sugiura, Masahisa. Some evidence of hydromagnetic waves in the earth's magnetic field: *Phys. Rev. Letters*, v. 6, no. 6, p. 255-257, 1961.

Observations of damped oscillations at College, Alaska, may be considered as evidence of hydromagnetic waves propagated to the earth from its outer atmosphere. The waves are nearly elliptically polarized, suggesting that they are generated at an altitude of several earth radii and propagated along the lines of magnetic force. They are mostly confined to the auroral zones and occur simultaneously in the northern and southern hemispheres. They are probably generated by a sudden motion of the gas or by an electric field suddenly imposed on the gas. — D. B. V.

- 187-430. Campbell, Wallace H. Natural electromagnetic energy below the ELF range: U. S. Natl. Bur. Standards Jour. Research, v. 64D, no. 4, p. 409-411, 1960.

The transition of natural signals from sferics slowtails to geomagnetic micropulsations was observed between 2.0 and 0.2 cycles per second. Micropulsations with periods of 5-30 sec have characteristics which closely relate to solar terrestrial disturbance phenomena. The low latitude diurnal amplitude variation has maximums at 0945 and 1000 local meridian time. Similar groups of oscillations appear in Alaska and California. Simultaneous pulsation of λ 3,914 aurora and magnetic field micropulsations has been observed in Alaska. — Author's abstract

- 187-431. Tamao, Tsutomu. Deviations of geomagnetic field and hydromagnetic characteristics in the outer exosphere: Tôhoku Univ. Sci. Repts., ser. 5, v. 12, no. 3, p. 159-168, 1961.

The mechanism of the current system responsible for deviations of the geomagnetic field from the dipole field, observed in the exosphere at 5-7 earth radii by Sonnett and others (see Geophys. Abs. 186-480), is discussed. The diamagnetic effect of the thermal plasma is insufficient to explain the deviations; trapping of diffused solar particles having a velocity of 10^8 cm per sec in the weakly disturbed region is required.

Since the contribution from the component of gas kinetic pressure perpendicular to the direction of the field is partly canceled by the diamagnetic effect of the trapping particles, the net contribution from the pressure anisotropy is strengthened in the formation of current. It may be that the source of the observed deviations of the field is a ring current resulting from protons of several tens of Kev diffused into and accelerated within the region of 7-12 earth radii. — D. B. V.

- 187-432. Yoshino, Takeo. Observation of aurora noise at Syowa Base [with Japanese abstract]: Antarctic Rec., no. 11, p. 179-183, 1961.

An investigation of the property of radio waves radiating from the highly ionized gas in the troposphere when occupied by an aurora was carried out at Syowa Base in the Antarctic to find the explanation of the mechanism of aurora luminescence and to analyze the phenomenon of troposphere caused by proton beams from the sun. The radio waves were observed mainly at 3,000 megacycles and occasionally at 60 megacycles. Observations continued from March 15, 1959 through January 15, 1960. To analyze the results a simultaneous comparison is being made with data from terrestrial magnetism, earth currents, and strength and optical spectrum of the aurora and ionosphere. This has been completed for May 23, 1959, and the results are illustrated in a graph. — V. S. N.

- 187-433. Wakai, Noboru. Seasonal variation of f_oF_2 and abnormal ionization in F region at Syowa Base in Antarctica [with Japanese abstract]: Antarctic Rec., no. 11, p. 195-199, 1961.

The results of analyses of vertical sounding of the ionosphere at Syowa Base (lat 69°00' S., long 39°35' E.) for the period February 1959 through January 1960 are reported. The correspondence of monthly median values of f_oF_2 between Arctic and Antarctic regions and the abnormal ionization in the F region are discussed. The diurnal variations of the monthly median values of f_oF_2 in each month show a systematic delay in the appearance of the maximum value of f_oF_2 after 12 noon. A comparison of data from stations in both the Arctic

and Antarctic auroral zones shows a fixed delay time to be consistent at each station. It is observed that the delay time of E and F1 layers have a simple correlation with the zenith angle of the sun, but that of the F2 layer has a complex correlation with the solar zenith angle and the geomagnetic longitude.

It is proposed that the abnormal ionization in the F region should be listed in the table of ionospheric characteristics in high latitude. These abnormal traces, which are neither normal nor oblique and transient, often occur in the ionograms observed at Syowa Base; these so-called F's traces generally appear just before or after the time when Es ionization or polar black-out occurs. — V. S. N.

- 187-434. Davis, T. Neil. An investigation of the morphology of the auroral displays of 1957-58: Alaska Univ. Geophys. Inst. Sci. Rept., no. 1, 107 p., 1961.

The results of a study of auroral morphology based on the all-sky camera records obtained during the International Geophysical Year from a close-spaced network of stations in Alaska and from an array of stations extending from Choteau, Mont., across Canada to Thule, Greenland, are reported. The aspects studied include the time and latitude dependency of the incidence, azimuthal alinement, and direction of horizontal motion of auroral forms, and the relation of these aspects to magnetic disturbance. Detailed analyses of individual auroral displays and the concurrent magnetic disturbance indicate detailed association of the alinement and direction of motion of auroral forms with the density and direction of ionospheric currents. The ionospheric current flow is generally parallel to the alinement of auroral forms and is opposite in direction to the observed motion within the forms. — V. S. N.

- 187-435. Afanas'yeva, V. I., and Kalinin, Yu. D. Ochen' bol'shiye i bol'shiye geomagnitnyye buri i nekotoryye voprosy ikh teorii [Very great and great geomagnetic storms and certain problems of their theory]: Akad. Nauk SSSR, 3d Sess. IGY Program, no. 4, Geomagnetic disturbances, p. 5-14, 1960.

The theory of geomagnetic storms is discussed on a basis of the data given in the geomagnetic storms catalogues for 1878-1959. The storms are considered to be due to turbulence caused by corpuscular solar emission streaming through interplanetary plasma. By applying the principles of magnetohydrodynamics to the turbulence of the plasma, it was found that the magnetic field around the earth can be amplified by 600 times or more. A 30-year period in the duration of moderate magnetic storms was detected. A periodic variation in density of the interplanetary medium is considered as a contributing agent, causing a displacement of the maximum in the number of storms in the 11-year cycle. — A. J. S.

- 187-436. Akasofu, S-I [Syun-Ichi], and Chapman, S[ydney]. The sudden commencement of geomagnetic storms: Vrania, no. 250, 35 p., 1960; reprinted in Alaska Univ. Geophys. Inst. Contrib., ser. B, no. 54, 1961.

Many magnetic storms begin suddenly and simultaneously all over the earth. These sudden commencements are denoted by Sc; different local types that may be distinguished by the sign and order of sudden changes of horizontal intensity are denoted by Sc(+), Sc(-+), Sc(+), Sc(-), and Sc(++). The known statistical facts are summarized for the daily and yearly variations of frequency and amplitude of Sc's of different types, and for Si's (the sudden im-

pulses shown sometimes by magnetographs) that are not followed by any easily recognizable storm. The conventional current diagrams for the external primary Sc field are analyzed in two parts, one part being of type Sc(+), the other corresponding to a current system that is strongest in polar regions and probably generated there. The combination of the two parts, in different proportions at different places, explains the production of different local types of Sc. Theoretical explanations of Sc are discussed. The Sc(+) part of the field is attributed to field changes produced by sudden retardation of a stream of ionized solar gas impinging on the earth's field at a distance of a few earth radii. The polar current system is thought to be energized by entry of solar particles (or alternatively shock waves) into the polar regions. The Sc(+) field change appears to be transmitted to the earth's surface by hydromagnetic waves. A bibliography of 92 references is included. — V. S. N.

187-437. Akasofu, Syun-Ichi, and Chapman, Sydney. A study of magnetic storms and auroras: Alaska Univ. Geophys. Inst. Sci. Rept., no. 7, 209 p., 1961.

New notations for magnetic disturbance fields are proposed, based on the theoretical consideration of the electric current systems by which they are produced. A typical magnetic storm begins when the onrush of the front of the solar gas is halted by the earth's magnetic field. This effect (DCF field) is observed as a sudden increase of the horizontal component of the earth's field (ssc). The change of the field during ssc is often complex; such complexity is ascribed to a current system generated in the polar ionosphere (DP current). Changes of electromagnetic conditions in the polar regions are communicated, without delay, to lower equatorial latitudes, even to equatorial regions. The equatorial jet is affected by such a change and produces the abnormal enhancement of ssc along the magnetic dip equator.

Extensive analysis of several magnetic storms indicates that capture of the solar particles in the outer geomagnetic field occurs when irregularities embedded in the solar stream impinge on the earth. The motions and resulting currents and magnetic fields of such "trapped" solar particles are studied in detail for a special model. It is proposed that during the storm a transient "storm-time" belt or ring current appears well outside the outer radiation belt at about 6 earth radii. When the ring current is appreciably enhanced, the earth's magnetic field is reversed in limited regions. This involves the formation of neutral lines of two types one of which is connected with the auroral ionosphere by lines of force and could be the source of particles that produce the aurora polaris. Several typical DP substorms resulting from the appearance of the auroral electrojet, when the aurora changes from the diffuse to the active form, are studied. — V. S. N.

187-438. Chapman, S[Sydney], and Kendall, P. C. An idealized problem of plasma dynamics that bears on geomagnetic storm theory: oblique projection: Jour. Atmos. Terrest. Physics, v. 22, no. 2, p. 142-156, 1961.

An exact solution is given for the problem of a cylindrical neutral sheet of plasma with given initial surface density of angular momentum which advances into a unidirectional magnetic field whose intensity at distance r from the axis varies as $1/r^3$. The initial densities of charge (\pm) and of angular momentum determine the particle orbits and the distance of closest approach of the sheet. This problem has a bearing on the efficiency of the geomagnetic field as a scatterer of particles in an incident solar stream. Some of the particles will be turned back toward the sun. — D. B. V.

- 187-439. Dessler, A. J., Hanson, W. B., and Parker, E. N. Formation of the geomagnetic storm main-phase ring current: Jour. Geophys. Research, v. 66, no. 11, p. 3631-3637, 1961.

It is suggested that hydromagnetic waves generated by the impact of solar plasma on the geomagnetic field may form shock waves in the magnetosphere, thus providing a mechanism for establishing the diamagnetic main-phase ring current. If so, the decay time of the ring current should be less during years of sunspot minimum than during sunspot maximum. — D. B. V.

- 187-440. MacDonald, Gordon J. F. Spectrum of hydromagnetic waves in the exosphere: Jour. Geophys. Research, v. 66, no. 11, p. 3639-3670, 1961.

A disturbance in the exosphere generates waves in three partially separable modes. The modes are described by considering the vorticity about a line of force, the two-dimensional divergences of velocity in the plane perpendicular to the line of force, and the component of velocity along the line of force. The propagation of vorticity is one-dimensional and there is no geometrical attenuation. It is suggested that this mode is associated with the sudden commencement of a magnetic storm. High-frequency micropulsations may also be associated with vorticity mode propagation. — D. B. V.

- 187-441. Bell, Barbara, Major flares and geomagnetic activity: Smithsonian Contrib. to Astrophysics, v. 5, no. 7, p. 69-83, 1961.

Relations between geomagnetic activity and major (importance $\geq 2+$) solar flares are studied with primary attention to magnetic type and location of the flaring sunspot group. The data cover the years 1937-59 and include 580 observed major flares. It is found that a major flare occurring in association with a magnetically complex (γ or $\beta\gamma$) sunspot group is much more likely to be followed by a major geomagnetic storm than is a similar flare in a unipolar (α) or bipolar (β) group. Great-storm flares show the expected concentration toward the central regions of the solar disc, and also an unexpected concentration in the northern solar hemisphere. In the 23 years studied, northern spot groups produced 62 percent of all observed major flares, and 86 percent of those followed within 3 days by a great geomagnetic storm. This north predominance of great-storm flares appears about equally in each of the three sunspot maximum covered and is apparently not related to the 11-year or 12-year solar cycles. — Author's abstract

- 187-442. Chapman, Sydney. Sun storms and the earth: The aurora polaris and the space around the earth: Am. Scientist, v. 49, no. 3, p. 249-284, 1961.

A new theory for the origin of the aurora polaris developed over the past few years by Chapman and Akasofu (see Geophys. Abs. 181, 354, 185-432, 187-437) is reviewed. A general description is given of the form and location of the aurora in both the Northern and Southern Hemispheres followed by a discussion of the intimate connection between the aurora and the magnetic field of the earth and between the aurora and the sunspot cycle, the height of aurooras, their geographical location, the nature of auroral light, solar streams and clouds, and the development of auroral theory beginning with Birkeland's. The earth's magnetic shield and DCF magnetic disturbance, the capture of some solar gas by the geomagnetic field, and its behavior as a prisoner and as the source of the small minority of particles that travel down the lines of force into our atmosphere are discussed. — V. S. N.

- 187-443. Dessler, A. J. The stability of the interface between the solar wind and the geomagnetic field: *Jour. Geophys. Research*, v. 66, no. 10, p. 3587-3590, 1961.
- Coleman, P. J., Jr., and Sonett, C. P. Note on hydromagnetic propagation and geomagnetic field stability: *Jour. Geophys. Research*, v. 66, no. 10, p. 3591-3592, 1961.

Dessler presents evidence to show that the interface between the solar wind and the geomagnetic field is stable in a gross sense. Those world-wide fluctuations that are transmitted from the interface to the earth's surface by hydromagnetic waves must then be due solely to energy-density fluctuations in the solar wind. If so, theories of aurora, Van Allen radiation, or magnetic storms that utilize the concept of turbulent solar injection in an important way must be reexamined.

Coleman and Sonett point out that Dessler's use of surface observations of magnetic activity to estimate the conditions at great distances above the surface is not valid in the light of available data. Hydromagnetic disturbances as great as 100% have been observed in the distant geomagnetic field by space probes, with no associated effects observed on the ground. — D. B. V.

- 187-444. Ondoh, T. A possible explanation of sc* observed at high geomagnetic latitudes: *Jour. Atmos. Terrest. Physics*, v. 21, no. 4, p. 284-287, 1961.

It is deduced that the preliminary reverse impulse of sc* is generated by a dynamo action of ionization due to high speed charged particles (10^4 km/s) impinging on the high latitude ionosphere or an initial diamagnetic effect due to such charged particles spiraling about the geomagnetic lines of force, and that hydromagnetic waves propagating along the geomagnetic line of force from the geomagnetic equatorial plane to the earth's surface cause the main impulse of sc* at high latitudes. Other hydromagnetic waves propagating obliquely or perpendicular to the geomagnetic lines of force cause the sudden increase of the geomagnetic field at low latitudes.

This model can explain the observation that sudden commencements have been registered earlier at high latitudes than at low latitudes and that the preliminary reverse impulse has preceded the main sc* impulse by one or two minutes. The model requires that ordinary sc at low latitudes should occur several tens of seconds earlier than the main impulse of sc* at high latitudes. Distortion of the geomagnetic field by impact of solar plasma has not been taken into account in these considerations. — D. B. V.

- 187-445. Yoshimatsu, T[akasaburo]. Universal time daily inequality of the time of maximum depression of ssc in storm-time [with Japanese abstract]: *Kakioka Magnetic Observatory Mem.*, v. 9, no. 2, p. 75-81, 1960.

One of the results of a study of the time characteristics of geomagnetic storms observed at the Kakioka Magnetic Observatory, Kakioka, Japan, during the period 1924 to 1959, is discussed. It was found that the time of maximum depression of the horizontal intensity of ssc measured during a geomagnetic storm undergoes a universal diurnal inequality; a predominant maximum and minimum occur near 14 hr and 8 hr, and a minor maximum and minimum occur at 20 hr and 17 hr. This characteristic was checked for each of three groups of storms, classified on the basis of size, and was further confirmed by comparison with results from observatories at Tucson, San Juan, Abinger, Wingst, and Huancayo. — V. S. N.

- 187-446. Yasuhara, M., and Maeda, H[iroshi]. Geomagnetic crochet of 15 November 1960: *Jour. Atmos. Terrest. Physics*, v. 21, no. 4, p. 289-293, 1961.

The unusually large geomagnetic bay of November 15, 1960 is described. The pattern of ionospheric currents necessary to produce the horizontal component of the bay is shown on a map. The evidence favors the conclusion that there must have been considerable penetration of solar X-rays into the D-region at the time of maximum development of the solar flare; this played an important role in the occurrence of sudden ionospheric disturbance and the large geomagnetic bay. — D. B. V.

- 187-447. Niblett, E. R. Geomagnetic variations between November 12 and November 16, 1960: *Canadian Jour. Physics*, v. 39, no. 4, p. 619-622, 1961; also in *Dominion Observatory Ottawa Contrib.*, v. 5, no. 8, 6 p., 1961.

Exceptionally large geomagnetic disturbances have been reported from observatories in many parts of the world during the interval November 12-16, 1960. Records of these disturbances at the Canadian stations at Victoria, Agincourt, Meanook, Baker Lake, and Resolute are described briefly. — D. B. V.

- 187-448. Stavrou, A[ngelos]. The Magnetic Observatory of Pendeli (Athens, Greece): *Geofisica Pura e Appl.*, v. 46, p. 95-109, 1960.

The new Pendeli Magnetic Observatory near Athens began operating in April 1958. Its location, foundation, physical plant, and instrumentation are described. The H and Z variometers are of the magnetic balance type; a fiber suspension declinometer is used for D. Absolute measurements are made with an Askania field magnetic theodolite; absolute declination is determined in a fiber declinometer, and absolute H is measured both by the classic Gauss method and, since 1959, by means of a QHM magnetometer. Inclination is measured by an earth inductor forming part of the magnetic theodolite. — D. B. V.

MAGNETIC PROPERTIES AND PALEOMAGNETISM

- 187-449. Sholpo, L. Ye. Sravnitel'nyye issledovaniya nekotorykh magnitnykh svoystv normal'no i obratno namagnichennykh effuzivnykh bazal'tov [Comparative investigations of certain magnetic properties of directly and inversely magnetized effusive basalts]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 6, p. 864-870, 1961.

From paleomagnetic investigations of the Pliocene effusive basalts of the Far Eastern Region of the U. S. S. R., a statistical analysis was made of correlations between systematic physical and chemical parameters of normally (N) and reversely (R) magnetized rocks. Certain magnetic properties of N and R samples are substantially and systematically different. From a comparison of field and laboratory studies of magnetic viscosity it was determined that viscous magnetization cannot be the only cause of I_n and Q differences of differently polarized samples. The observed reversed polarity of I_n of the samples can be explained both by the inversions of the earth's magnetic field as well as by one of the physical-chemical processes of self-reversal of thermoremanent magnetization. — A. J. S.

- 187-450. Smit, J., and Wijn, H. P. J. *Ferrites*: New York, John Wiley and Sons. 369 p., 1959.

The term "ferrites" is used to refer to all magnetic oxides containing iron as a major metallic component. In this text, the physical properties of ferromagnetic oxides in relation to their technical applications are discussed on an intermediate level. Part A, theory, includes the following chapters: on the properties and the origin of magnetic fields in matter, theory of ferromagnetism, ferrimagnetism, magnetic anisotropies, magnetization processes, and dynamics of magnetization processes. Part B discusses methods of measuring ferromagnetic properties, and part C the intrinsic properties of ferrites with spinel structure, with hexagonal structure, and with garnet structure. Part D deals with the polycrystalline ferrites: their structure, electrical properties, static initial permeability, frequency-dependence of the initial permeability, static hysteresis loops, and dynamic properties at high field strengths. — V. S. N.

- 187-451. Kern, John W. Effects of moderate stress on directions of thermoremanent magnetization: *Jour. Geophys. Research*, v. 66, no. 11, p. 3801-3805, 1961.

Experiments designed to test the effects of directed stress on the thermoremanent magnetization (TRM) of igneous and metamorphic rocks are described. Basalt and andesite specimens exhibited no anomalous directions of TRM when cooled from 600°C under uniaxial stresses of up to 350 bars. Metamorphic rocks with preferred crystallographic orientations were found to exhibit anomalous directions of induced TRM after such treatment. These anomalous TRM directions were apparently related to the lineation of the specimens rather than applied stress. Residual magnetizations of the metamorphic specimens were found to approach the direction of the magnetizing field upon progressive alternating-field demagnetization. — Author's abstract

- 187-452. Kern, John W. Stress stability of remanent magnetization: *Jour. Geophys. Research*, v. 66, no. 11, p. 3817-3820, 1961.

A criterion is developed for determining the stress required to affect a given component of remanent magnetization. This criterion is associated with the process of alternating field (a-f) demagnetization currently used to eliminate unstable components of magnetization for paleomagnetic studies. It is concluded that any effects of magnetoelastic coupling, or magnetostriction, can be removed or minimized by a-f demagnetization, and that the components of magnetization that are most resistant to a-f demagnetization are most reliable for paleomagnetic measurements, especially if stress effects are thought to be present. — D. B. V.

- 187-453. Stott, P. M., and Stacey, F. D. Stress effects on thermoremanent magnetization: *Nature*, v. 191, no. 4788, p. 585-586, 1961.
Hall, J. M. Stress effects on thermoremanent magnetization: *Nature*, v. 191, no. 4788, p. 586, 1961.

Stott and Stacey point out that although Hall and Neale (see *Geophys. Abs.* 185-437) have reported more accurate measurements of the direction of remanent magnetization, they used specimens with appreciable intrinsic anisotropies (as much as 13 percent); therefore, their results are not inconsistent with those of Stott and Stacey (see *Geophys. Abs.* 176-268) concerning the effect of stress on remanent magnetization.

Hall replies that anisotropy appears to be of negligible importance in the production of thermoremanent stress effects, and that the anisotropies of the specimens used in the investigation were one percent or less in all but those having pyrrhotite as a magnetic component. — D. B. V.

- 187-454. Petrova, G. N. On magnetic stability of rocks: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 70-76, 1959.

This is an English version of the paper published previously in Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 52-61, 1957 (see Geophys. Abs. 169-229). — V. S. N.

- 187-455. Carmichael, C[harles] M. The magnetic properties of ilmenite-hematite crystals: Royal Soc. [London] Proc., ser. A, v. 263, no. 1315, p. 508-530, 1961.

The magnetic properties of ilmenite-hematite solid solutions have been investigated, using the unusually large and pure hemo-ilmenite crystals from the Allard Lake region of Quebec. The magnetic component of these crystals is an ilmenite-hematite phase (about 19 mole percent of ilmenite in hematite) present as exsolution lamellae roughly 5μ long, 1μ wide, and 0.2μ thick. The crystals have a very strong anisotropy causing magnetization in the basal plane and a weak anisotropy which produces an easy direction of magnetization within the basal plane.

An improved ilmenite-hematite solvus curve has been produced by X-ray and Curie-point analysis of heat-treated crystals. Spontaneous reversal of magnetic polarity takes place with change in temperature in ilmenite-hematite having between 15 and 25 percent of ilmenite in hematite. This new reversing range of composition is quite different from that found by Uyeda (see Geophys. Abs. 175-291). The reversal is due to a new antiparallel moment which grows as temperature falls. This may be explained by an ordering of Fe^{2+} ions on alternate cation layers by an electron transfer mechanism between trivalent and divalent Fe atoms. — D. B. V.

- 187-456. Everitt, C. W. F. Thermoremanent magnetization: I. Experiments on single domain grains: Philos. Mag., v. 6, no. 66, p. 713-726, 1961.

Certain predictions by Neel concerning the properties of thermoremanent magnetization in fine-grained materials were tested by examining the effects of alternating-field demagnetization on a specimen that had been given partial and total thermoremanence. As predicted, a positive correlation was found between the blocking temperature and coercive force of individual magnetic grains. In confirmation of another of Neel's predictions, the ratio j_T/j_S of thermoremanence to spontaneous magnetization in grains with a particular blocking temperature T_B was found to be proportional to the hyperbolic tangent of the magnetizing field; but j_T/j_S was found to be independent of the coercive force of the grains, in apparent disagreement with a third prediction. In addition, the blocking temperatures were found to be almost independent of the magnetizing field up to 50 oersteds. — D. B. V.

- 187-457. Girdler, R. W. Some preliminary measurements of anisotropy of magnetic susceptibility of rocks: Royal Astron. Soc. Geophys. Jour., v. 5, no. 3, p. 197-206, 1961.

Measurements have been made on four sets of rocks, two of which showed anisotropy of magnetic susceptibility and two were isotropic. The maximum and intermediate principal susceptibilities lie in the cleavage plane for some Welsh slates and in the horizontal plane for some igneous rocks of the Skaergaard layered intrusion. In both cases the directions of natural remanent magnetization have been affected. The two sets of isotropic rocks are from

the northern Pyrenees and Deccan of India, respectively. Both may have been affected by stress environments, the nature of which did not cause measurable anisotropy. It is unlikely that the directions of natural remanent magnetization have been affected for these rocks. — Author's summary

- 187-458. Rees, A. I. The effect of water currents on the magnetic remanence and anisotropy of susceptibility of some sediments: Royal Astron. Soc. Geophys. Jour., v. 5, no. 3, p. 235-251, 1961.

Study of the magnetic properties of fine silts deposited in the laboratory shows that the deviations of the directions of remanence and of maximum susceptibility caused by flow of water during deposition can be accounted for by an extension of the theory in which the sediment is considered as an assemblage of quasi-spherical particles which roll on deposition into hollows in the bed. The magnitude of the angle through which the particles are rotated is determined by an equilibrium between the shearing couple and the magnetic restoring couple.

A method is proposed for correcting for the effects of currents in natural sediments from measurements of their remanence and anisotropy of susceptibility, and a field test of its validity is suggested. — D. B. V.

- 187-459. Sasajima, Sadao. γ -Titanohematites in nature and the role they play in rock-magnetism: Jour. Geomagnetism and Geoelectricity (Kyoto), v. 12, no. 4, p. 190-215, 1961.

The laboratory techniques and results are reported of an investigation of the chemical, crystallographic, and magnetic properties of naturally occurring γ -hematites with titanium (γ -titanohematite or γ -tihatite). The occurrence of γ -tihatite is limited to pressure free and oxygen rich parts of the earth's crust; it is never found in deep-seated or metamorphic rocks unless they have suffered secondary alteration, but it does occur in igneous rocks such as propylite and altered green tuff and in some sediments. γ -tihatite is produced by low temperature hydrothermal oxidation of titanomagnetite, by the low temperature and very slow oxidation of titanomagnetite accompanying weathering, and by dehydration of lepidocrocite. The natural remanent magnetism is acquired at temperatures lower than the Curie point of the mineral and therefore may be attributed to chemical remanent magnetization or isothermal remanent magnetization. The intensity and stability of remanent magnetism of rocks containing γ -tihatite minerals are found to vary widely and are generally unstable as compared to that of titanomagnetite. — V. S. N.

- 187-460. Faynberg, F. S., and Semenov, A. S. Izmeneniye mineral'nogo sostava i magnitnoy vospriimchivosti zhelezosoderzhashchikh rud v zavisimosti ot temperatury [Change in mineral composition and magnetic susceptibility of iron-bearing ores depending on temperature]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 99-106, 1960.

An experimental study of high temperature effects on the magnetic susceptibility of weakly magnetized ore and other rocks due to variation in their mineralogical composition is reported. The samples were 4-5 cm cubes heated either in air or in a reducing medium to a temperature of 800°C. The results of the experiments are tabulated. — A. J. S.

- 187-461. Scott, G. G., and Meyer, André, J. P. Gyromagnetic ratio of pyrrhotite: Phys. Rev., v. 123, no. 4, p. 1269, 1961.

The gyromagnetic ratio of pyrrhotite, determined by measurements of the Einstein-deHaas effect, was found to be 1.9 ± 15 percent. — D. B. V.

- 187-462. Kalashnikov, A. G. Some results of investigation of magnetic properties of rocks and geological bodies; Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 77-84, 1959.

This is virtually the same paper as that published in Akad. Nauk SSSR, Komitet po geodezii i geofizike, Tezisy dokladov na XI general'noy assamblee Mezhdunarodnogo Geodezicheskogo i Geofizicheskogo Soyuzu [Theses of papers presented at the 11th general assembly of the International Union of Geodesy and Geophysics], p. 5-7, 1957 (see Geophys. Abs. 175-288). — V. S. N.

- 187-463. Larochelle, A. Design of a Curie point meter; Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Bull., no. 69, 18 p., 1961.

A torsion balance type instrument designed to determine the Curie point of ferromagnetic minerals in rock specimens is described in detail and illustrated. The instrument consists essentially of a torsion balance, a heating unit and thermocouple, an electromagnet, and a recording system. The Curie point of a substance is the temperature at which the substance loses its ferromagnetic properties (spontaneous magnetization) upon being heated. As this property depends entirely upon the chemical composition of the substance, it is useful in identifying the ferromagnetic members of a solid solution series present in a rock. Another application is the detection of the simultaneous presence in rocks of minerals of different Curie points. Such a coexistence has been proposed to account for in place reverse magnetic polarization of certain rocks. An investigation of this type in a suite of igneous rocks is described briefly. — V. S. N.

- 187-464. Bol'shakov, A. S. Ob ispol'zovanii astaticheskikh sistem malykh razmerov [Application of astatic systems of small dimensions]; Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 1025-1030, 1961.

The two astatic systems of Russian magnetometers used for paleomagnetic measurements are analyzed and compared: the Yanovskiy magnetometer with a distance $l=25-40$ cm between the magnets of the astatic system, and the Dolginov magnetometer with $l=7$ cm. The latter magnetometer is smaller and lighter weight. Its suspension filament is thinner; therefore, it has a higher sensitivity. The analysis was made to evaluate the experimental error due to the small value of l of Dolginov's magnetometer. It was found that the astatic system in which $l=\sqrt{2}R_{\min}$ gives the same sensitivity for magnetization as that produced by the system in which l is infinitely long (R_{\min} is the minimum distance along the bar from the sample to the magnet). The errors due to the smaller l were found to be either negligibly small, or could be eliminated by accurate construction of the apparatus and by an appropriate method of measurement. — A. J. S.

- 187-465. Creer, K. M. Superparamagnetism in red sandstones; Royal Astron. Soc. Geophys. Jour., v. 5, no. 1, p. 16-28, 1961.

Susceptibility measurements were made down to liquid hydrogen temperatures on a Keuper red mudstone with unstable remanent magnetization and on an Old Red sandstone with stable remanent magnetization. The results show that most of the magnetic content of the former is apparently paramagnetic, and that in the latter an apparent paramagnetic component is present together

with a component having a susceptibility independent of temperature. In both cases the magnetization-applied field relationship is nonlinear, suggesting that both rocks contain ferromagnetic material in a superparamagnetic state, with a calculated particle size of the order of 20 Å; this material is thought to be hydrous α -Fe₂O₃ constituting the cement. The remanent magnetization of red rocks is thought to be due in part to the larger grains of red cement and in part to black hematite grains; these are more abundant in the stable rock.

Magnetization of the cement might occur soon after formation, or during a sintering process during deep burial, or in some cases during geologically recent tropical weathering. The calculated grain size of about 20 Å for the superparamagnetic particles differs appreciable from that of about 1,000 Å previously estimated for the viscously magnetized particles. Experiments are in progress to resolve this anomaly. — D. B. V.

Kopf, Manfred, and Wawrzik, Martin. Acoustic velocity and susceptibility measurements on rocks of the Triassic and Zechstein from the western Thuringian basin. See *Geophys. Abs.* 187-572.

187-466. Vasil'yev, A. V., and Semenov, A. S. *Magnitnaya vospriimchivost' pochv* [Magnetic susceptibility of soils]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 110-113, 1960.

An investigation of the magnetic susceptibility of soils in eastern Transbaikal is reported. The K value for the soil was found to be several times larger than that of the bedrock (Jurassic deposits) and of alluvial conglomerates underlying the soil. Such an anomalous susceptibility is thought to be due to the presence of ferromagnetic minerals formed by biogenic activity. — A. J. S.

187-467. Stacey, F. D., Joplin, Germaine, and Lindsay, J. Magnetic anisotropy and fabric of some foliated rocks from S. E. Australia: *Geofisica Pura e Appl.*, v. 47, p. 30-40, 1960.

The magnetic anisotropy of several types of foliated rocks from southeast Australia, measured by the torque-meter method, shows that the alignment of long axes of magnetic grains in rocks normally follows the pattern of foliation evident in field observations. In a sharp fold in a lit-par-lit formation the magnetic anisotropy indicated an otherwise undetected lineation independent of the bedding, superimposed on the foliation determined by the layering. In two adamellites, each having two alignment patterns separated by an angle of 30°, the magnetic data are consistent with two foliations rather than with one foliation plus a lineation. Magnetic anisotropy data can be ambiguous for rocks in which two or more grain alignment processes have operated, but combined with other observations it can provide a valuable new tool in the study of rock fabrics. — D. B. V.

187-468. Khramov, A. N., Petrova, G. N., Komarov, A. G., and Kochevura, V. V. *Metodika paleomagnitnykh issledovaniy* [Methods of paleomagnetic investigations]: Leningrad, Gostoptekhizdat, 131 p., 1961.

Paleomagnetism is treated from the standpoint of the history of the earth's magnetic field; solution of problems of stratigraphy, geochronology, paleogeotectonics, and paleogeography; and certain problems of formation and evolution of rocks. After a discussion of the physical basis of paleomagnetism, the objectives and problems of paleomagnetic investigations are explained.

Subsequent chapters deal with the preparation for and conducting of paleomagnetic investigations at the desk, laboratory, and in the field. The field procedures include measurement of the natural magnetization I_n of samples, processing magnetometric data, stability evaluation of natural remanent magnetization of rocks, preparation of reports on paleomagnetic investigations, and solution of geophysical and geological problems. In conclusion, the basic unsolved problems of the methods of paleomagnetic investigations are discussed. — A. J. S.

- 187-469. Irving, E., Stott, P. M., and Ward, M. A. Demagnetization of igneous rocks by alternating magnetic fields: *Philos. Mag.*, v. 6, no. 66, p. 225-241, 1961.

Secondary components of magnetization in basalts, the presence of which often limits their usefulness in paleomagnetic studies, can be removed by alternating magnetic fields. The procedures are described and tests based on the internal consistency of the results are devised to judge their reliability. These are applied successfully to a series of measurements on specimens from the Tertiary basalts of New South Wales, Australia. The Early Tertiary pole position calculated from these measurements is lat 63° S., long 137° E., in good agreement with that calculated earlier for the Older Volcanics of Victoria (see *Geophys. Abs.* 170-244). — D. B. V.

- 187-470. Griffiths, D[onald] H[arrison], King, R[oy] F[avell], and Wright, A. E. An assessment of the difficulties involved in using Quaternary varved sediments for palaeomagnetic studies of the secular variation [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 11-14, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 515-518, 1958 (see *Geophys. Abs.* 176-264). — V. S. N.

- 187-471. DuBois, P. M. Palaeomagnetism and geological correlation [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 33-38, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 509-514, 1958 (see *Geophys. Abs.* 176-274). — V. S. N.

- 187-472. Blakett, P. M. S. Comparison of ancient climates with the ancient latitudes deduced from rock magnetic measurements: *Royal Soc. [London] Proc.*, v. 263, no. 1312, p. 1-30, 1961.

A systematic comparison has been made of the ancient magnetic latitudes of Europe, North America, India, Australia, and South Africa with the evidence of ancient climates as deduced from geological data, in particular from the distribution of salt, glaciations, and fossil corals. In spite of some discrepancies, the general agreement is close enough to lend support to the assumption that the ancient magnetic latitudes, calculated on the hypothesis of an axial dipole field, do represent also the ancient geographical latitudes. This support for the reliability of the magnetic data as a whole gives support for the hypothesis of continental drift and is opposed to the hypothesis that the earth's ancient field differed greatly from that of a dipole. — Author's abstract

- 187-473. Evison, F. F. Rock magnetism in western Europe as an indication of continental growth: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 320-335, 1961.

The paleomagnetic interpretation of rock magnetism has led to an increasingly elaborate set of geodynamic postulates, which now include polar wandering, continental drift, and the rotation of continents and parts of continents. An alternative approach is suggested by the hypothesis of widespread continual plastic flow of basement rocks. Remanence data for western Europe are analysed from this viewpoint, assuming that the position of the poles has always been virtually the same as at present. The inferred pattern of flow is away from the high standing interior and towards the Northeastern Atlantic Basin. The amount of flow increases with the age of the rock; an accelerated rate of flow is indicated during the Hercynian revolution and a relatively slow rate in more recent times. These results are in accord with the concept of continental growth by plastic flow under gravity. — Author's summary

187-474. Creer, K. M., Irving, E., Nairn, A. E. M., and Runcorn, S. K[ieith]. Paleomagnetic results from different continents and their relation to the problem of continental drift [with French abstract]: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 1-10, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 492-501, 1958 (see *Geophys. Abs.* 176-273). — V. S. N.

187-475. Irving, E. Paleomagnetic directions and pole positions, part 3. Pole numbers 3/1 to 3/87: *Royal Astron. Soc. Geophys. Jour.*, v. 5, no. 1, p. 70-79, 1961.

The results of 87 paleomagnetic determinations available since part 2 (see *Geophys. Abs.* 184-490) are compiled in a 20-column table. — D. B. V.

187-476. Bowen, Robert. Paleotemperature analyses of Belemnoides and Jurassic paleoclimatology: *Jour. Geology*, v. 69, no. 3, p. 309-320, 1961.

One hundred specimens of Jurassic Belemnoides of world-wide origin were analyzed and their paleotemperature record compiled from mass-spectrometric measurements; their δ -values in parts per mil are averages of whole specimens and are related to the standard PDB-1. Results obtained are compared with those of paleomagnetism and other fields of investigation. It is shown that in the Jurassic the earth had larger tropical and semitropical belts than at present. The positions of the poles remain uncertain but the North Pole probably occupied a position somewhere in east Asia; India lay in the temperature zone much farther from the equator than at present; Alaska and New Guinea were both cool-water areas; and the poles were much warmer than at present showing a temperature range around 20° as compared with about 60° today. — V. S. N.

187-477. Doell, Richard R., and Cox, Allan [V.]. Palaeomagnetism of Hawaiian lava flows: *Nature*, v. 192, no. 4803, p. 645-647, 1961.

Remanent magnetization has been measured on at least one specimen from each of 152 Hawaiian lava flows sampled so far. Results of these preliminary measurements are summarized as follows: (1) The historic flows have directions of magnetization closely grouped about the present geomagnetic field direction; (2) none of the flows shows reversed polarity; (3) the scatter in directions from flow to flow in a given sequence is much smaller than generally reported in comparable studies elsewhere; (4) the average directions of mag-

netization of most of the thick sequences appear to differ significantly both from the present geomagnetic field and from the theoretical dipole field, and average directions in different sequences differ from each other.

If the geomagnetic field reversal theory is true, all the flows sampled are younger than early Pleistocene. The results on the thick sequences suggest that low rates of secular variation have prevailed in Hawaii; the results from the historic flows support this interpretation, and direct measurements back to about 1900 also show less secular variation (less than 2 percent) than is typical elsewhere in the world. — D. B. V.

- 187-478. Larochelle, A. Application of palaeomagnetism to geological correlation: *Nature*, v. 192, no. 4797, p. 37-39, 1961.

Pole positions calculated from paleomagnetic measurements on rocks from Mount Megantic, 75 miles east of the Monteregian Hills in Quebec, are shown stereographically and compared with the positions inferred from rocks from the Monteregian Hills and dated rocks from elsewhere in North America. A Cretaceous age for both the Monteregian Hills and Mount Megantic is indicated. Recent K-Ar dating also confirms both the synchronicity and the Cretaceous age of the two rock units. — D. B. V.

- 187-479. Creer, K. M. Preliminary palaeomagnetic measurements from South America [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 15-32, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 3, p. 373-390, 1958 (see *Geophys. Abs.* 179-321). — V. S. N.

- 187-480. Wilson, R. L. Palaeomagnetism in Northern Ireland. Pt. 1—The thermal demagnetization of natural magnetic moments in rocks: *Royal Astron. Soc. Geophys. Jour.*, v. 5, no. 1, p. 45-58, 1961.

A paleomagnetic investigation of some hematite- and maghemite-bearing baked laterites underlying Tertiary lava in Northern Ireland is described. A thermal demagnetization technique eliminated a secondary component of magnetization along the present earth's field, revealing that the lava and baked laterite agree in direction. This allowed a determination of the strength of the earth's field (reversed at the time of baking) and the temperature of baking.

This determination of a geologically ancient field strength is particularly significant, as many such determinations from rocks of different ages might allow estimates of ancient latitudes for the various continents, independent of estimates derived from directions of magnetization. — D. B. V.

- 187-481. DuBois, R. L. Remanent magnetization of Carboniferous limestone: *Royal Astron. Soc. Geophys. Jour.*, v. 5, no. 3, p. 230-234, 1961.

The remanent magnetization of Carboniferous limestone contiguous to iron ore in England was measured. The average declination of S. 41° W. and inclination of -29° correspond to a pole position of lat 40° N., long 122° E. Intensities of remanent magnetization range between 0.4×10^{-6} and 27.5×10^{-6} emu per cm^3 . — D. B. V.

- 187-482. Bidgood, D. E. T. Differential secondary magnetization in some British Cambrian rocks: *Nature*, v. 192, no. 4797, p. 39-40, 1961.

Magnetic results were obtained for 11 out of 12 oriented specimens from 3 horizons in the Hartshill quartzites and Hyolithus limestones from 2 localities near Nuneaton, England. The direction of remanent magnetization of the quartzites was similar to that of Cambrian rocks from Wales, but the mean vector for the limestones was about 90° removed. After demagnetization both groups showed a reduction in the amount of scatter, and both showed a displacement toward the southwest that cannot be attributed to removal of a secondary component parallel to the present geomagnetic field. The change in intensities produced by a-c washing was markedly different (the limestones lost about 85 percent whereas the quartzites showed little change), suggesting that the two rock types have taken on very different components of secondary magnetization.

The observations may be explained as follows: The quartzites and limestones, both weakly magnetized parallel to the Cambrian geomagnetic field, were brought to or near the surface by uplift and erosion by Triassic time. While the thick Triassic red beds, now exposed to the northwest, were being deposited, the Cambrian rocks were penetrated by iron-bearing ground waters which, in depositing new iron minerals and oxidizing existing minerals to new forms, imposed a chemical remanent magnetization; as this process depended on permeability, it was more extensive in the limestones.

If the quartzites after washing give the true record, the Cambrian pole lay at lat 18° N., long 165° E.; this is in good agreement with those calculated for British and Norwegian Cambrian rocks. — D. B. V

- 187-483. Deutsch, E. R., Radakrishnamurty, C., and Sahasrabudhe, P. W. Palaeomagnetism of the Deccan Traps [with French abstract]: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 39-59, 1959.

This paper was published previously in Annales Géophysique, v. 15, no. 1, p. 1-21, 1959 (see Geophys. Abs. 177-303). — V. S. N.

- 187-484. Faynberg, F. S. Ob anomal'noy namagnichennosti trappov v nizhnem techenii r. Chuny [On the anomalous magnetization of traps on the lower course of the Chuna River]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 107-109, 1960.

The results of investigations of magnetic properties of 300 samples taken from 10 large trap outcrops in the Chuna River area of eastern Siberia are reported. It was found that in nine outcrops the remanent magnetization varies between -80° and -20° , and in one outcrop $i=+6^\circ$. It was also established that the angle of "inclination" of the I_r vector and the ratio of I_r/I_i have a correlation such that the traps of higher remanent magnetization have a large (about 80°) negative "inclination." — A. J. S.

- 187-485. Kochegura, V. V., and Sholpo, L. Ye. K voprosu o magnitnoy stabilnosti izverzhennykh porod [On the problem of magnetic stability of igneous rocks]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 149-156, 1960.

The magnetic properties were determined for rock samples taken on a 170 m profile in Eocene basaltic lava in the Far Eastern Region of the U. S. S. R. The directions of the vectors of natural remanent magnetization are distinctly different from the direction of the present magnetic field of the earth, having sometimes a reversed polarity. The experiments showed, however, that in

spite of the reversed polarity preserved for millions of years, the possibility of considerable changes both in direction and magnitude of magnetization of these rocks is not excluded. — A. J. S.

- 187-486. Sholpo, L. E. Paleomagnitnyye issledovaniya v zonakh perekhoda ot normal'no k obratno namagnichennym tolshcham [Paleomagnetic investigations in transition zones from normally to inversely magnetized formations]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 157-159, 1960.

The results of paleomagnetic investigations of samples taken from 14 outcrops of plateau basalts in the Primorskiy and Khabarovsk regions and in Kamchatka are discussed. The value of the Q -ratio of samples taken from normally magnetized layers of lava is on the average considerably greater than that taken from inversely magnetized layers. This observation is considered to be important for further investigations of the paleomagnetic problem. — A. J. S.

- 187-487. Kochegura, V. V., and Sholpo, L. Ye. Paleomagnitnyye issledovaniya dal'nevostochnykh bazal'tov [Paleomagnetic investigations of basalts from the Far East]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 160-164, 1960.

The results of paleomagnetic investigations of more than 500 samples taken from 26 outcrops in central Kamchatka, the Sovetskaya Gavan region, and the southern part of the Primorskiy region, U. S. S. R., are reported. According to their I_n vectors, the Neogene basalts are composed of alternate layers of normally and inversely magnetized lava. The coordinates of the magnetic poles calculated for each normally magnetized horizon were found to differ considerably from the coordinates determined for the inversely magnetized horizons. However, the mean position of the earth's magnetic pole during the period of the normal and reversed magnetization observed was found to coincide with the present position of the geographic pole of the earth. The positions of the magnetic pole during the Neogene suggest two components of magnetic moment of the earth: the M_a component along the geographic axis of the planet, and the M_e component in the plane perpendicular to M_a . The first determines the polarity of the earth's magnetic field and undergoes periodic inversion, while the M_e component (1/10 of the total magnetic moment) maintains an approximately constant direction. A certain correlation between secular variation of the earth's magnetic field and the process of extrusion of lava flows is suggested. — A. J. S.

- 187-488. Hibberd, F. H. Secondary magnetization and the palaeomagnetism of some Pliocene rocks of Japan: Jour. Geomagnetism and Geoelectricity [Kyoto], v. 12, no. 4, p. 222-226, 1961.

The effect of secondary magnetization on the apparent position and polarity of a paleomagnetic pole is examined and applied to measurements made by Momose [see Geophys. Abs. 178-298] on Pliocene rocks. It appears that in the Lower-Middle Pliocene the pole was near 70° N., 150° W., and that the polarity in the Lower Pliocene was normal and in the Middle Pliocene was reversed. A reversal of the earth's field appears to have occurred near the Lower-Middle Pliocene boundary. — Author's abstract

- 187-489. Green, Ronald. Palaeomagnetism of some Devonian rock formations in Australia: Tellus, v. 13, no. 1, p. 119-126, 1961.

The directions of remanent magnetization are found to be remarkably consistent throughout the Canberra volcanics and porphyries, the Murrumbidgee sandstones, and the Nethercote basalts in southern New South Wales, Australia; these formations are Late Silurian-Early Devonian, Middle Devonian, and Late Devonian in age. The low inclination indicates that throughout this period Australia lay $10-15^\circ$ away from the equator, the pole lying in the South Atlantic at lat 64.9° S., long 19.6° W. The rocks are evidently magnetically stable. The paleomagnetic data support the belief that southeast Australia experienced tropical conditions during the Devonian. — D. B. V.

187-490. Boesen, R., Irving, E., and Robertson, W. A. The palaeomagnetism of some igneous rock bodies in New South Wales: Royal Soc. New South Wales Jour. and Proc., v. 94, pt. 6, p. 227-232, 1961.

Measurements of direction and intensity of magnetization of rock specimens from four igneous bodies—Prospect intrusion, Gibraltar syenite, Gingenbullen dolerite, and some Tertiary basalts—in eastern New South Wales are given in tables, and the interpretation of the results discussed. The directions of natural remanent magnetization in the Prospect dolerite, the Gibraltar syenite, and the Gingenbullen dolerite (after treatment in 150 oersteds) are stable and may be identified with the direction of the geomagnetic field at the time these intrusions cooled. Assuming that the geomagnetic field at those times was that of a geocentric dipole, the pole positions (south) are calculated and found to be in the region of Tasmania near the pole obtained previously for the Tasmanian dolerites (see Geophys. Abs. 166-280) but lower in latitude than that obtained for the Older Volcanics of Victoria (see Geophys. Abs. 173-290). This suggests that these intrusions are older than the latter and of an age comparable to the former, that is, they are Mesozoic.

The study of the Tertiary basalts (Berrima, Moss Vale, and Robertson area) is part of a general paleomagnetic study of Tertiary basalts of New South Wales. The stability results will be reported in another paper. — V. S. N.

MAGNETIC SURVEYS

187-491. Alldredge, Leroy R., and Van Voorhis, Gerald D. Depth to sources of magnetic anomalies: Jour. Geophys. Research, v. 66, no. 11, p. 3793-3800, 1961.

The characteristics of several long magnetic total field intensity profiles, all nearly straight and more than 2,000 miles long, have been determined. After obtaining a real nondipole field by subtracting the centered dipole field total intensity, a smooth curve was drawn through this nondipole field using a stiff spline curve. The distance between crossover points of the smooth field and the nondipole field was determined and the results plotted on a histogram.

The results confirm the fact that most anomalies have a very short wavelength; 93 percent had crossover distances of less than 60 nautical miles. The form of the smooth curves indicates a nearly sinusoidal departure from a dipole field having crossover points between 2,100 and 5,200 nautical miles. The most natural explanation is that the short-wave length anomalies are due to crustal effects and the long-wave length anomalies to causes within the core. The large gap between groupings supports the hypothesis that the mantle is a forbidden region for magnetic sources. Calculations based on simple models illustrate this conclusion. — D. B. V.

- 187-492. Wesley, James Paul. Oscillating vertical magnetic dipole above a conducting half-space: California Univ. Lawrence Radiation Lab., UCRL-6467, 17 p., 1961.

The electromagnetic field produced by a vertical oscillating magnetic dipole above a plane conducting earth is obtained in integral form. An exact solution in closed form is obtained for the dipole and the point of observation located on the surface of the earth. For points of observation less than a wavelength in the conducting earth away from the source, $k_1\rho \ll [k_2\rho] \ll 1$, the magnetic field varies as ρ^{-3} and the electric field as ρ^{-2} . For distances from the source greater than a wavelength in the conducting earth but less than a wavelength in air, $k_1\rho \ll 1 < [k_2\rho]$, the magnetic field varies as ρ^{-m} where $2 < m < 3$, and the electric field as ρ^{-n} where $2 < n < 3$. For distances greater than a wavelength in air, both the electric and magnetic field components vary as ρ^{-2} . — V. S. N.

- 187-493. Smith, R. A. Some theorems concerning local magnetic anomalies: Geophys. Prosp., v. 9, no. 3, p. 399-410, 1961.

Formulas are derived and discussed that can be applied, with negligible computation, to either total field or vertical magnetometer observations to yield limits to the depth and intensity of magnetization of the disturbing bodies. (See also Geophys. Abs. 177-305.) — D. B. V.

- 187-494. Watkins, N. D. The relative contributions of remanent and induced magnetization to the observed magnetic field in northeastern Alberta: Geophys. Prosp., v. 9, no. 3, p. 421-426, 1961.

The ratios of induced to remanent magnetic intensities have been determined for samples of Precambrian rock from the Canadian shield in northeastern Alberta. The remanent magnetization is found to be relatively insignificant and can be assumed to be zero in interpretation of magnetic anomalies.

Some other implications of the magnetic measurements are discussed briefly. These include the use of reverse remanent magnetization as an indication of overturning; the decrease of intensity of remanent magnetization with age, and the value of an aeromagnetic map in resolving some geologic mapping problems in a highly diversified metamorphosed area. — D. B. V.

- 187-495. Polonskiy, A. M. Ovychnisleniy magnitnykh momentov trekhmernykh tel [On calculation of magnetic moments of three-dimensional bodies]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 871-875, 1961.

The magnetic moments (M) of spherical or prolate ellipsoidal bodies are discussed, and an approximate method of calculation is proposed. Instead of using the horizontal component H of the field in the calculation, a formula using the vertical field component Z is proposed: $M = -\frac{1}{2\pi} \iint X(\xi, \eta) \xi d\xi d\eta$, where X is a projection of the horizontal component, H, on the x-axis. This formula is applicable for any nonvertical magnetization of these bodies, and for the sphere the maximum error is 6.4 percent (see also Mikov, Geophys. Abs. 169-240). — A. J. S.

- 187-496. Ponomarev, V. N. Vertikal'nyye gradiyenty vertikal'noy sostavlyayushchey magnitnogo polya i tekhnika ikh izmereniy [Vertical

gradients of the vertical component of the magnetic field and the technique of their measurements]: *Prikladnaya Geofizika*, no. 25, p. 157-176, 1960.

This is a mathematical analysis of variation characteristics of the magnetic field gradient Z'_z when measured simultaneously with its anomalous vertical component Z by a magnetometer of the MP-1 type. The vertical gradients Z'_z for spherical bodies and for an infinitely extended horizontal layer are calculated, and anomalies of Z and Z'_z produced by several bodies are discussed. The methods of depth determination for disturbing bodies of simple geometry are given. Errors in determination of geophysical parameters by the methods discussed are evaluated, and suggestions are made for improvement in the technique of Z'_z determination. — A. J. S.

Troshkov, G. A., and Shalayev, S. V. Application of Fourier transformation to solutions of the inverse problem of gravity and magnetic prospecting. See *Geophys. Abs.* 187-289.

Avdulov, M. V. On interpretation of gravity and magnetic observations by the method of theoretical fields. See *Geophys. Abs.* 187-296.

187-497. Jensen, Homer. The airborne magnetometer: *Sci. American*, v. 204, no. 6, p. 151-156, 158-162, 1961.

The revolution in mineral exploration brought about by the use of the airborne magnetometer and related techniques is discussed. The nature of the magnetic field of the earth and its regional irregularities and small scale disturbances that may be detected by the airborne instruments are reviewed. Characteristic anomaly curves and results in terms of contour maps are shown. The nature of the magnetometer and a typical installation in a plane are described and illustrated. — V. S. N.

187-498. Jenny, W. P. High aeromagnetic accuracy provides detailed coverage: *World Oil*, v. 153, no. 4, p. 90-92, 1961.

With present instruments and techniques, continuous aerial micromagnetic profiles can be surveyed for 50-100 miles with an accuracy that can be reproduced to $\pm \frac{1}{2}$ gamma. A dual level arrangement is used in which one instrument is attached to the tail of the aircraft and the other is flown on a cable 200 feet below. This arrangement allows selection of the more effective level of operation. Records of profiles flown over a salt dome in the Gulf of Mexico illustrate the reproducibility of measurements by the micromagnetic method. — J. W. C.

187-499. Rikitake, Tsuneji, and Tanaoka, Iwao. A differential proton magnetometer: *Tokyo Univ. Earthquake Research Inst. Bull.*, v. 38, pt. 2, p. 317-328, 1960.

A magnetometer that records the difference in total geomagnetic intensity between two points is described. By mixing the signals caused by free precession of protons from the two detecting coils, the best signal is recorded on a pen-writing oscillograph. Present accuracy of the differential magnetometer is about 0.2γ per 10 m; this can be increased by increasing the distance between the coils. The apparatus was designed to detect very local anomalies accompanying activity of Mihara Volcano. — D. B. V.

- 187-500. Kudryavtsev, Yu. I. Chastotnyy metod izmereniya v karotazhe magnitnoy vospriimchivosti [The frequency method of measuring in logging of magnetic susceptibility]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 87-98, 1960.

The pickup system for the magnetic susceptibility method of logging is discussed, and two variants of this instrument are proposed. The pickup consists of a cylindrical induction coil of length l having a core of diameter d and an effective permeability μ_d . It is operated on a stabilized current of frequency f and voltage V in its coil when in the air. The voltage V changes for a value $\Delta V = \text{function}(\mu \delta D)$ when placed in a borehole; μ is the rock permeability (the susceptibility K may be used instead), δ is the rock's electric conductivity, and D is the borehole diameter. The circuit diagrams for the K-logging apparatus based on the frequency-impulse principle and the frequency-semiconductor are given. The apparatus was tested in a borehole in the area of an iron deposit and showed a satisfactory performance. — A. J. S.

- 187-501. Bromery, Randolph W., Zandle, Gerald L., and others. Aeromagnetic maps of Pennsylvania: U. S. Geol. Survey Geophys. Inv. Map GP-239-GP-245, GP-254-GP-259, GP-266-GP-268, GP-270-GP-278, and GP-280-GP-282, 1961.

Aeromagnetic maps have been published at a scale of 1:24,000 (1 inch = about 2/5 mi) for the following: 239, Womelsdorf quadrangle, Berks, Lebanon, and Lancaster Counties; 240, Sinking Spring quadrangle, Berks and Lancaster Counties; 241, Ephrata quadrangle, Lancaster County; 242, Terre Hill quadrangle, Lancaster and Berks Counties; 243, Leola quadrangle, Lancaster County; 244, New Holland quadrangle, Lancaster County; 245, Gap quadrangle, Lancaster County; 254, Lebanon quadrangle, Lebanon County; 255, Richland quadrangle, Lebanon and Lancaster Counties; 256, Manheim quadrangle, Lancaster and Lebanon Counties; 257, Lititz quadrangle, Lancaster and Lebanon Counties; 258, Columbia East quadrangle, Lancaster County; 259, Lancaster quadrangle, Lancaster County; 266, part of the Alburtis quadrangle, Lehigh, Berks, and Northampton Counties; 267, part of the Hummelstown quadrangle, Dauphin County; 268, part of the Palmyra quadrangle, Dauphin and Lebanon Counties; 270, York quadrangle, York County; 271, Red Lion quadrangle, York County; 272, Glen Rock and part of the New Freedom quadrangles, York County; 273, part of the Bernville quadrangle, Berks County; 274, part of the Mechanicsburg quadrangle, Cumberland and York Counties; 275, New Cumberland quadrangle, Cumberland, Dauphin, and York Counties; 276, part of the Mount Holly Springs quadrangle, Adams, Cumberland, and York Counties; 277, part of the Dillsburg quadrangle, Adams, York, and Cumberland Counties; 278, part of the Arendtsville quadrangle, Adams and Cumberland Counties; 280, Hampton quadrangle, Adams and York Counties; 281, Abbottstown quadrangle, Adams and York Counties; and 282, West York quadrangle, York County. — W. L. G.

- 187-502. Bromery, Randolph W., Natoff, Nora C., and others. Aeromagnetic maps of Pennsylvania: U. S. Geol. Survey Geophys. Inv. Map GP-269, and GP-284-GP-287, 1961.

Aeromagnetic maps have been published at a scale of 1:24,000 (1 inch=about 2/5 mile) for the following: 269, Middletown quadrangle, Dauphin, Lancaster, Lebanon, and York Counties; 284, Gettysburg quadrangle and part of the Taneytown quadrangle, Adams County; 285, McSherrystown quadrangle and part of the Littlestown quadrangle, Adams County; 286, Hanover quadrangle

and part of the Manchester quadrangle, Adams and York Counties; and 287, Seven Valleys quadrangle and part of the Lineboro quadrangle, York County, — W. L. G.

- 187-503. Bromery, Randolph W., White, Bernard L., and others. Aeromagnetic map of part of the Fairfield quadrangle and part of the Emmitsburg quadrangle, Adams County, Pennsylvania, and Frederick County, Maryland: U. S. Geol. Survey Geophys. Inv. Map GP-283, 1961.

This aeromagnetic map shows by contour lines the total intensity at about 500 feet above ground level for part of the Fairfield quadrangle, Adams County, Pennsylvania, and part of the Emmitsburg quadrangle, Frederick County, Maryland. — W. L. G.

- 187-504. Eargle, D. H[oye], Trumbull, J. V. A., and Moxham, R[obert] M. Preliminary aeroradioactivity and geologic maps of Texas: U. S. Geol. Survey Geophys. Inv. Map GP-246, GP-248, and GP-251, 1961.

Preliminary aeroradioactivity and geologic maps that show by contour lines the total intensity at about 500 feet above ground level have been published for the following: 246, Floresville SE quadrangle, Karnes and Wilson Counties; 248, Stockdale SE quadrangle, Karnes, De Witt, and Wilson Counties; and 251, Karnes City NW quadrangle, Karnes County. — W. L. G.

- 187-505. Trumbull, J. V. A., Eargle, D. H[oye], and Moxham, R[obert] M. Preliminary aeroradioactivity and geologic map of the Stockdale SW quadrangle, Karnes and Wilson Counties, Texas: U. S. Geol. Survey Geophys. Inv. Map GP-247, 1961.

This preliminary aeroradioactivity and geologic map has been published at a scale of 1:31,680 (1 inch = about 1/2 mile) for the Stockdale SW quadrangle, Karnes and Wilson Counties. — W. L. G.

- 187-506. Brown, R. D. Jr., Eargle, D. H[oye], and Moxham, R[obert] M. Preliminary aeroradioactivity and geologic maps of Texas: U. S. Geol. Survey Geophys. Inv. Map GP-249 and GP-250, 1961.

The following preliminary aeroradioactivity and geologic maps have been published at a scale of 1:31,680 (1 inch = about 1/2 mile): 249, Falls City NW quadrangle, Atascosa, Karnes, and Wilson Counties; and 250, Falls City NE quadrangle, Karnes and Wilson Counties. — W. L. G.

- 187-507. Eargle, D. H[oye], Brown, R. D., Jr., and Moxham, R[obert] M. Preliminary aeroradioactivity and geologic map of the Falls City SW quadrangle, Atascosa, Karnes, and Live Oak Counties, Texas: U. S. Geol. Survey Geophys. Inv. Map GP-252, 1961.

This preliminary aeroradioactivity and geologic map has been published at a scale of 1:31,680 (1 inch = about 1/2 mile) for the Falls City SW quadrangle, Atascosa, Karnes, and Live Oak Counties. — W. L. G.

- 187-508. Eargle, D. H[oye], and Moxham, R[obert] M. Preliminary aeroradioactivity and geologic map of the Falls City SE quadrangle, Atascosa, Karnes, and Live Oak Counties, Texas: U. S. Geol. Survey Geophys. Inv. Map GP-253, 1961.

This preliminary aeroradioactivity and geologic map has been published at a scale of 1:31,680 (1 inch=about 1/2 mile) for Falls City SE quadrangle, Atascosa, Karnes, and Live Oak Counties. — W. L. G.

187-509. Pemberton, Roger H. Geophysical survey coverage in Canada: Canadian Mining Jour., v. 82, no. 4, p. 84-88, 1961.

The currently available airborne magnetometer survey coverage of Canada sponsored by the Dominion and the provinces and that available from various airborne survey contractors in Canada are shown on maps. "Operation Research" is discussed to show how and why those engaged in mining exploration can use this approach to solve their primary problem of finding more orebodies. Many complex problems are involved in the interpretation of magnetic survey results, but time spent in analyzing the problems beforehand and calculating not only the probabilities but also the best profit return per dollar spent increases the chances of success. An airborne magnetic survey to locate sulfide deposits in the Mattagami district is discussed as an example. — V. S. N.

187-510. Canada Geological Survey. Aeromagnetic maps of Gulf of St. Lawrence: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Geophys. Papers 1012G, 1015G-1024G, 1960.

The following aeromagnetic maps have been published at a scale of 1:63,360 (1 inch=1 mile) for the Gulf of St. Lawrence area: 1012G, and 1015G-1024G. — W. L. G.

Fleming, H. W., and Brooks, R. R. Geophysical case history of the Clearwater deposit, Northumberland County, New Brunswick, Canada. See Geophys. Abs. 187-192.

187-511. Canada Geological Survey. Aeromagnetic maps of Ontario: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Geophys. Papers 960G-1009G, 1960; and 1100G-1139G, 1961.

Aeromagnetic maps that show by contour lines the total magnetic intensity at about 500 feet above ground level have been published for the following: 960G, Mojikit Lake, 961G, D'Orsonnens Lake, 962G, Sim Lake, Thunder Bay District; 963G, Kawitos Lake, 964G, Opikeigen Lake, Kenora and Thunder Bay Districts; 965G, Machawaian Lake, 966G, Kabania Lake, 967G, Nankika Lake, 968G, Sagiminnis Lake, 969G, Wapikopa Lake, Kenora District; 970G, Makoki Lake, 971G, Mahamo Lake, Thunder Bay District; 972G, Kellow Lake, 973G, Triangular Lake, Kenora and Thunder Bay District; 974G, Fort Hope, 975G, Stark Lake, 976G, Lansdowne House, 977G, Wapitotem Lake, 978G, Mameigwess Lake, 979G, Kanuchuan Lake, Kenora District; 980G, Kapikotongwa Lake, 981G, Ogoki Lake, Thunder Bay District; 982G, Harvey Lake, 983G, Makokibatan Lake, Kenora and Thunder Bay Districts; 984G, McIntyre Lake, 985G, Norton Lake, 986G, Windsor Lake, 987G, Owen Lake, 988G, Pulham Lake, 989G, Winisk Lake, Kenora District; 990G, Percy Lake, 991G, Patience Lake, 992G, Dusey Lake, 993G, Kagiarni Falls, 994G, Maxey Lake, Thunder Bay and Cochrane Districts; 995G, Wabassi Falls, 996G, Shibley Lake, 997G, Kitchie Lake, 998G, Goods Lake, 999G, Prime Lake, Kenora District; 1000G, Louella Falls, 1001G, La Rose Lake, 1002G, Eby Falls, 1003G, Big Canoe Lake, Cochrane District; 1004G, Nottik Island, 1005G, Sebert Lake, Cochrane and Kenora Districts; 1006G, Pym Island, 1007G, Fishtrap Lake, 1008G, Symons Lake, and 1009G, Greig Lake, Kenora District.

The following aeromagnetic maps show by contour lines the total magnetic intensity at about 1,000 feet above ground level: 1100G, Arrow Lake, 1101G, Perching Gull Lake, 1102G, Shebandowan Lake, 1103G, Savanne, 1104G, Upsala, 1105G, Pakashkan Lake, 1106G, Weaver Lake, 1107G, Harmon Lake, 1108G, Seseganaga Lake, 1109G, Barrington Lake, Thunder Bay District; 1110G, Gunflint Lake, 1111G, Titmarsh Lake, 1112G, Huronian, 1113G, Be-divere Lake, Rainy River and Thunder Bay Districts; 1114G, Firesteel River, Kenora, Rainy River and Thunder Bay Districts; 1115G, Petry, 1116G, Cottle Lake, 1117G, Bell Lake, 1118G, Sturgeon Lake, 1119G, Kashaweogama Lake, Kenora and Thunder Bay Districts; 1120G, Louisa Lake, 1121G, Kawnipi Lake, 1122G, Pickerel Lake, 1123G, Sapawe, Rainy River District; 1124G, Gulliver Lake, Kenora and Rainy River Districts; 1125G, Bonheur, 1126G, Unaka, 1127G, Watcomb, 1128G, Ycliff, 1129G, Schist Lake, Kenora District; 1130G, Crooked Lake, 1131G, Poohbah Lake, 1132G, Kasakokwog Lake, 1133G, Steep Rock Lake, Rainy River District; 1134G, White Otter Lake, Kenora and Rainy River Districts; 1135G, Ignace, 1136G, Nameigwess Lake, 1137G, Yonde, 1138G, Sioux Lookout, and 1139G, Expanse Lake, Kenora District. — W. L. G.

187-512. Canada Geological Survey. Aeromagnetic maps of Manitoba: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Geophys. Papers 1029G-1044G, 1047G-1050G, 1055G-1058G, 1064G, 1065G, 1072G, 1073G, 1078G-1083G, and 1086G-1091G, 1961.

Aeromagnetic maps that show by contour lines the total magnetic intensity at about 1,000 feet above ground level have been published for the following quadrangles: 1029G, Egenolf Lake; 1030G, Whitmore Lake; 1031G, Colbeck Lake; 1032G, Erickson Lake; 1033G, Snyder Lake; 1034G, Thanout Lake; 1035G, Hugill Creek; 1036G, Finner Lake; 1037G, Turner Lake; 1038G, Sucker Lake; 1039G, Kasmere Lake; 1040G, Wolk Lake; 1041G, Veal Lake; 1042G, Tice Lake; 1043G, Putahow Lake; 1044G, Bagg Lake; 1047G, Goldsand Lake North; 1048G, Carswell Lake; 1049G, Carriere Lake; 1050G, Carlson Lake; 1055G, Hjalmarson Lake; 1056G, Sawbill; 1057G, Brochet; 1058G, Abram Lake; 1064G, Engen Lake; 1065G, Whiskey Jack Lake; 1072G, Lac Brochet; 1073G, Misty Lake; 1078G, Munroe Lake; 1079G, Canfield Lake; 1080G, Doig Lake; 1081G, Booth Lake; 1082G, Calder Lake; 1083G, Sandhill Lake; 1086G, Askey Lake; 1087G, Corbett Lake; 1088G, Drake Lake; 1089G, Todd Island; 1090G, Lowry Lake; and 1091G, Blevins Lake. — W. L. G.

187-513. Canada Geological Survey. Aeromagnetic map of Saskatchewan and Manitoba: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Geophys. Paper 1028G, 1961.

This aeromagnetic map shows by contour lines the total intensity at about 500 feet above ground level for the Coronation Mine area. — W. L. G.

187-514. Canada Geological Survey. Aeromagnetic map of Northwest Territories: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Geophys. Paper 1027G, 1961.

This aeromagnetic map shows by contour lines the total intensity at about 1,000 feet above ground level for the magnetic anomaly east of Quinn Lake, District of MacKenzie. — W. L. G.

Stewart, Harris B., Jr., Raff, Arthur D., and Jones, E. L. Explorer Bank—a new discovery in the Caribbean. See Geophys. Abs. 187-606.

- 187-515. Vacquier, Victor, Duff, Arthur D., and Warren, Robert E. Horizontal displacements in the floor of the northeastern Pacific Ocean: *Geol. Soc. America Bull.*, v. 72, no. 8, p. 1251-1258, 1961.

A total magnetic intensity survey in the northeastern Pacific Ocean revealed a north-south pattern of magnetic anomalies, which is cut through by the Murray, the Pioneer, and the Mendocino faults. The amount of slip along these faults is measured by fitting the magnetic anomaly pattern across the faults. The combined left-lateral displacement across the Mendocino and the Pioneer faults is 1,420 km. — Authors' abstract

- 187-516. Mason, Ronald G., and Raff, Arthur D. Magnetic survey off the west coast of North America, 32° N. latitude to 42° N. latitude: *Geol. Soc. America Bull.*, v. 72, no. 8, p. 1259-1260, 1961.

A ship-towed magnetometer survey of an area 250-300 miles wide off the foot of the continental slope along the coast of California has revealed a narrow pattern of anomalies of about 400 gammas magnitude trending north-south for more than 500 miles. The pattern is interrupted at the known faults and elsewhere; offset of the pattern at the Murray fault suggests a right-lateral displacement of about 84 nautical miles. The anomalies are such as might be expected of slablike structures underlying the ocean floor; geological possibilities include basic lava flows, topography of the main crustal layer, and intrusion of ultrabasic material from the mantle. — Authors' abstract

- 187-517. Raff, Arthur D., and Mason, Ronald G. Magnetic survey off the west coast of North America, 40° N. latitude to 52° N. latitude: *Geol. Soc. America Bull.*, v. 72, no. 8, p. 1267-1270, 1961.

An extensive high-resolution magnetic survey of total field at sea level reveals unusual north-south lineations and much crustal faulting. Computations indicate that the linear pattern is due to strongly magnetized mafic rocks beneath the sediments. — Authors' abstract

- Raff, Arthur D. The magnetism of the ocean floor. See *Geophys. Abs.* 187-612.

- 187-518. *Engineering and Mining Journal*. Geophysical re-survey for Surinam jungle: *Eng. Mining Jour.*, v. 162, no. 4, p. 95, 1961.

An amphibian plane has been equipped with four geophysical probes for a follow-up of a previous aeromagnetometer survey of the Surinam jungle. The instruments include an electromagnetic (EM) system, a Gulf Mark III magnetometer, a sensitive scintillation counter, and an AFMag detector. With this combination of instruments it should be possible to locate magnetic, radioactive, or sulfide ore bodies. — V. S. N.

- Bullerwell, W. Geophysical investigations. See *Geophys. Abs.* 187-325.

Griffiths, Donald Harrison, King, Roy Favell, and Wilson, Charles Douglas Vernon. Geophysical investigations in Tremadoc Bay, North Wales. See *Geophys. Abs.* 187-582.

- 187-519. LeBorgne, E[ugène]. Valeurs de la composante verticale du champ magnétique terrestre dans la Bretagne Centrale [Values of the vertical component of the geomagnetic field in central Brittany]: *Inst. Physique de Globe Paris Annales*, v. 30, p. 117-124, 1960.

A vertical magnetic survey was made, using a Schmidt balance, of an area of about 2,500 km² centered approximately on Pontivy in central Brittany in order to determine the exact nature and origin of the large local magnetic anomalies. The anomalous zone is bounded by granite and granulite massifs. In the northern part of the area surveyed the anomalies are predominantly positive and are attributed to diabases; in the southern part negative anomalies are more common and are attributed to an inverse remanent magnetization of the Brioverian schists. — D. B. V.

- 187-520. Hrách, Stanislav, Jelen, Miroslav, and Mašín, Jan. Letecké geofyzikální mapování skarnových ložisek u Županovic (Morava) [Aerial geophysical mapping of skarn deposits near Županovice (Moravia) (with English summary)]: (Czechoslovakia) Ústřed. Ústav. Geol. Vestník, v. 36, no. 1, p. 13-21, 1961.

An aeromagnetic survey was made in the vicinity of the skarn deposits near Županovice, Czechoslovakia, in a search for their possible extension. Results were compiled as a series of profiles and a map of total intensity anomalies. In addition to anomalies over the known deposits, the results showed an anomaly near Bělčovice that was subsequently found to be due to mineralized skarn. Ground magnetic surveys in the entire central part of the area, where magnetic intensity is generally higher, showed good correspondence with the airborne results; only two small anomalies, probably due to serpentines, were not recorded by the latter.

Radiometric measurements were made at the same time as the aeromagnetic survey; results are compiled in a series of profiles of gamma-ray intensity. The natural radioactivity of the rocks is higher in the central part of the area thus also suggesting a higher ore content there. — D. B. V.

- 187-521. Ștefănescu, Sabba [S.]; Stoenescu, Scarlat; Airinei, Ștefan; Botezatu, Radu; Popovici, Dorin; and Ionescu, Florian. Geophysical surveying for iron near Constanța (Rumanian People's Republic): Acad. Roumaine, Rev. Geol.-Geog., v. 5, no. 1, p. 119-132, 1961.

The discovery of a regional magnetic anomaly in the Constanța area of Rumania was followed by detailed magnetic and gravity surveys. An iron ore deposit was found to coincide with the geophysical anomalies. It is a magnetic amphibolite schist, which has a northwest strike and a dip of 90°. Several magnetic and gravity maps are given. — J. W. C.

- 187-522. Ivanov, O. D. Primeneniye magnitorazvedki pri poiskakh mednokolchedannykh mestorozhdeniy [Use of magnetic exploration for prospecting for chalcopyrite deposits]: Razvedka i Okhrana Nedr, no. 9, p. 32-35, 1961.

Magnetic exploration in the southern Urals and Mugodzhary has proved successful for mapping hydrothermally altered zones that form aureoles around chalcopyrite deposits. A local magnetic low in an area of greenstones derived from basic effusives is an indirect indication of the presence of a chalcopyrite mineralization. The magnetic susceptibility of the host rock is decreased due to the hydrothermal alteration. Practice has shown that a copper mineralization not accompanied by a magnetic low is of little interest. — J. W. C.

- 187-523. Tikhonov, V. I., and Rivosh, L. A. Novyye dannyye o tektonicheskom stroenii yuzhnoy Kamchatki (po rezul'tatam geologicheskikh

i aeromagnetnykh rabot) [New data on the structure of southern Kamchatka (according to the results of geologic and aeromagnetic work): Akad. Nauk SSSR Izv. Ser. Geol., no. 6, p. 59-69, 1961.

The results of geologic and aeromagnetic surveys of the southern part of the Kamchatka Peninsula reveal the fundamental outlines of the geologic structure and show that there is a distinct interdependence between the structure and the magnetic field on a broad scale. Sketch maps are given of the magnetic anomalies and of the essential structural features. The magnetic data suggest that on the Okhotsk Sea side of the peninsula the old metamorphic rocks dip beneath the Tertiary formations of the west Kamchatka depression. — D. B. V.

Moorcroft, E., and Dowling, D. R. Gravity and magnetic surveys over aeromagnetic anomaly—Hundred of Chandada. See Geophys. Abs. 187-335.

187-524. Christoffel, D. A. Total magnetic field measurements between New Zealand and Antarctica: Nature, v. 190, no. 4778, p. 776-778, 1961.

Some results of a survey of the total geomagnetic field between New Zealand and Antarctica, an area never previously surveyed magnetically, are reported. The anomalies are parallel to the bathymetric trough, are generally steep-sided, and have flattened peaks in some cases. Assuming that they are caused by dikes of magnetic material of a thickness comparable to the ocean depth, and using the method of Henderson and Zietz (see Geophys. Abs. 135-10507), the depth of the disturbing body is calculated as 3,000-4,000 fathoms below sea level (that is, a short distance below sea bottom) and the susceptibility contrast as $0.6-1.6 \times 10^{-3}$ cgs, increasing uniformly southward.

These anomalies strikingly resemble those off the California coast (Mason, see Geophys. Abs. 176-285). An explanation of their nature and direction might be that the suboceanic basalt layer has been buckled downwards owing to lateral compression, and fissures normal to the thrust direction have permitted intrusion of lavas from beneath. — D. B. V.

MICROSEISMS

187-525. Okano, Kennosuke. Observational study on microseisms, Part 1: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 44, p. 1-22, 1961; Part 2, *ibid.*, no. 47, p. 1-15, 1961.

Part 1 of this paper covers essentially the same observations (Abuyama Station) as previously reported (see Geophys. Abs. 182-441, 184-511) and emphasizes the importance of using vector seismographs to study the arrival directions of microseisms by analysis of the orbital motions of the earth's particles. Part 2 discusses the results of investigations carried out at the Aso and Yura stations. The following conclusions are made: The previous inference that microseismic waves are generated near the coastline is substantiated; microseismic waves are generated most frequently where the Continental Shelf is steep; no appreciable difference in mean amplitude among waves from different directions was observed, which suggests that microseisms are generated near continental margins rather than at the coastline; microseisms generated by seasonal winter winds are of like mean period regardless of direction of arrival, but among microseisms generated by typhoons those propagated from districts having a longer distance of propagation of swells show longer periods. — V. S. N.

- 187-526. Santo, Tetsuo [Akima]. The observation of microseisms at a wave gauge station (Part 3). On the origin of microseisms: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 2, p. 241-254, 1960.

A new relation is discovered between the position of a cyclone center, its rate of travel, and its central pressure when it generates the maximum microseismic disturbance at a given station. This relation can be explained by supposing an "eye of the microseismic storm" around the cyclone center, from the boundary of which the highest swells reaching the coast near the station are sent out. From microseismic observations made at a wave gauge station it is clear that the energy of swells is converted into microseisms at some steep coast. No second harmonics were found in the computed period spectrum of swells. This examination supports the standing wave theory of microseism origin. (See also Geophys. Abs. 179-351, 186-536.)—D. B. V.

- 187-527. Upton, P. S. Generation of microseismic storms in the Coral Sea: Queensland Univ. Dept. Geology Papers, v. 5, no. 7, 16 p., 1960.

The study of microseismic storms as recorded at Brisbane and Townsville, Queensland, has been carried on in some detail to gain information on the generation and propagation of these storms and to determine their use as forecasters of cyclone development and tracking aids. Microseismic storms can be correlated with either a cyclonic disturbance or with a cold front. This investigation has concentrated on the regular group microseisms associated with the tropical cyclones, and amplitude ratios have been studied to determine their use for tracking cyclones. The results firmly establish that a relationship exists between the microseism amplitude and the distance of the cyclone from the recording station and confirms that in the Coral Sea region, these microseisms are generated close to the center of the cyclone and are propagated through the earth's crust. The parameters controlling the actual generation and governing the amplitude from cyclone to cyclone were not discovered. — V. S. N.

- Shimozuru, Daisuke. Volcanic micro-seisms—Discussion on the origin. See Geophys. Abs. 187-632.

RADIOACTIVITY

- 187-528. Wright, P. M., Steinberg, E. P., and Glendinin, L. E. Half-life of samarium-147: Phys. Rev., v. 123, no. 1, p. 205-208, 1961.

The half life of SM^{147} , the isotope responsible for the natural radioactivity of that element, has been determined by specific alpha activity measurements using a liquid scintillation counting technique as $(1.05 \pm 0.02) \times 10^{11}$ yr.—D. B. V.

- 187-529. Mahadevan, C., Tilak, V. V. S. S., and Aswathanarayana, U. Radioactivity of some rock types of Andhra State, India: Geol. Soc. India Jour., v. 2, p. 11-22, 1961.

Beta activity has been determined for 37 rock samples and alpha activity for 15 rock samples from various parts of Andhra Pradesh, India. The results confirm earlier studies (see Geophys. Abs. 164-256, 167-238, 170-267, 172-207) in which the beta-activity of a rock was found to be cumulatively conditioned by its mineralogic (quartz, feldspar, and heavy minerals) and chemical ($Fe_2O_3:FeO$ ratio, silica, potash, alumina, and calcium oxide) constitu-

ents and by its petrogenetic history. The discrepancies in the equivalent uranium content of rocks as deduced from their beta and alpha activities, are traced to the variations in the concentration of beta-emitting K^{40} and in U:Th ratios. Results are given in tables and graphs. — V. S. N.

- 187-530. Hatuda, Zinichiro [Zin'itiro], and Nishimura, Susumu. Variations in radioactivity and chemical elements across igneous contacts [in Japanese with English abstract]: Japanese Assoc. Mineralogists, Petrologists, Econ. Geologists Jour., v. 45, no. 5, p. 163-173, 1961; supp. rept., v. 46, no. 2, p. 33-38, 1961.

Large variations in chemical composition and alpha-activity take place along traverses normal to contacts resulting from the intrusion of granitic materials into various rocks. The alpha-activity variation is found to be more conspicuous in the intrusive rocks than in the wall rocks. Spectrographic analysis indicates that across the contact of a shallow intrusive there is a conspicuous increase of volatile matter within the invading rock in the direction toward the boundary; across the contact of deeper intrusives, the distribution of volatile matter is obscure. No unusual variation in distribution of beta activity has been found. In the supplementary report a study of the rocks across the Tanakami and Koya contacts is reported; a relationship between the radioactivity type and the chemical elements or normative constituents is observed. (See also Geophys. Abs. 172-208, 178-324.) — V. S. N.

- 187-531. Starik, I. Ye., Nikolayev, D. S., Kuzelov, Yu. V., and Legin, V. K. Sootnosheniye radioaktivnosti osadkov Azovskogo i Chernogo morey [Correlation of radioactivity of Azov and Black Sea sediments]: Akad. Nauk SSSR Doklady, v. 139, no. 2, p. 456-459, 1961.

Study of the distribution of radioactive elements in sediments from the Black Sea and Sea of Azov shows that specific features of sedimentation are clearly reflected in the concentration and distribution of uranium, but scarcely expressed in variations in thorium and radium concentration. The differences can be explained by the fact that these elements behave differently in solution, depending on the physico-chemical character of the solution. — D. B. V.

- 187-532. Zolotov, A. V. Nekotoryye dannyye po issledovaniyu obraztsov pochvy i rasteniy v rayone Tunguskoy katastrofy 1908 g. [Some data from investigations of soil and plant samples in the area of the Tungus catastrophe of 1908]: Akad. Nauk SSSR Doklady, v. 140, no. 1, p. 103-106, 1961.

Investigation of the radioactivity of soils and plant materials in the area of the Tungus meteor explosion of 1908 throws no light on the relationship of the radioactivity anomaly to the catastrophe, but it is noted that some growing trees with distinct annual growth rings could be used as sensitive indicators of increases in radiation and of the time of contamination of a place by fallout from nuclear explosions. — D. B. V.

- 187-533. Israël, H[ans]. Der Diffusions-Koeffizient des Radons in Bodenluft [The diffusion coefficient of radon in soil air]: Zeitschr. Geophysik, v. 27, no. 1, p. 13-17, 1961.

The discussion provoked by E. Budde's paper on the diffusion of radon in soil air is continued. (See also Geophys. Abs. 174-314, 180-330, 184-515.) — D. B. V.

- 187-534. Srivastava, P. K., and Gupta, U. C. The use of CsI(Tl) crystal for the determination of absolute gamma emission rates: Jour. Sci. Indus. Research [India], v. 20B, no. 6, p. 243-246, 1961.

A single-channel scintillation spectrometer with a CsI(Tl) crystal as detector has been used for the determination of absolute gamma emission rates of some radio nuclides. Absolute efficiency of cylindrical cesium iodide detectors (1 in. thick and 1.5 in. diam) has been calculated for gamma ray energies from 0.1 to 5 Mev for point sources situated on the axis of the detector. Peak-to-total ratio for the detector has also been measured. — Authors' abstract

RADIOACTIVITY SURVEYING AND LOGGING

- 187-535. Balyasnyy, N. D., Kogan, R. M., Nimiforov, M. V., Renne, O. S., and Fridman, Sh. D. Radioizotopnyy analiz gornyykh porod i pochv po energeticheskomu sostavu gamma-luchey v prizemnoy atmosfere [Radioisotopic analysis of rocks and soils according to the energy spectrum of gamma-rays in the bottom layer of the atmosphere]: Akad. Nauk SSSR Doklady, v. 140, no. 4, p. 807-810, 1961.

The results of analysis of the gamma-ray spectrum observed over different types of ground (chernozem soils and a zone of hydrothermally altered igneous rocks) demonstrate the possibility of distinguishing rocks and soils by such measurements either on the ground or from planes flying several tens of meters above the ground. Results are presented in graphs and tables. In tests in the European part of the U. S. S. R., concentrations of K^{40} and Tl^{208} (ThC'') could be measured with an accuracy of 15-20 percent from a flying altitude of 25-35 m and 20-min exposure. (See also Geophys. Abs. 185-497.) — D. B. V.

- 187-536. Yakzhin, A. A. Poiski i razvedka uranovykh mestorozhdeniy [Exploration and prospecting for uranium deposits]: Moscow, Gosgeoltekhizdat, 480 p., 1961.

This is a textbook intended for university students. The topics treated are physical-chemical and radioactive properties of uranium, its uses, and methods of analysis. The genetic types of economic uranium deposits (exogenic, endogenic, and metamorphogenic) are discussed, and the uranium-bearing belts, areas, and epochs are considered. The second half of the book is devoted to exploration methods and mining processes. — A. J. S.

- 187-537. Yevstrakhin, V. A. Znachenie radiometricheskikh metodov dlya poiskov mestorozhdeniy neradioaktivnykh poleznykh iskopayemykh [Importance of radiometric methods of prospecting for deposits of nonradioactive mineral resources]: Razvedka i Okhrana Nedr, no. 10, p. 38-43, 1961.

The use of airborne, ground, and logging radioactivity surveys for detection of nonradioactive mineral deposits is discussed. Examples are given of an hydrothermal-pneumatolitic niobium deposit associated with a syenite porphyry, a pneumatolitic-hydrothermal beryllium deposit, a hydrothermal-metasomatic rare earth deposit, a niobium deposit in carbonates, a phosphorite in a region of very low relief, and an ilmenite-rutile deposit. — J. W. C.

- 187-538. Moyd, Louis, and Moyd, Pauline. Gamma ray-neutron beryllium detector as a reconnaissance tool: Am. Inst. Mining Metall. Petroleum Trans., v. 217, Tech. Paper 60H95, p. 372-376, 1960.

The Beryllometer, a field instrument for the detection of beryllium, is described and its field application discussed. The instrument can be used directly on outcrops, mine workings, dumps, or drill cores and cuttings to detect and delineate beryllium mineralization in any form. It can prove the absence of beryllium in occurrences where it has been erroneously reported and can provide rough quantitative analyses immediately in the field. The reactions are specific for beryllium. The disadvantages of the instrument, such as low effective depth penetration and bulkiness, are not serious drawbacks in comparison with its advantages. — V. S. N.

- 187-539. Zolotov, A. V., and Kukhareno, N. K. *Sobstvennyy fon i spectral'naya chuvstvitel'nost' razryadnykh schetchikov gamma-izlucheniya* [Internal background and spectral sensitivity of radiation counters of gamma-radiation]: *Razvedochnaya i Promyslovaya Geofizika*, no. 35, p. 29-34, 1960.

The internal radiation background of 300 counters having tungsten cathodes was measured to investigate their contamination with radioactive substances (apparently thorium). The internal radioactive background of BS-9 counters varied: 28 percent had a background of less than 50 impulses per min, 15 percent had 50-100 impulses per min, and about 40 percent had 100-150 impulses per min. The values of internal background for 75 MS-9 and AMM-9 counters with copper cathodes were 240-250 impulses per min on the average. The spectral sensitivity of radiation counters tested was found to vary within 16.0 percent of the average value (see also Geophys. Abs. 178-344). — A. J. S.

- 187-540. Schmidt, Robert G. *Natural gamma aeroradioactivity of the Savannah River Plant area, South Carolina and Georgia*: U. S. Geol. Survey Geophys. Inv. Map GP-306, 1961.

The natural gamma radioactivity measured at about 500 feet above ground over the Savannah River Plant area—approximately 10,000 sq mi along the central part of the border between South Carolina and Georgia—is shown on a base map by color shading to give approximate ranges of radioactivity in counts per second. A generalized geologic map of the area and an explanatory text are included.

The natural radiation level is closely related to the type of soil or rock at the surface of the ground. Locally this relation is so good that geologic contacts may be mapped from changes in radiation level. The SRP area is in two major physiographic provinces: the Piedmont, underlain by steeply inclined metamorphic and igneous rocks; and the Coastal Plain, underlain by gently dipping sedimentary rocks of Late Cretaceous to Quaternary age. The range of radioactivity is great in both provinces—250 to 2,100 counts per second in the Piedmont and 150 to 1,300 counts per second in the Coastal Plain. The radioactivity of the major rock units in each province is discussed. — V. S. N.

- 187-541. Mitchell, F. J. *Radioactivity survey in eastern West Virginia*: West Virginia Geol. and Econ. Survey Rept. Inv., no. 21, p. 1-12, 1961.

The radioactivity survey program in West Virginia was confined to the eastern counties because the most promising rocks, the Devonian black shales, crop out in this region, and because in this area of parallel folds surveys could be conducted along the strike of the formations. The magnitude of radioactivity of the rock units in the Valley and Ridge area of Pocahontas, Greenbrier, and Pendleton Counties, and of some rock units in Jefferson and Berke-

ley Counties is shown in a table; the highest average radioactivity of 3.1 μ r per hr was found for the Chemung formation (Devonian). No economic deposits were found. — V. S. N.

- 187-542. Moxham, R[obert] M., and Eargle, D. H[oye]. Airborne radioactivity and geologic map of the Coastal Plain area, southeast Texas: U. S. Geol. Survey Geophys. Inv. Map GP-198, 1961.

The airborne radioactivity data measured at 500 feet above the ground over the central part of a surveyed area of 14,700 sq mi in the Coastal Plain of southeast Texas is compiled with the geology of the area on a mosaic of county road maps, scale 1:250,000. Radioactivity is shown by color shading to give approximate ranges in counts per second. An accompanying text discusses the general geology, radioactivity measurements, character of the gamma radiation, compilation of data, and interpretation of data.

The adjusted net count rate recorded over the various geologic formations ranges from less than 70 counts per second over the Carrizo sand in southeast Guadalupe County to about 800 counts per second over the Jackson group in western Karnes County. In the Balcones fault zone in the northwest the complex bedrock outcrop pattern is mantled in many places by fluvial terrace deposits that are the source of the measured gamma radiation and, thus, there is little correlation between survey data and geologic boundaries. South and east of this faulted area, however, more linear patterns coincident with outcrop belts of stratigraphic units become apparent. — V. S. N.

- 187-543. Schmidt, Robert G. Aeroradioactivity of the Hanford Plant area, Washington and Oregon: U. S. Geol. Survey Geophys. Inv. Map GP-307, 1961.

The natural gamma radioactivity measured at about 500 feet above ground over the Hanford Plant area, approximately 1,000 sq mi in northern Oregon and central to southern Washington, is shown on a base map by color shading to give approximate ranges of radioactivity in counts per second. The natural gamma radiation measured has a moderate range of 160-900 counts per second and is generally related to the type of rock or soil at the surface. The bedrock is Cretaceous to Recent in age and is extensively mantled by Pleistocene and Recent eolian deposits. The natural radiation of the major rock and soil types in counts per second is as follows: lake- and stream-deposited strata, 200-600; plateau basalt and loess, 400-800; loess in the eastern part, 560-700; and Recent alluvium in the western part along the Yakima River, 200-400. Measured radiation greater than 1,000 counts per second is believed to be due to activities within the Hanford AEC reservation. — V. S. N.

- Hráč, Stanislav, Jelen, Miroslav, and Mašín, Jan. Aerial geophysical mapping of skarn deposits near Županovice (Moravia). See Geophys. Abs. 187-520.

- 187-544. Burke, Kevin. Tongjum uranium deposit (with Korean abstract): Korea Geol. Survey Bull., no. 4, p. 152-155, 1960.

A carborne scintillation-counter survey has led to the discovery of coatings of pitchblende and uranium secondary minerals on joints associated with a post-Cretaceous fault near Tongjum in the Republic of Korea. The occurrence, the first indication of hydrothermal uranium mineralization in Korea, is of no economic value itself but is an encouragement to further prospecting. — Author's abstract

- 187-545. Pitulej, W. Examination of radiometric anomalies between Gladstone and St. Helens: Tasmania Dept. Mines Tech. Repts., no. 5 for 1960, p. 75-77, 1961.

In 1958 the Bureau of Mineral Resources airborne scintillograph recorded six anomalies in three areas between Gladstone and St. Helens in northeastern Tasmania. These were recently investigated on the ground by Geiger counter, but no readings were noted greater than twice background. — Author's summary

- 187-546. Hughes, T. D. Radiometric anomalies—Bicheno and Coles Bay area: Tasmania Dept. Mines Tech. Repts., no. 5 for 1960, p. 92-94, 1961.

Four anomalies detected in the Bicheno to Coles Bay area of northeastern Tasmania by an airborne scintillometer survey were shown by ground examination to be of no economic importance. — V. S. N.

- 187-547. Sukhanov, B. I., and Rukavishnikov, V. G. Neuprugoye rasseyaniye neytronov s energiyey 14 Mev na yadrakh natriya, zheleza, nikelya, svintsa [Inelastic scatter of neutrons with energies of 14 Mev in nuclei of sodium, iron, nickel, and lead]: Atomnaya Energiya, v. 11, no. 4, p. 398-399, 1961.

Spectrums of inelastic scatter of neutrons are measured by the transit time method in the energy interval 0.6-4.0 Mev during bombardment of natural mixtures of isotopes of sodium, iron, nickel, and lead with an energy of 14 Mev. Results are presented on a graph and tabulated. — J. W. C.

- 187-548. Belykh, V. A., Sen'ko-Bulatnyy, I. N., Shulyat'yev, S. A., and Yakub, L. I. O vliyanii aktivatsii kremniya bystryimi neytronami pri aktivatsionnom karotazhe na mestorozhdeniyakh boksitov [On the activation effect of silicon by fast neutrons in activation logging in bauxite deposits]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 905-909, 1961.

In activation logging of bauxites the total number of activated atoms formed by radiation from a Po-Be source according to the reaction $Al^{27}(n, \gamma)Al^{28}$ and the integral γ -field are measured. However, such a measurement may be affected by the reactions $Al^{27}(n, p)Mg^{27}$ and $Si^{28}(n, p)Al^{28}$ since the source spectrum also contains high energy neutrons of 0.5 to 11.0 Mev. The effect of these additional reactions on the results of γ -field measurements is analyzed. Activation of SiO_2 by fast neutrons affects measurements in dry bauxite boreholes but has little or no effect in boreholes where drilling mud is used. — A. J. S.

- 187-549. Fridman, Sh. D. Ob issledovaniyakh spektral'nogo sostava γ -izlucheniya gornyykh porod v yestestvennom zaleganii [Regarding investigations of the spectral composition of γ -radiation of rocks in their natural occurrence]: Akad. Nauk SSSR Izv. Ser. Geofiz. no. 8, p. 1187-1197, 1960.

The possibility of spectrometric study of gamma radiation of rocks in place is discussed. The parameters characterizing the energy spectrum of gamma quanta in the approximate energy interval of 0.2-3.0 Mev are determined on the assumption that the rocks investigated do not contain a high concentration of elements of high atomic number. Nondirective (isotropic) detectors were

used. The quantity of information thus obtained is evaluated both for the source of the radiation measured and for the absorbing medium. — A. J. S.

- 187-550. Zolotov, A. V. Raspredeleniye medlennykh neytronov v odnorodnoy srede [Distribution of slow neutrons in a homogeneous medium], in *Yadernaya Geofizika: Moscow, Gostoptekhizdat*, p. 195-200, 1959.

The problem of the distribution of slow neutrons (thermal and epithermal) in water and water-saturated sand layers is considered with respect to the neutron, neutron-gamma, and induced activity logging methods. The correlation between thermal and epithermal neutron density in water and quartz sand of varying water saturation at various distances from the neutron emitting source was studied experimentally, and the results are presented graphically. The gauss distribution for thermal neutrons does not agree well with the experimental data, even when water content of the medium is low. — A. J. S.

- 187-551. Migunov, B. B. Vozmozhnosti primeneniya neytronnykh metodov pri issledovanii skvazhin rudnykh mestorozhdeniy [Feasibility of application of neutron methods to borehole investigation of ore deposits]: *Prikladnaya Geofizika*, no. 30, p. 192-197, 1961.

The neutron-neutron and induced radioactivity logging methods are investigated for possible use in prospecting for ore deposits. The effectiveness of the methods for lithium, manganese, boron, chlorine, cobalt, silver, cadmium, indium, rare elements, tantalum, tungsten, mercury, and titanium is evaluated. — A. J. S.

- 187-552. Rodermund, Carl G. Reservoir evaluation in empty bore holes by a new logging technique: *Kentucky Geol. Survey Spec. Pub.* 4, ser. 10, p. 7-10, 1961.

A new logging method, designed for use under empty bore-hole conditions, makes use of the unusual effects of gas on the various devices and combines them with quantitative results. The gamma-gamma density tool is used in conjunction with the neutron or induction log to provide porosity and gas saturation information. Gamma ray, caliper, and temperature surveys provide information for a consistent and valid interpretation. — V. S. N.

Per'kov, N. A. Combination and method of geophysical logging investigations of carbonate reservoirs. See *Geophys. Abs.* 187-204.

- 187-553. Trusheim, Ferdinand. Über radioaktive Leithorizonte im Buntsandstein Norddeutschlands zwischen Ems und Weser [On radioactive guide horizons in the Buntsandstein in north Germany between the Ems and Weser]: *Erdöl u. Kohle*, v. 14, no. 10, p. 797-802, 1961.

Reuter, Helmut. Geochemische Untersuchungen einer radioaktiven Anomalie in einem norddeutschen Buntsandsteinprofil [Geochemical investigations of a radioactive anomaly in a north German Buntsandstein Profile]: *ibid.*, p. 802-803, 1961.

The radioactive anomalies in the Gray Clays of the Hardeggen Series in north Germany are of great lateral extent and can be used as a stratigraphic horizon marker. Study of cores from the Goldenstedt T 2 borehole near Vechta in south Oldenburg shows that the radioactive substance is syngenetic uranium, concentrated in centimeter-thick layers of dark dolomitic shale that was formed under paraeuxenic conditions.

The companion paper presents details of the geochemical investigation of the core samples and conditions of origin of the uranium-bearing sediments. — D. B. V.

- 187-554. Solomasov, A. I. Interpretatsiya dannykh neytronnogo gamma-metoda dlya opredeleniya vodo-neftyanogokontakta v perforirovannykh skvazhinakh [Interpretation of data of the neutron gamma method for determining the water-oil contact in perforated wells]: *Geologiya Nefti i Gaza*, no. 6, p. 48-52, 1959.

The water-oil contact can be determined by the neutron gamma log only in uniform beds with constant composition and porosity. The Devonian terrigenous reservoirs of the Bashkir A.S.S.R. and the Tatar A. S. S. R. fulfill these requirements. The results are presented of a study of 74 producing wells in the Tuymazy field. Several types of neutron gamma curves for water-oil contacts are illustrated and analyzed. — J. W. C.

Jordan, Louise. Salt in Wellington formation, Grant County, Oklahoma. See *Geophys. Abs.* 187-210.

SEISMIC EXPLORATION

- 187-555. Bois, Pierre, Chauveau, Jean, and Hémon, Charles. Étude analogique de la déformation d'un signal sismique [Analogical study of the deformation of a seismic signal]: *Acad. Sci. [Paris] Comptes Rendus*, v. 253, no. 1, p. 165-167, 1961.

It is shown by means of a simple example how a suitable analogical model shows the reflections and transmission of a seismic signal through a layer in which velocity is not uniform. The model is as follows: two semi-infinite mediums, each with a characteristic longitudinal wave velocity and density, are separated by a layer having intermediate velocity and density that vary with depth only; a signal of known form propagates by parallel wave fronts to the boundary surfaces of the layer. The records of the signals reflected and transmitted by the bed in the overlying and underlying mediums are reproduced.

It is concluded that the reflected signals may be considerably deformed, whereas the transmitted signals show only a slight contraction and slight terminal oscillation. The bed behaves as a low-pass filter in reflection and as a high-pass filter in transmission. — D. B. V.

- 187-556. Das Gupta, S[ushil] C[handra]. On pressure waves in the coastal region: *Geofisica Pura e Appl.*, v. 48, p. 49-52, 1961.

An attempt is made to calculate the thickness of the semiliquid layer below the water column that has been postulated (Pekeris, see *Geophys. Abs.* 135-10569) to explain different aspects of pressure waves in water, including offshore "singing" (see *Geophys. Abs.* 147-13221, 177-185, 179-114). It is found that 1,000 feet is probably a good approximation of the true value. — D. B. V.

- 187-557. Urupov, A. K. O pereschete effektivnykh skorostey v sredneplastovyye v sluchaye dvukhsloynoy sredy [On the conversion of effective velocities into mean formational velocities for the case of a two-layered medium]: *Prikladnaya Geofizika*, no. 30, p. 79-91, 1961.

Two methods are presented for conversion of effective seismic wave velocities into mean velocities for the sediments of the Russian platform that

overlie the main reflecting horizon. These sediments are represented by two units with respect to lithology and velocity. A halogen-carbonate or carbonate layer constitutes the lower stratum and has a velocity approximately twice that of the terrigenous upper stratum. Formulas for determination of mean velocity in terms of reduced traveltime curves by both methods are given with auxiliary formulas to account for errors caused by deviation of seismic rays in the upper layer from the vertical and also by refraction at the interface between the layers. — A. J. S.

187-558. Kul'chikhina, T. N. Ob usloviyakh obrazovaniya tochek vozvrata i zamknutykh petel'na godografakh otrazhennykh voln [On the conditions under which cusps and closed loops are formed on the traveltime curves of reflected waves]: Razvedochnaya i Promyslovaya Geofizika, no. 35, p. 3-12, 1960.

An analytical solution of a two-dimensional kinematical problem for a circular separation boundary with a homogeneous overlying medium is discussed, and the conditions under which cusps and closed loops are formed on the traveltime curves of the waves reflected from such a boundary are demonstrated (see also Geophys. Abs. 165-339). — A. J. S.

Bolt, Bruce A. Theoretical phase velocities for a lunar seismic experiment. See Geophys. Abs. 187-83.

187-559. Kharaz, I. I., and Boyko, V. N. Nekotoryye rezul'taty primeneniya gruppirovaniya vzryvov v predelakh vneshney zony Predkarpatskogo progiba [Certain results of application of grouped shots in the area of the outer zone of the Cis-Carpathian depression]: Razvedochnaya i Promyslovaya Geofizika, no. 35, p. 24-29, 1960.

Results of experimental seismic exploration for testing the grouping of seismographs and shots in the outer zone of the Cis-Carpathian depression are reported. Seismograms for single shots and grouped shots are given for comparison; the total weight of the charges for each shot was 13.4 kg and the depth of explosion was 12 m. The seismograms of the grouped shots are superior to those of the single charges; they permit identification of sedimentary horizons that could not be identified by the single charge technique. The arrangement of the charges for a given base does not influence the accuracy of the seismic recording. — A. J. S.

187-560. Ivanov, L. I. Primeneniye seysmorazvedki dlya izucheniya pologikh platformennykh struktur Bashkirii [Use of seismic surveying for study of the gentle platform structures of Bashkiria]: Geologiya Nefti i Gaza, no. 9, p. 51-57, 1959.

Several examples are examined of the use of seismic surveying for exploration of the gentle platform structures in the Bashkir A. S. S. R. Seismic surveying has not been very effective in this area because of the experimental nature of much of its operations, inadequate apparatus, and shortage of field parties. Of the 21 structures that have been mapped by seismic surveying, 9 were first discovered by this method. The geologic conditions of the Bashkir A. S. S. R. require 75-150 km of profile on an average for an area of 100 km². The present field parties are equipped with 30- and 60-channel arrays. — J. W. C.

187-561. Agocs, W[illiam] B. Seismic field procedure: Jour. Mines, Metals, and Fuels [India], v. 9, no. 7, p. 28-29, 43, 1961.

A seismic field program is outlined as an example of the organization necessary to ensure a minimum cost of operation and a high yield rate from the seismic survey. — V. S. N.

- 187-562. Nagumo, Shozaburo, and Kawashima, Takeshi. On the variable area representative of the seismic record section: *Japan Geol. Surv. Bull.*, v. 11, no. 10, p. 613-618, 1960.

The method of variable area representation of the seismic record is tested by field data and its usefulness proved. — V. S. N.

- 187-563. Kunetz, G[ésa]. Essai d'analyse de traces sismiques [Attempt at analysis of seismic traces (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 3, p. 317-341, 1961.

If good field records are submitted to a series of transformations that are the reverse of those leading from a velocity log to a synthetic seismogram, the result should provide more detailed and more accurate information on the variation of velocities with depth. This problem is examined theoretically. The inverse procedure involves two main steps, "deconvolution," or suppression of the effect of filtering, and "analysis," or discrimination between direct and multiple reflections. The procedure is described and discussed.

In the analysis, the rapidly increasing accumulation of errors due to noise on the record and to the approximate nature of the physical assumptions is partially accounted for by a continuous readjustment of the results. Satisfactory analysis of a rather noisy synthetic record is achieved, but the method is still too unstable to be applied to field records. An alternative method of successive approximations is outlined. — D. B. V.

- 187-564. Baranov, V[ladimir]. Énergie des vibrations et filtrage non linéaire [Energy of vibrations and nonlinear filtering (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 3, p. 342-349, 1961.

In a manner somewhat analogous to gravimetry, where a strong regional anomaly conceals small local anomalies, oscillations of continuous character may obscure seismic reflections. Though variable in time, these vibrations (composed partly of noise, partly of unwanted secondary reflections) correspond to a fairly constant physical quantity, the energy of motion of the surface of the ground, which must be removed to give the actually reflected waves.

After showing that in the simplest case the density of this energy can be expressed almost exactly by a formula, it is shown how the nonlinear filtering defined by this formula can be realized. Examples are given. — D. B. V.

- 187-565. Delaplanche, J. Quelques exemples d'utilisation des films synthétiques [Some examples of utilization of synthetic seismograms (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 3, p. 427-443, 1961.

The synthetic seismogram is a geophysical instrument. Examples taken from several areas are presented in order to define this tool and to show how it may be used at all stages of exploration. In the field it can aid choice of techniques to be used, determination of volume control, and choice of filters. In interpretation of results, it can aid identification and checking off of reflections, analysis of real signals in terms of stratigraphy, study of the character of reflections on a regional scale and density of synthetic seismograms to be used, and reevaluation of information contained in old seismic records. — D. B. V.

- 187-566. Krey, Theodor, Schmidt, Gerhard, and Seelis, Karl-Heinz. Über die Möglichkeit den reflexionsseismisch erfassbaren Tiefenbereich zu erweitern [On the possibility of extending the attainable depth range of seismic reflection]: Erdöl u. Kohle, v. 14, no. 7, p. 521-526, 1961.

Examples are quoted to show how two of the difficulties that arise in extending the penetration of reflection shooting—the increase of energy absorption and the decrease of reflection coefficients with depth—have been met successfully in the Siegerland mining region of Germany. A third difficulty, the increased chance of multiple reflections, can be overcome by magnetic tape techniques. A fourth difficulty, that of correct depth determination when dips are steeper in the sedimentary cover than in deeper beds of interest (common in salt dome regions), can be surmounted by careful mathematical treatment of the recorded data. — D. B. V.

- 187-567. Ballakh, I. Ya. Proverka vozmozhnosti ispol'zovaniya seysmorazvedki dlya pryamykh poiskov neftegazovykh zalezhey [Test of the possibility of using seismic surveying for direct prospecting of oil and gas pools]: Akad. Nauk SSSR Doklady, v. 137, no. 5, p. 1174-1176, 1961.

Tests in the Mukhanov oilfield confirm the feasibility of determining oil pool limits by means of seismic reflections from oil-water interfaces, as suggested in an earlier paper by Ballakh and Mirchink (see Geophys. Abs. 178-355). The oil-bearing limits within three Devonian horizons in the Mukhanov field and the limits of the Okeansk and North Chernov oilfields to the north were indicated by reflection profiles. — D. B. V.

- 187-568. Levyant, V. B. Opyt provedeniya gruppovykh vzryvov v usloviyakh Stalingradskoy oblasti [An experiment in conducting group shots under conditions of the Stalingrad Region]: Razvedochnaya i Promyslovaya Geofizika, no. 35, p. 15-23, 1960.

The application of group shots for tracing and separation of useful waves in combination with grouping of seismographs and high frequency filters in amplifiers is discussed. The results of such an arrangement tested by the reflection method in the Stalingrad Region are given as a demonstration of the high effectiveness of such a combined technique in seismic prospecting using maximum frequencies from 70 to 100 cycles per second (see also Geophys. Abs. 175-357). — A. J. S.

- 187-569. Konovalov, M. M. Uproshchennoye opredeleniye popravok v godografy otrazhennykh voln za poverkhnostnyye usloviya [Simplified determination of corrections in travelttime curves of reflected waves for surface conditions]: Razvedochnaya i Promyslovaya Geofizika, no. 35, p. 61-65, 1960.

A technique for improvement in seismic reflection profile data by taking into account the topography of the low velocity zone (ZMS) is discussed. Conditions of a flat and of a rough surface of the ZMS are considered, and nomograms are given for computing corrections for the ZMS effect. — A. J. S.

- 187-570. Gurvich, I. I. O podekrannykh otrazhennykh volnakh v seysmorazvedke [On sub-screen reflected waves in seismic surveying]: Vyssh. Ucheb. Zavedeniy Izv., Geologiya i Razvedka, no. 1, p. 100-116, 1961.

The problem is considered where seismic waves are reflected from boundaries of a layer located directly under a layer which has a seismic velocity higher than that of any of the layers above or immediately below. This layer is named the screening layer, because it obscures seismic waves refracted at the layers below where velocities are lower. The presence of such a screening layer has specific effects on the kinematics and dynamics of the waves reflected from the boundaries located below. These waves are named sub-screen reflected (PEO) waves. In the analysis presented the kinematics of PEO waves in horizontally and inclined layered mediums is discussed. — A. J. S.

- 187-571. Neprochnov, Yu. P. O vybore optimal'nykh usloviy vzryva pri morskikh seismicheskikh issledovaniyakh metodom prelomlennykh voln [On the selection of the optimum shot conditions in marine seismic investigations by the method of refracted waves]: *Razvedochnaya i Promyslovaya Geofizika*, no. 35, p. 12-15, 1960.

In seismic prospecting at sea the recurrent shocks from a deep shot carry about 40 percent of the shot's energy and produce secondary arrivals of waves on seismograms, complicating the latter. Raitt (see *Geophys. Abs.* 159-94) proposed that the quasiperiodic pulsations and shocks from the gas bubble can be used effectively if the depth of the shot is taken equal to the predominant length of the recorded seismic wave in water. The size of the charge must be selected so that the period of the bubble pulsation is equal to the prevalent period of the recorded seismic wave. A graph of optimum depth was tested in the Black Sea for 0.4 kg charges. The test showed a satisfactory agreement with the theoretical curve. — A. J. S.

Kundorf, W., and Rotter, D. On the application of the seismic self-impulse method in the investigation of dynamic effects of rock pressure. See *Geophys. Abs.* 187-593.

- 187-572. Kopf, Manfred, and Wawrzik, Martin. Schallgeschwindigkeits- und Suszeptibilitätsmessungen an Gesteinen der Trias und des Zechsteins aus dem westlich Thüringer Becken [Acoustic velocity and susceptibility measurements on rocks of the Triassic and Zechstein from the western Thuringian basin (with English and Russian summaries)]: *Geologie*, v. 10, no. 2, p. 214-230, 1961.

Velocity data on the Triassic and Zechstein rocks of the western Thuringian basin in East Germany, obtained from extensive acoustic velocity measurements made on drill cores and surface rocks using an ultrasonic pulse generator, permit calculation of the elastic wave velocities of the different stratigraphic units. As seismic reflectivity is essentially influenced by density, density is used to calculate acoustic inertias and reflection coefficients. Anisotropy due to stratification is found in sandstones with alternating clay intercalations. Borehole seismic results and velocity determinations made near boreholes are comparable to a certain extent.

Magnetic investigations show a small magnetic mineral content, particularly in the lower Keuper, but also in the lower Bunter sandstone, the "Red Röt," and the Myophoria beds; lower Keuper beds at the surface could produce local magnetic anomalies. — D. B. V.

- 187-573. World Oil. 'Suitcase seismic' records obtained from 4,000 feet: *World Oil*, v. 153, no. 4, p. 119, 1961.

A portable shallow seismic apparatus is described, and the weight and power requirements of the various components are listed. The equipment utilizes an expander which provides a preprogramed rate of gain increase on the seismogram. During the early, high amplitude arrivals, the gain of the amplifiers is low; the gain is then increased as the seismic energy decreases. — J. W. C.

187-574. Kharchenko, G. Ye., and Kharchenko, F. M. Malogabaritna seismichna ustanovka dlya inzhenerno-geologichnykh to gidrogeologichnykh doslidzhen' [Small-size seismic apparatus for engineering-geological and hydrogeological investigations]: Akad. Nauk Ukrayin. RSR Dopovidī, no. 9, p. 127-129, 1960.

The feasibility of designing a simplified small-size, first arrival seismograph is discussed, and its operation principle is analyzed with respect to engineering-geological and hydrogeological applications. — A. J. S.

187-575. Shima, Etsuzo. Note on the magnetic circuit of the moving-coil type seismometer [in Japanese with English summary]: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 4, p. 545-557, 1960.

The leakage flux in the magnetic circuit of a moving-coil seismometer can be calculated most practically and simply by a method that assumes that the shape of the path of the flux approximates a circle. In this paper the magnetic circuit usually used in seismometers is investigated in detail in order to check the validity of this assumption, and to determine how to achieve a large useful flux. The theory pertinent to the design of a magnetic circuit is reviewed briefly, a model circuit is analyzed, and the magnetic circuits of 8 borehole seismometers are examined. Good agreement is found between the values calculated by the method in question and those obtained by direct measurements of the useful fluxes with the 8 seismometers, and it is concluded that the approximation can be used safely. — D. B. V.

187-576. Brown, M. V., Northrop, John, Frassetto, Roberto, and Grabner, L. H. Seismic refraction profiles on the continental shelf south of Bellport, Long Island, New York: Geol. Soc. America Bull., v. 72, no. 11, p. 1693-1706, 1961.

Seven reversed seismic refraction profiles were made from the Bellport Coast Guard Station to 45 miles offshore. The profiles show a thin layer of mud (compressional velocity 5,030-5,260 fps) above the wedge of unconsolidated ($v=5,700-6,040$ fps), semiconsolidated ($v=6,370-6,770$ fps), and consolidated ($v=7,470-10,700$ fps) sediments that covers the basement ($v=16,300-18,300$ fps). The thickness of the sediment layer increases seaward from 1,927 to 7,598 feet, the greatest increase coinciding with the appearance of the consolidated layer. Comparison of these results with well logs in the area indicates that the unconsolidated layer can be correlated with the Upper Cretaceous Magothy formation and the semiconsolidated layer with the Upper Cretaceous Raritan formation which overlies the gneisses and schists of the basement under Long Island. Strong evidence for a fault was found 8 miles offshore and again 19 miles offshore. — D. B. V.

187-577. Zumberge, James H., and Gast Paul [W.]. Geological investigations in Lake Superior: Geotimes, v. 6, no. 4, p. 10-13, 1961.

The results of investigations in the summer of 1961 of part of the Lake Superior basin by geophysical exploration, core studies, and geochemical studies are reported briefly. Continuous seismic profiles were made with a Sparker over 250 miles of traverse between Isle Royale and the Upper Peninsula of Michigan and between Isle Royal and the Minnesota shore. Preliminary study of the profiles indicates deep bedrock valleys 1,000 feet below lake level along the Minnesota shore. — V. S. N.

187-578. Offshore. Seismic survey underway off Oregon: Offshore, v. 16, no. 1, p. 19, 1961.

A seismic survey, using a gas exploder for the impulse, is underway to search for possible petroleum structures off the Oregon coast. — V. S. N.

187-579. Meador, Jimmie G. Marine seismograph and Sparker survey in the Mackenzie River, Northwest Territories, in *Geology of the Arctic*, v. 2: Internat. Symposium on Arctic geology, 1st, Calgary, Alberta, 1960, Proc., p. 1153-1156, 1961.

A Sparker traverse of the Mackenzie River from Hay River to the Sans Sault Rapids, a distance of 650 miles, recorded seismic reflections from the river bottom and from 1 to 3 sub-bottom horizons to a depth of 400-1,600 feet in a continuous profile at a rate of 40 miles per day. In addition, a marine seismic survey conducted in selected areas at a rate of 70 shot locations per day mapped the geologic horizons to the basement. Both methods were used also to detail the Norman Wells reef oilfield beneath the Mackenzie River. — V. S. N.

187-580. Redpath, Bruce B. Seismic operations, in *Jacobsen-McGill Arctic research expedition to Axel Heiberg Island, Preliminary Report 1959-1960: Montreal, McGill Univ.*, p. 101-107, 1961.

Preliminary results of seismic operations to determine ice depths on the White and Thompson Glaciers, and on the McGill Icecap, Axel Heiberg Island, Queen Elizabeth Islands, Canada, are reported. All depth determinations were made using reflection methods. Representative depths of ice range from 240 to 470 m. Three refraction lines were run, and the traveltime curves illustrate to some extent the effects of temperature and ablation on the velocities. — V. S. N.

187-581. Roethlisberger, Hans. Seismic refraction soundings in permafrost near Thule, Greenland, in *Geology of the Arctic*, v. 2: Internat. Symposium on Arctic geology, 1st, Calgary, Alberta, 1960, Proc., p. 970-980, 1961.

The applicability of various seismic methods for engineering purposes has been investigated in the Thule area. Special attention has been given to the refraction method in the cases where shallow ice (up to 200 feet) occurs overlying frozen ground (till), or where frozen ground (till, outwash) up to a few hundred feet thick overlies bedrock. Seismic velocities have been measured in different types of sediments of the Thule formation and in the crystalline basement rock. Very high velocities were found for all types of rock; the temperature was about -10°C, and most pores and cavities were probably filled with ice. It was discovered that for shallow soundings of a few hundred feet, the seismic methods can probably be used more elaborately in permafrost than in unfrozen material, as later pulses can be identified on the records shortly after first breaks. A negative velocity gradient in frozen ground is believed to be responsible for this. — Author's abstract

Weber, J. R. Comparison of gravitational and seismic depth determinations on the Gilman Glacier and adjoining ice-cap in northern Ellesmere Island. See *Geophys. Abs.* 187-323.

187-582. Griffiths, Donald Harrison, King, Roy Favell, and Wilson, Charles Douglas Vernon. Geophysical investigations in Tremadoc Bay, North Wales (with discussion): *Geol. Soc. London Quart. Jour.*, v. 117, pt. 2, p. 171-187, 1961.

Seismic refraction and proton magnetometer surveys were made of Tremadoc Bay, off North Wales, and across the coastal flats of Morfa Dyffryn to check the results of a gravity survey of North Wales that suggested Tremadoc Bay might be a Triassic basin. Seismic results indicate the presence of three layers. The top layer with maximum thickness of 1,800 feet and a velocity of 6,500 fps, is thought to be Mesozoic or Tertiary; all evidence indicates a major fault on the eastern boundary. The middle layer with maximum thickness of 6,000 feet and a velocity of 6,500 fps is probably Ordovician. The third and lowest layer is interpreted as Cambrian. A regional low over Cardigan Bay to the south points to a structural origin for the bay, although the anomaly may be due to a major granitic intrusion. — V. S. N.

187-583. Lliboutry, Louis, and Vivet, Roland. Épaisseurs de glace et débit solide de la Vallée Blanche supérieure (Massif du Mont-Blanc) [Ice thicknesses and solid flow of the upper Vallée Blanche (Mont Blanc Massif)]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 15, p. 2274-2276, 1961.

Two refraction profiles at right angles to each other were surveyed on the upper Vallée Blanche in the Mont Blanc Massif in the Alps. The results show that the ice thickness is remarkably constant at about 145 m, plus 30 m of snow and névé.

From these results and measurements of ice flow, it is calculated that the mean net annual precipitation here is the equivalent of 270 cm of water. It was assumed in these calculations that the mass balance is actually in equilibrium, as appears to be the case. — D. B. V.

187-584. Dohr, G[erhard]. Über die Beobachtungen von Reflexionen aus dem tieferen Untergrunde im Rahmen routinemässiger reflexionsseismischer Messungen [On the observations of deep reflections within the compass of routine seismic reflection surveys (with English abstract)]: *Zeitschr. Geophysik*, v. 25, no. 6, p. 280-300, 1959.

Since 1958 a number of seismic crews in Germany have been attempting to record deep reflections in routine reflection surveys as part of a program of investigation of the crust under central Europe. Results obtained to date are reviewed here. Deep reflections observed in many areas are discussed, with examples of seismograms and graphs of statistics. The recorded reflections can be referred to the Conrad discontinuity, which appears to be continuous but variable in depth under central Europe. Its surface may correlate with near-surface tectonics in some areas. Reflections from the M-discontinuity have been observed occasionally. — D. B. V.

187-585. Vartanov, S. P., and Kornev, V. A. Novyye dannyye o geologicheskoy stroynii severnogo Kaspiya (po rezul'tatam morskikh seysmicheskikh issledovaniy) [New data on the geology of the

north Caspian (according to the results of marine seismic study): Akad. Nauk SSSR Doklady, v. 136, no. 5, p. 1172-1175, 1961.

Several seismic profiles were made in the northern Caspian Sea in 1958 in conjunction with gravity and magnetic surveys. From analysis of these profiles the geologic units underlying the region have been identified, and their stratigraphic and structural relationships have been worked out. Four profiles are presented and discussed. — D. B. V.

- 187-586. Vol'vovskiy, B. S., and Vol'vovskiy, I. S. Seysmicheskiye issledovaniya po opornomu regional'nomu profilyu Amu-Dar'ya (Karabekaul)-Nuratau (Koytash) [Seismic investigation along the research regional profile Amu Dar'ya (Karabekaul)-Nuratau (Koytash)]: Akad. Nauk Turkmen. SSR Izv., no. 3, p. 28-34, 1961.

The results of a seismic survey along the 320 km profile Amu Dar'ya-Nuratau are reported. The purpose of the survey was to determine subsurface structure and the depth of the Paleozoic basement. Four hundred and fifty shots of 600 kg explosive each produced on the average about 1,000 seismograms from which the nature of the deep seismic waves was determined. The three seismic stations operated during the survey are described, the types and groups of seismic waves are interpreted, and the profile is described and illustrated in a diagram. — A. J. S.

- 187-587. Tal'-Birskiy, B. B. Primeneniye seysmorazvedki v Bukharo-Khivinskoy neftegazonosnoy provintsii [Use of seismic prospecting in the Bukharo-Khivin oil-gas province]: Vses. Nauchno-Issled. Geologorazved. Neft. Inst. Trudy, no. 30, p. 73-78, 1961.

The geologic section and structure in the Bukharo-Khivin region of the Uzbek S. S. R. are very favorable for seismic surveying. The first seismic exploration for oil began in 1955, and 15 field parties were operating by 1959. Six seismic reflecting marker horizons are distinguished in the Meso-Cenozoic section. Each of these horizons is related to a great rhythm in sedimentation characterized by a sharp change from terrigenous to carbonate and evaporite. — J. W. C.

- 187-588. Teplitskiy, V. A. Nekotoryy rezul'taty seysmorazvedochnykh rabot v predelakh Bukharo-Gazlinskoy i Chardzhou-Pitnyakskoy zon [Some results of seismic prospecting operations within the Bukharo-Gazly and Chardzhou-Pitnyak zones]: Vses. Nauchno-Issled. Geologorazved. Neft. Inst. Trudy, no. 30, p. 79-82, 1961.

Seismic surveys during 1956-59 have yielded much information on the Bukharo-Khivin region. The configuration of the surface of the Paleozoic basement is described and illustrated by a cross section that also shows boundary velocities of refracted waves. The basement surface is characterized by several depressions and projections, which are linear in form. — J. W. C.

- 187-589. Central Water and Power Research Station Poona. Mettur Tunnel scheme. I. Seismic refraction on bed-rock: India Ministry of Irrigation and Power Central Water and Power Research Sta. Poona Ann. Research Mem., 1960, p. 224-225, 1961.

Results of seismic refraction surveys in the area of the proposed Mettur Tunnel show a considerable depth of highly elastic and massive bed rock covering the site. — V. S. N.

- 187-590. Central Water and Power Research Station Poona. Geophysical investigations: India Ministry of Irrigation and Power Central Water and Power Research Sta. Poona Ann. Research Mem., 1960, p. 230-248, 1961.

Results are reported briefly from seismic refraction surveys to locate two dam sites and a waste weir site (Navalpur) for the Hathmati River reservoir project, alternative weir sites on the Koyna River, a spillway site for the dam under construction on the Badua (Bihar) River, and the Navagam dam site for the Narmada River project. Electrical resistivity surveys were made also at the Navalpur weir site and electrical resistivity and magnetic surveys at the Navagam site. — V. S. N.

Kovylin, V. M. New data on the thickness of bottom sediments of the Indian Ocean. See Geophys. Abs. 187-610.

- 187-591. Sasa, Yasuo, and Izaki, Akira. Analysis and geologic interpretation of sonic survey on the western passage of Tsugaru Strait, Japan (2) [in Japanese with English abstract]: Jour. Geography [Tokyo], v. 70, no. 4 (723), p. 181-192, 1961.

The geology and geomorphology of the Tsugaru Strait are described based on an examination of rock specimens dredged from more than 2,000 localities and on further interpretation of the seismic profiles from a sonic survey (Sparker— see also Geophys. Abs. 185-563). — V. S. N.

Zverev, S. M. On the sedimentary structure in some portions of the Pacific Ocean from data on seismic reflected waves. See Geophys. Abs. 187-615.

STRENGTH AND PLASTICITY

- 187-592. Central Water and Power Research Station Poona. Modulus of elasticity of rock cores: India Ministry of Irrigation and Power Central Water and Power Research Sta. Poona Ann. Research Mem., 1960, p. 264-266, 1961.

The compressive and tensile strengths and the modulus of elasticity under compression and tension were determined for the weak tuff breccias found in the rock cores from the Koyna River weir site. The stress range adopted for the measurements of strains for the tuff breccia samples was from 0 to 200 psi for compressive and 0 to 80 psi for tensile loads. It was found that the strains within the selected range of stress followed Hooke's law. An average value for Young's modulus under compression and tension was found to be about 1.3×10^6 psi. — V. S. N.

- 187-593. Kundorf, W., and Rotter, D. Über die Anwendung der seismischer Eigenimpulsmethode bei der Erforschung dynamischer Auswirkungen des Gebirgsdruckes [On the application of the seismic self-impulse method in the investigation of dynamic effects of rock pressure (with English summary)]: Zeitschr. Geophysik, v. 27, no. 1, p. 35-47, 1961.

The present state of the method of natural seismic fields (self-impulse method) as applied to the investigation of rock stress is discussed in the light of research conducted in coal and ore mines. — D. B. V.

- 187-594. Wiebanga, W. A., and Manganwidjoyo, A. Some correlations between rock parameters, derived from Wuerker's "Annotated tables of strength and elastic properties," 1956: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 60-AY208, p. 377-380, 1960.

Some of the correlations between rock parameters to be found by study of Wuerker's "Annotated tables of strength and elastic properties of rocks," 1956 are discussed. The empirical relations concern dry rocks of varying porosity. Curves and equations interrelating the specific gravity, compressive strength, bar velocity, and Poisson's ratio are presented. — V. S. N.

- 187-595. Hiramatsu, Yoshio, and Oka, Yukiotoshi. Barodynamic experiments on the failure of rock around underground excavations: *Kyoto Univ. Eng. Research Inst. Tech. Rept.*, no. 82, v. 11, no. 5, p. 65-76, 1961.

The stress in rock around an underground excavation depends upon the topography, the nature of the ground, and the shape and size of the excavation. Barodynamic experiments are preferable to investigate the failure to be expected from earth pressures because they satisfy the law of similarity. The barodynamic experiments on the failure of ground around large excavations in the Yanahara and Kamioka mines are discussed. Models, geometrically similar to the excavations and surrounding areas, were placed in a centrifuge in such a way that the direction of centrifugal force corresponded to the direction of gravity in the prototype. In the prototype stress is caused only by gravity, while in the model it is caused by centrifugal force as well. However, since the force of gravity acting on the model is so small in relation to the centrifugal force it may be ignored; therefore, the ratio of stress at any point in a model to stress at the corresponding point in a prototype is a constant which depends upon the revolutions per minute of the centrifuge. The stress states in the two are thus similar. If model and prototype are composed of the same material, the strains are similar. It is concluded from these experiments that it is possible to foresee qualitatively what and where failure of rock will occur, but it is difficult to obtain data to predict exactly whether failure will take place or not because of the lack of homogeneity of the ground, especially around large openings. — V. S. N.

- 187-596. Snyder, James D., and Dellwig, Louis F. Plastic flowage of salt in mines at Hutchinson and Lyons, Kansas: *Kansas Geol. Survey Bull.*, no. 152, pt. 2, p. 31-46, 1961.

Plastic flowage in the pillars and floors of salt mines at Hutchinson and Lyons, Kans., is indicated by buckling, spalling, and fracturing. Data from detailed measurements of the relative sizes of pillars in newly opened rooms over an 11-month period indicate that flowage is due to the pressure of the overburden and is controlled by the percentage of salt excavated and the configuration of the excavation. Development of the structures results from spreading of the pillars by plastic flow and from movement along the lubricating underlying shale. The orientation and rate of flowage in the base, top, and middle of pillars are governed by the direction of easiest relief of stress, which, in turn, is controlled by the mining plan. — V. S. N.

- 187-597. Krausz, A. S. Etching technique to study plastic deformation of ice: *Jour. Glaciology*, v. 3, no. 30, p. 1003-1005, 1961.

A thermal-etching technique to study the underlying and governing physical phenomena in the creep behavior of ice is described. It has been found that when ice evaporates very slowly, the disturbed regions soon become visible because of the faster evaporation at these sites, that is, when ice is kept in saturated air thermal etching occurs. A few of the interesting results of application in study of grain boundary migration and of subboundary and slip line formation are described and illustrated. — V. S. N.

187-598. Kamb, W. Barclay. The glide direction in ice: *Jour. Glaciology*, v. 3, no. 30, p. 1097-1106, 1961.

The failure to detect experimentally a glide direction in the ice crystal is satisfactorily explained by assuming that the crystal glides simultaneously in three symmetry-equivalent directions with a response to the shear stress component in each direction that is the same as that observed for the crystal as a whole or for polycrystalline aggregates—the typical non-linear, power-type flow law. The 1120 direction is identified as the glide direction that accommodates the plastic properties of the ice crystal into modern concepts of crystal plasticity. — V. S. N.

Biot, M. A. Theory of folding of stratified viscoelastic media and its implications in tectonics and orogenesis. See *Geophys. Abs.* 187-251.

Biot, M. A., Odé, H., and Roever, W. L. Experimental verification of the theory of folding of stratified viscoelastic media. See *Geophys. Abs.* 187-252.

SUBMARINE GEOLOGY

187-599. Ewing, Maurice, and Landisman, Mark. Shape and structure of ocean basins, in *Oceanography: Am. Assoc. Adv. Sci. Pub.*, no. 67, p. 3-38, 1961.

The shape of the ocean basins in relation to continents, the area of the basins in relation to their depth, the pattern of transition from continent to ocean, and the form and extent of the Mid-Atlantic Ridge are discussed. The crustal structure of a typical ocean basin and the anomalous structure of the Mid-Atlantic Ridge as deduced from seismic evidence are described. The evidence from seismic waves, particularly surface waves, shows that the difference in structure between ocean basin and continent is true not only for the underlying crust but also for the mantle. Thermal, electrical, and other geophysical and geochemical evidence for the structure of the mantle are discussed briefly. It is pointed out that even the present limited knowledge about the upper mantle can lead to decisive judgments on some theories of the origin of continents and ocean basins. A bibliography of 72 items is included. — V. S. N.

187-600. Bullard, E[dward] C. Forces and processes at work in ocean basins, in *Oceanography: Am. Assoc. Adv. Sci. Pub.*, no. 67, p. 39-50, 1961.

Recent advances in our knowledge of the processes at work on the ocean floor are reviewed primarily to define the range of possible processes and to suggest further observations and experiments that may distinguish between them. The following are discussed: sedimentation in the abyssal plain and oceanic rises, and the role of turbidity currents; sedimentation along the con-

tinental shelf and possible interpretations for the observed structures; the nature and extent of submarine volcanism; and the larger tectonic pattern and its relation to the evidence for continental drift and convection currents. — V. S. N.

- 187-601. Arrhenius, Gustaf. Geological record on the ocean floor, in *Oceanography: Am. Assoc. Adv. Sci. Pub.*, no. 67, p. 129-148, 1961.

A general review is made of the wealth of information offered by the pelagic sediments for quantitative study of the past story of the solid earth, its ocean and atmosphere, and its interrelation with outer space. The characteristics of the Pacific Basin that make it particularly well suited as a recipient of representative sedimentary sequences are outlined. The sediments are discussed as a key to polar wandering, intensity changes in low-latitude atmospheric circulation, and climatic fluctuations; and the importance of study of solid particles—volcanic ash, quartz grains, cosmic spherules—in the interpretation of the record is treated. — V. S. N.

- 187-602. Carson, Rachel L. *The sea around us*: New York, Oxford University Press, 2d ed., 237 p., 1961.

Since the original edition of this book was published in 1951 many new discoveries have been made concerning the life, waters, and currents of the oceans and of the form of the ocean basins. In this 2d edition, the most important of the new findings are described in a series of notes in an appendix and are keyed to appropriate passages in the original text. The text is divided into three parts. Part I discusses the beginnings of the oceans in terms of earth history, the life at the surface and at depth and their interdependence, sedimentation in the ocean basins, volcanic activity and island formation, and the fluctuations of sea level throughout earth history. Part 2 discusses the motion of the sea on the surface and at depth and, part 3, the interrelation of man and the sea. — V. S. N.

- 187-603. Snodgrass, James M. *Introducing oceanography*: *ISA Jour.*, v. 8, no. 8, p. 75-79, 1961.

The science of oceanography is appraised briefly in this article, the first in a series of six. The difficulties of research work in the oceans and the generally used tools—cable-connected devices, manned and unmanned vehicles, free instruments, and buoys—are discussed. Expendable instruments seem to be one of the most promising approaches to the solution of the tremendous demands being made today for increased knowledge of the oceans; however, research on this type of device is still in the early stages, and history is only beginning for oceanography. — V. S. N.

- 187-604. Krishnan, M. S. *The mid-ocean ridges*: *India Nat. Inst. Sci. Proc.*, v. 26, pt. A, supp. 1, p. 195-218, 1960.

The mid-ocean ridges are located, and information on their form, structure, and origin as suggested by various authorities is discussed. The system is divided into three types: (1) The Mid-Atlantic and Mid-Indian type which Krishnan attributes to fractures developing in the crust as a result of the separation and drifting of continents; (2) the swell in the East Pacific (Easter Island-Albatross Plateau) that maybe due to comparatively mild compression of the oceanic crust resulting in slight doming without rupture or

thrusting; and (3) the Mid-Pacific ridge system that may be attributed to the formation of major shear zones in the Pacific Basin when the Atlantic and Arctic Oceans began to take shape by the more or less simultaneous movements of North America and Asia towards the Pacific basin. The Mid-Pacific Mountains may have originated as great magma intrusions along the initial shear belts; irregular pressures exerted on different parts of the Pacific Basin, especially to the north of the Mid-Pacific ridges, have broken up the oceanic crust into numerous major and minor blocks. — V. S. N.

187-605. Holtedahl, Olaf, and Holtedahl, Hans. On "marginal channels" along continental borders and the problem of their origin: Uppsala Univ. Geol. Inst. Bull., v. 40, p. 183-187, 1961.

Fairly recent oceanographic investigations by U.S.S.R. scientists in the sea off the Antarctic continent have shown that a very marked depression exists in the inner part of the shelf area south of Australia. This depression has an orientation parallel to the trend of the coast line and is evidently of the same type as the submarine "marginal channels" or trenches which have been described from various northern coastal regions (off Norway, W. Greenland, N. E. Labrador, N. Ellesmere Land, and others). The U.S.S.R. authors have independently arrived at the same conclusion regarding these phenomena in the southern area as the present writers have in the northern one, namely that the depressions probably indicate the existence of crustal fractures along which the land mass inside them has been uplifted in Cenozoic time. Certain problems concerning the origin of the channels are briefly discussed. — Authors' abstract

Picciotto, Edgard E. Geochemistry of radioactive elements in the ocean and the chronology of deep-sea sediments. See Geophys. Abs. 187-3.

187-606. Stewart, Harris B., Jr., Raff, Arthur D., and Jones, E. L. Explorer Bank—a new discovery in the Caribbean: Geol. Soc. America Bull., v. 72, no. 8, p. 1271-1274, 1961.

An "atoll-like" bank rising from nearly 1,000 fathoms to 15 fathoms about 95 miles off the Caribbean coast of Honduras was discovered and investigated by the U.S. Coast and Geodetic Survey ship, Explorer, in 1960. A towed magnetometer showed that the primarily calcareous bank has an igneous core. — D. B. V.

187-607. Heezen, Bruce C., Tharp, Marie, and Ewing, Maurice. The floors of the oceans. 1. The North Atlantic: Geol. Soc. America Spec. Paper 65, 122 p., 1959.

This is the text accompanying Sheet 1 of the physiographic diagram of the Atlantic Ocean, which will eventually consist of 5 sheets on a scale of about 1:5,000,000. The three major morphologic divisions are the continental margin, subdivided into three categories of provinces; the ocean basin floor, subdivided into the abyssal floor, oceanic rises, and seamount groups; and the mid-oceanic ridge, subdivided into crest and flank provinces. Each province is defined, briefly described, and illustrated with profiles and photographs of echo-sounding records. Pertinent earthquake, heat flow, magnetic, gravimetric, and other geophysical data are included in the discussions.

The boundaries of the physiographic provinces, defined solely by bottom topography, show good correlation with variations in crustal structure as determined by seismic refraction measurements and by gravity and magnetic

anomalies; they also correlate well with distribution patterns of bottom sediments. They are thus really morphotectonic provinces. — D. B. V.

- 187-608. Metcalf, W. G. Chain-17 in the Romanche Trench: *Oceanus*, v. 8, no. 1, p. 2-7, 1961.

Bathymetric and hydrographic surveys in the Romanche Trench area on the equator resulted in the location of a saddle point in the Mid-Atlantic Ridge at about long 15° W. that forms a passage for deep water. A brief preliminary discussion of the results is given. — V. S. N.

- 187-609. Emery, K[enneth] O., and Bentor, Y[aakow] K. The continental shelf of Israel: Israel Ministry of Devel., Geol. Survey Bull., no. 26, p. 25-41, 1960.

Detailed sounding profiles made across the Mediterranean continental shelf of Israel show the presence of sand, mud, and rock bottom. Some of the rocks are in the form of submerged kunkar ridges which have served as dams to cause the deposition of mud and sand on their shoreward sides. That these sediments have been derived mostly from the Nile River is indicated by a southward shoaling of the flat areas of the shelf. In contrast, the shelf edge, believed to have been eroded across rock bottom, deepens to the south, probably in response to downwarping of the earth's crust under the weight of the Nile Delta off Egypt. — Authors abstract

- 187-610. Kovylin, V. M. Novyye dannyye o moshchnosti donnykh otlozheniy Indiysskogo okeana [New data on the thickness of bottom sediments of the Indian Ocean]: *Akad. Nauk SSSR Doklady*, v. 136, no. 4, p. 924-926, 1961.

The results of seismoacoustic determinations of bottom sediment thickness at several places in the Indian Ocean are presented. Sections across the Java Trench and off Zanzibar are given. In the former, a maximum thickness of 1,450 m occurs in the Bali Basin; in the latter, thickness does not exceed 500 m and decreases gradually away from the coast. In the open ocean, bottom sediments are less than 200 m thick. The great contrast between the thickness in the coastal areas and that in the central Indian Ocean indicates that the sedimentary material is mainly land-derived. — D. B. V.

- 187-611. Bezrukov, P. L., Zatonkiy, L. K., and Sergeev, I. V. Gora Afanasiya Nikitina v Indiysskom okeane ("Afanasiy Nikitin Mountain" in the Indian Ocean): *Akad. Nauk SSSR Doklady*, v. 139, no. 1, p. 199-202, 1961.

A submarine mountain range in the Indian Ocean, discovered in the course of echo-sounding in December 1959 by the Vityaze expedition and named in honor of Afanasiy Nikitin, is described briefly. A bathymetric map and two profiles are given. — D. B. V.

- Starik, I. Ye., and Zharkov, A. P. Rate of sedimentation in the Indian Ocean according to data of the radiocarbon method. See *Geophys. Abs.* 187-53.

- 187-612. Raff, Arthur D. The magnetism of the ocean floor: *Sci. American*, v. 205, no. 4, p. 146-148, 150-154, 156, 1961.

A magnetometer survey of a strip of the northeast Pacific Ocean several hundred miles wide and extending 1,400 miles from Mexico to the Queen Charlotte Islands off British Columbia has revealed a north-south magnetic lineation throughout the area. The pattern is sharply broken along east-west lines from south to north by the Murray, Pioneer, and Mendocino faults. By matching magnetic "contour" lines on either side of the faults a total westward displacement of more than 700 nautical miles is found between the blocks of crust south of the Pioneer and north of the Mendocino faults. Were it not for the fault breaks some of the striations could be followed for more than 1,000 miles, and there is no reason for the lineations not to continue outside the surveyed area. Possible underlying structures that could produce this magnetic pattern are discussed; it is suggested that the present structure is the fossil record of ancient stresses, most probably from an east-west force of tension or compression. In the most probable model, the strongly positive anomalies represent ribbons of highly magnetic, volcanic basalt that flowed into channels formed by the stresses. The north-south direction of the pattern may indicate a connection with rotation. Various factors such as the effect of tidal action on rotation, of the thicker continental crust on the oceanic crust, and of earth tides are considered as sources of stress. Detailed magnetic and gravity surveys in all oceans are being planned. — V. S. N.

187-613. Bullard, Edward [C.]. The Mohole: Endeavour, v. 20, no. 80. p. 188-196, 1961.

This is a review of the background and history of the Mohole project to drill to the M-discontinuity, including results of trial drilling. Three test holes drilled near Guadalupe Island off the west coast of Mexico yielded some results of scientific value, in addition to their technological import. The sediments were found to be only 180 m thick and underlain by fresh basalt. The fact that the sediments are all Miocene eases the problem posed by the small thicknesses of unconsolidated sediments found on the ocean floor all over the world; it suggests that much of the material between the M-discontinuity and the ocean floor is composed of sediments interlayered with basalt. Temperature measurements indicate a high heat flow value (twice the average for the oceans), which confirms measurements made in the vicinity with short probes. — D. B. V.

187-614. Krause, Dale C. Geology of the sea floor east of Guadalupe Island: Deep-Sea Research, v. 8, no. 1, p. 28-38, 1961.

A gently rolling surface of very soft folded sediment lies at the anomalously shallow depth of 1,900 fathoms east of Guadalupe Island and is surrounded by deeper sea floor. The region was subject to intense activity during Tertiary time but has been deformed relatively little in comparison to the surrounding area in which large tectonic features such as volcanoes, ridges, basins, and deeps occur. It appears to have a normal oceanic crust because it has (1) a long depositional history, (2) north-south magnetic anomalies that are typical of the northeastern Pacific Ocean basin, and (3) a normal crustal thickness. — V. S. N.

187-615. Zverev, S. M. On the sedimentary structure in some portions of the Pacific Ocean from data on seismic reflected waves: *Annali Geofisica*, v. 14, no. 2, p. 187-196, 1961.

This is virtually the same as the paper published in *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 2, p. 80-86, 1961 (see *Geophys. Abs.* 185-589). — D. B. V.

VOLCANOLOGY

- 187-616. González Jenaro, R[eyna], and Foshag, William F. The birth of Parícutin, in *Smithsonian treasury of science*, v. 2: New York, Simon and Schuster, Inc., p. 398-421, 1960.

This classic description of the birth of Parícutin Volcano in Mexico in 1943 was published originally in the *Smithsonian Report* for 1946 (see also *Geophys. Abs.* 159-195, 167-287). — V. S. N.

- 187-617. A. J. G. N. Eruption of Mount Cameroon in 1959: *Overseas Geology and Mineral Resources*, v. 8, no. 2, p. 211-212, 1961.

Mount Cameroon (lat 9°14' N., long 9°10' E.) in West Africa is one of the world's largest volcanoes, rising to about 13,350 feet above sea level. Early in 1959 a series of eruptions took place, the most important of which occurred between February 8 and the end of March from three adjacent vents at a height of 8,000 feet. Mount Cameroon is composed chiefly of basalt lavas and tuffs; it is the only active member of a belt of volcanoes extending for 1,200 miles in a NNE direction from Annabon Island in the Gulf of Guinea to Lake Chad. Activity has been recorded since 1909. The most recent activity caused little damage; the largest lava flow was about 30 feet thick and had a width of nearly half a mile. — V. S. N.

- 187-618. Markhinin, Ye. K., and Alypova, O. M. O stat'ye G. S. Gorshkova "Nekotoryye voprosy teorii vulkanologii" [On S. G. Gorshkov's paper "Some questions of the theory of volcanology"]: *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 5, p. 101-103, 1961.

Gorshkov's seismic evidence concerning the magma reservoir under Klyuchevskaya Volcano in Kamchatka (see *Geophys. Abs.* 176-359, 177-380) is attacked as insufficiently conclusive. Seismograms from only one earthquake were used (Japan, Nov. 17, 1953). The focal parameters of that earthquake were not determined exactly, nor was observational error estimated. In comparing records of the Klyuchi and Magadan stations Gorshkov did not take into account differences in microseismic background and differences in magnification of the instruments. Gorshkov's "retarded" transverse wave arrivals at Klyuchi station could have been later and stronger phases of the transverse waves, the weaker early arrivals having been obscured by microseisms; in some cases they could have been sS arrivals, frequently observed in records of earthquakes in the Far East.

In the stronger Japanese earthquake of June 30, 1958, when the level of microseismic noise at Klyuchi was not high, transverse wave arrivals showed no unusual features, though Gorshkov's screening effect should have been manifest. Furthermore, arrivals from south Japanese earthquakes that have been recorded at Klyuchi some 10-19 sec after P-wave arrivals have also been recorded at Magadan and Petropavlovsk, and evidently correspond to sP waves.

Thus Gorshkov's qualitative estimates of the depth and dimensions of the Klyuchevskaya magma chamber and of the elastic constants of its contents cannot by any means be considered to be established, and the far-reaching conclusions drawn from them are entirely unjustified. — D. B. V.

- 187-619. Bogoyavlenskaya, G. Ye. Vulkan Bezymyanny na Kamchatke i yego aglomeratovyy potok [Bezymyanny Volcano on Kamchatka and its agglomerate flows]: *Akad. Nauk SSSR Lab. Vulkanologii Trudy*, no. 18, p. 3-34, 1960.

The structure and features of past eruptions of Bezymyanny Volcano are described, followed by a discussion of the agglomerate flows of March 30, 1956, and brief petrographic and chemical descriptions of its lavas and pyroclastic material. — D. B. V.

187-620. Svyatlovskiy, A. Ye. Ichinskiy vulkan v Sredinnom Kamchatkom khrebe (ocherk stroyeniya) [Ichinskiy Volcano in the Central Range of Kamchatka (outline of the structure)]: Akad. Nauk SSSR Lab. Vulkanologii Trudy, no. 18, p. 35-42, 1961.

The geologic setting, morphology, and structure of Ichinskiy Volcano are described briefly and its eruptive history reconstructed. It is an andesite-dacite volcano of central type, rising above an early Quaternary andesite-basalt plateau in the Central Range of the Kamchatka Peninsula. Volcanic activity in the region ceased a few hundred years ago, but there is still some fumarolic activity on the north flank of the volcano. — D. B. V.

187-621. Markhinin, Ye. K. Vulkanizm Kuril'skikh ostrovov [Volcanism of the Kurile Islands]: Akad. Nauk SSSR Izv. Ser. Geol., no. 6, p. 45-58, 1961.

Volcanism is extinct in the outer zone of the Kurile Island Arc, whereas it is still active in the inner zone. The outer zone is characterized by relatively high and the inner by relatively low gravity anomalies. The history of development of volcanism in the Kurile Islands is outlined.

Present volcanism is mainly the explosive type. Lavas of different composition may be erupted by different volcanoes at the same time, but in some cases a change from basic to silicic lavas in the course of time has been observed. Caldera formation has been extensive; some tens of km³ of material must have been removed from the upper crust to form these depressions. Intensive solfataric activity has given rise to sulfur deposits and alunitized zones; almost three fourths of the Kurile volcanoes are solfataric at the present time. Recent eruptions were those of Berg in the winter of 1951-52, Karpinskiy and Krenitsyna in 1952, Sarycheva in 1954 and 1956, and Zavaritskiy in 1957. The paper concludes with a brief discussion of the petrochemistry of the Quaternary volcanic rocks. — D. B. V.

187-622. Sekiya, H. An analysis of volcanic activity of Mt. Asama (4th paper)—An analysis of volcanic activity by the method of multiple correlation [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 4, p. 121-130, 1961.

The relation between the eruptions of Mount Asama and the sum of earthquakes and tremors originating from the volcano and that between the eruptions and the quantity of smoke observed during the period January 1949 to October 1959 is statistically studied. Formulas are given for determining the regression plane for the anticipation of the monthly probability of eruptions (Z) from data of the same month, the anticipation of probability of eruptions in the next month (Z'), the regression plane for anticipation of the sum of kinetic energies of the explosions in a month (E) by data of the same month, and the anticipation of the sum of kinetic energies of explosion for the next month (E'). It was found that the multiple correlation coefficient of the monthly probability of eruptions is larger than that of the monthly sum of the kinetic energies of explosions. The volcanic activity anticipated by the regression plane was compared with the actual phenomena for the period January 1939 to July 1960. Results show that when Z or $E=0$ few eruptions occurred but when Z or E was larger than 0 frequent eruptions occurred. The relation between the occur-

rence of the eruptions and the calculated value of Z or E is clearer than the relation between the eruptions and the sum of volcanic earthquakes and that between the eruptions and the quantity of smoke. Preceding the great eruption of September 23, 1950, Z and E were larger than during any other rest period. — V. S. N.

- 187-623. Ito, Yoshiro. Tilting motion of the ground as related to the volcanic activity of Mt. Aso and micro-process of the tilting motion of ground and structure: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 42, p. 1-55, 1961.

The results of tiltmeter observations at two points near the active crater of Aso Volcano from 1953-59 and the conclusions reached concerning the relationship between tilting and volcanic activity are discussed. During the period two major and several minor eruptions occurred. It is concluded that the ground around Aso crater begins to rise upward several months before a large eruption; the amount of upheaval is balanced by the subsidence following the eruption—immediately in one case, several months later in another. A very large, anomalous ground tilt of 100 inches observed at Hondo Station before the eruption of June 24, 1958, was ascertained to be correct by precise leveling before and after the eruption. Therefore, it is believed that large eruptions can be forecast by tiltmeter observations at suitable points around an active crater. — V. S. N.

- 187-624. Murai, Isamu. On the mud-flows of the 1926 eruption of Volcano Tokachi-dake, Central Hokkaido, Japan: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 1, p. 55-70, 1960.

In the violently explosive eruption of Tokachi-dake Volcano on May 24, 1926, devastating mud flows were caused by collapse of the central cone and by the sudden melting of snow by burning clouds of pumice and scoria that descended the western flank of the volcano. The volume of pyroclastic deposits is estimated at about 20,000,000 m³, and the volume of mud flow deposits caused by collapse of the central cone is estimated at about 5,000,000 m³. — D. B. V.

- 187-625. Ichimura, Takeshi. Geological investigations on the Zao volcanoes. 5. — Kumano volcano: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 2, p. 255-290, 1960.

The results of field and laboratory study of the geology of Kumano Volcano in the southern half of North Zao, Japan, are presented. Kumano is believed to have originated in the beginning of the Quaternary. Activity in historic times, recorded only since A. D. 884, has taken place mainly in the Okana crater, opened on the western flank in prehistoric times. The most violent recorded activity was an explosion of ash, lapilli, and scoria in 1895. The most recent eruption was in 1939, when several still-active fumaroles were formed. — D. B. V.

Yokoyama, Izumi. Gravity survey on the Aira caldera, Kyusyu, Japan. See Geophys. Abs. 187-333.

- 187-626. Decker, Robert W., and Hadikusomo, Djajadi. Results of the 1960 expedition to Krakatau: Jour. Geophys. Research, v. 66, no. 10, p. 3497-3511, 1961.

Activity of Anak Krakatau observed on January 12-13, 1960, consisted of explosive vulcanian-type eruptions of pyroclastics from fine ash to blocks 2

m in diameter, occurring at $\frac{1}{2}$ -10 min intervals. Four maps showing the volcano's growth since 1950 are presented. Fathometer measurements show that the 1883 caldera floor is being gradually leveled with volcanic detritus. Seismic records indicate that the eruptions begin some 200 m below sea level and churn their way to the surface. Steam generated where the magma reaches the porous pyroclastic base of Anak Krakatau is considered an important contribution to the periodic gas explosions.

Energy released in individual large explosive eruptions is estimated as 170 tons of TNT equivalent. Over 20-min increments the rate of energy release is nearly constant at 3.1×10^{13} cal, or 31,000 tons of TNT equivalent, per day. — D. B. V.

- 187-627. Gregg, D. R. Volcanoes of Tongariro National Park—A New Zealand Geological Survey Handbook: New Zealand Dept. Sci. Indus. Research Inf. Ser., no. 28, 82 p., 1960.

A popular and well-illustrated account is given of the volcanic area of the North Island of New Zealand. The Tongariro volcanoes lie at the southern end of a volcanic belt that stretches for a thousand miles across the southwest Pacific from New Zealand to Samoa. All active volcanoes, boiling springs, and geysers of New Zealand are found along this volcanic belt that extends in a northeast trending line through the center of the North Island. The major volcanoes and their eruptions are described, and the structural setting of the volcanic belt is discussed briefly. — V. S. N.

- 187-628. Verstappen, H. T. Some "volcano-tectonic" depressions of Sumatra, their origin and mode of development: Konink. Nederland. Akad. Wetensch. Proc., ser. B, v. 64, no. 3, p. 428-443, 1961.

The three "volcano-tectonic" lakes in Sumatra—Kerintji, Singkarak, and Toba—are evidently formed in a preexisting graben structure. There is no evidence of "volcano-tectonic" uparching prior to eruption, but at Toba there has been considerable young tectonic movement. This concept is the opposite of van Bemmelen's hypothesis that the depressions were formed by subsidence after eruption. The term "volcano-tectonic depression" should be abandoned, or its definition should be changed to "tectonic depression with occasional volcanic activity along faults." — D. B. V.

- Gorshkov, G. S. Petrochemistry of volcanic rocks in relation to the formation of island arcs. See Geophys. Abs. 187-256.

- 187-629. Minakami, Takeshi. Fundamental research for predicting volcanic eruptions (pt. 1): Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 4, p. 497-544, 1960.

The characteristics of volcanic earthquakes and crustal deformation associated with eruptions are discussed in comparison with tectonic earthquakes and deformation. Four types of volcanic earthquakes are distinguished: (1) The A-type, originating at the base of a volcano or at depths of 1-10 km, usually occurring before and in the first stage of activity. Motions cannot be distinguished from those of shallow tectonic earthquakes; P- and S-waves are characteristic. (2) B-type, with focuses limited to a radius of 1 km around the crater, shallower than the A-type; these occur in swarms and frequently are associated with vulcanian type activity, never with strombolian or hawaiian type. Surface waves predominate. (3) Explosion earthquakes, accompanying individual explosive eruptions, with an amplitude related to the magnitude of the explosion. Vibrations are similar to those of the B-type, but

magnitudes are larger. (4) Volcanic pulsation or microtremor, associated with strombolian or hawaiian type eruptions and sometimes with vulcanian, mainly surface waves.

The explosion earthquake is really a special kind of B-type earthquake; B-type earthquakes exceeding a certain magnitude are followed by explosive eruptions. In general, explosions in andesite and dacite volcanoes are preceded by a marked increase in B-type earthquakes. Also, the more frequent the B-type earthquakes, the greater the probability of large-magnitude shocks. — D. B. V.

- 187-630. Tanaka, Y[utaka], and Amano, H. Volcanic earthquake swarms of Hakoneyama and deeper earthquakes near the volcano [in Japanese with English abstract]: *Quart. Jour. Seismology* [Tokyo], v. 25, no. 4, p. 109-120, 1961.

Swarms of volcanic earthquakes are common in the Hakoneyama caldera, an inactive member of the Fuji volcanic zone. During the period from September 1959 to March 1960 swarms of earthquakes with epicenters several km deep took place under the Kamiyama area of the volcano. Study of seismograph records reveal that (1) the earthquakes occurred in groups each lasting over a period of 6 to 30 hr, (2) the earthquakes had great acceleration but small amplitude, (3) the relation between frequency "N" and amplitude "A" is $NA^{2.5} = \text{const}$, which indicates earthquakes medium in character between the two types of volcanic earthquakes common to Ususan, Asamayama, or Torishima, and (4) the relation between frequency "N" and the time interval of successive shocks "t" of the earthquakes, $[N]t^{1.8} = \text{const}$, shows that the Hakoneyama swarms are related to the tides of the nearby Pacific Ocean. The earthquake zones associated with the Fuji volcanic zone are discussed, and it is noted that the Hakone zone has a tendency to be active at the same time as the Northern Izu zone. Every zone tends to become active when a great earthquake occurs nearby. — V. S. N.

- 187-631. Tanaka, Y[utaka]. Relation between volcanic earthquakes and tidal phases [in Japanese with English abstract]: *Quart. Jour. Seismology* [Tokyo], v. 26, no. 1, p. 7-15, 1961.

Deformation of the earth's crust as a result of tidal pressures can cause volcanic earthquakes to occur when the epicentral region of a volcano is near the seacoast. The relationship between the frequency of volcanic earthquakes and the tidal phases was investigated for eight Japanese volcanoes located near the seacoast or forming islands. Results are illustrated in tables and graphs. — V. S. N.

- 187-632. Shimozuru, Daisuke. Volcanic micro-seisms—Discussion on the origin [in Japanese with English abstract]: *Volcanol. Soc. Japan Bull.*, ser. 2, v. 5, no. 3, p. 154-162, 1961.

An understanding of the nature and origin of volcanic microseisms (microtremors or harmonic tremors) is important for the prediction of volcanic eruptions, particularly those of the strombolian or hawaiian type. An analysis was made of the frequency distribution of microseisms for Kilauea, Nyiragongo, Mihara, Aso, and Sakurajima Volcanoes from seismographs of the same frequency characteristics located not more than 600 m from the source. The results indicate that the predominating period of the microseisms becomes shorter as the volcano becomes more silicic. It is concluded that volcanic microseisms are generated by free longitudinal vibrations of a viscous lava

column with an effective length of 500 m. The natural period for each volcano, as calculated by verifying the viscosity of the column, agreed satisfactorily with the observed predominating period of volcanic microseisms. — V. S. N.

- 187-633. Ivanov, V. V. Osnovnyye stadii gidrotermal'noy deyatel'nosti vulkanov Kamchatki i Kuril'skikh ostrovov i svyazannyye s nimi tipy termal'nykh vod [The main stages of hydrothermal activity of Kamchatka and Kurile Islands volcanoes and associated types of thermal waters]: *Geokhimiya*, no. 5, p. 473-485, 1958.

Study of the fumarolic and solfataric gases and thermal waters of the Kamchatka-Kurile volcanic belt leads to the conclusion that the character and intensity of hydrothermal activity associated with contemporary volcanoes are determined not only by magma chamber activity but also by thermodynamic and hydrologic conditions in higher horizons. Fumarole gases are high-temperature volcanic exhalations that do not pass through ground water; solfataric gases are relatively low-temperature "residual" volcanic gases that are filtered through ground water. Four stages of hydrothermal activity are distinguished.

Superheated alkaline sodium chloride thermal waters are formed in abyssal high-temperature reducing environments associated with magma chambers; these carry particularly large amounts of heat and are important as sources of geothermal power, as in New Zealand and Italy (see also *Geophys. Abs.* 178-436). — D. B. V.

- 187-634. Studdt, F. E. Preliminary survey of the hydrothermal field at Rabaul, New Britain: *New Zealand Jour. Geology and Geophysics*, v. 4, no. 3, p. 274-282, 1961.

Many hot springs are located around the shoreline of the breached caldera in which Rabaul is situated. Their hydrology and chemistry suggest that there is convective circulation of sea water in a zone of subsidence close to two young volcanoes. Although total heat flow is not known and there appears to be little thermoartesian pressure or hot water storage, it may be possible to exploit part of the hydrothermal field to supply Rabaul's power requirements, now furnished by expensive diesel generators. Further investigations are necessary before final assessment can be made. Geophysical surveys may guide the drilling but the final proving can come only through test drilling. — D. B. V.

INDEX

Abstract	Abstract
Adamiya, Sh. A -----	43
Adylov, F. T -----	212
Afanas'yeva, V. I -----	435
Agarwal, R. G -----	217
Agocs, W. B -----	561
Ahmad, F -----	262, 263
Airinei, Ștefan -----	330, 521
A. J. G. N -----	617
Akasofu, Syun-Ichi -----	436, 437
Aki, Keiiti -----	363
Aksel'rod, S. M -----	206
Aleksandruk, V. M -----	13
Alexander, W. M -----	68, 70
Aliyev, A. G -----	214
Alldredge, L. R -----	491
Alypova, O. M -----	618
Amano, H -----	630
Andreyev, B. A -----	288
Angenheister, G. H -----	421
Arrhenius, Gustaf -----	601
Asano, Shuzo -----	152, 365
Astier, J. L -----	182
Aswathanarayana, U -----	529
Atherton, David -----	273
Atkins, E. R., Jr -----	199
Avdulov, M. V -----	296
Aver'yanova, V. N -----	110
Ayzavov, I. V -----	113
Bagdasarova, A. M -----	110
Baker, George -----	77
Balakina, L. M -----	114
Balavadze, B. K -----	361
Ballakh, I. Ya -----	567
Balyasnyy, N. D -----	535
Barabashev, N. P -----	84
Baranov, Vladimir -----	564
Baranovskaya, N. V -----	52
Bassett, W. A -----	15
Bauer, A -----	276
Baussus, H. G -----	235
Beals, C. S -----	75
Becker, Alex -----	324
Bedcher, A. Z -----	200
Bell, Barbara -----	441
Belousov, V. V -----	253, 254
Belykh, V. A -----	548
Bender, J. A -----	278
Ben-Menahem, Ari -----	116, 117
Bentor, Y. K -----	609
Berg, J. W., Jr -----	162, 320
Bernal, J. D -----	246
Bespalova, I. D -----	30
Bezrukov, P. L -----	611
Bidgood, D. E. T -----	482
Bil'man, B. M -----	106
Bilotserkovets', Yu. I -----	336
Biot, M. A -----	251, 252
Birch, Francis -----	370
Bjork, R. L -----	73
Blackett, P. M. S -----	472
Blackie, A -----	408
Bloom, A. L -----	14
Bloomfield, K -----	20
Boesen, R -----	490
Bogdanov, A. Sh -----	186
Bogoyavlenskaya, G. Ye -----	619
Bohor, B. F -----	209
Bois, Pierre -----	555
Boletin Sismológico del Ser- vicio Geológico Nacional de El Salvador -----	137
Bol'shakov, A. S -----	464
Bolt, B. A -----	83
Bondarenko, L. P -----	31
Boniwell, J. B -----	221
Borisova, K. D -----	37
Bortfeld, Reinhard -----	149
Botezatu, Radu -----	521
Bott, M. H. P -----	356
Bowen, Robert -----	476
Boyd, D -----	178
Boyko, V. N -----	559
Breusse, J. J -----	182
Brodskiy, A. I -----	8
Broecker, W. S -----	376
Bromery, R. W -----	501, 502, 503
Brooks, R. R -----	192
Brotzen, F -----	26
Brown, M. V -----	576
Brown, R. D., Jr -----	506, 507
Brown, R. J. E -----	354
Brunn, J. H -----	255
Bucher, A -----	403
Buchheim, Wolfgang -----	127
Bullard, E. C -----	393, 600, 613
Bullerwell, W -----	325
Bunch, T. E -----	72

	Abstract		Abstract
Bune, V. I -----	98, 107	Danilevich, S. I -----	29
Burke, Kevin -----	544	Das Gupta, S. C -----	556
Buyalov, N. I -----	232	Davis, T. N -----	434
		Decker, R. W -----	626
Cameron, J. B -----	129	Delaplanche, J -----	565
Cameron, R. L -----	274	Dellwig, L. F -----	596
Campbell, W. H -----	414, 430	Delpeut, Jean -----	402
Canada Geological Survey --	510, 511	Deniskin, N. A -----	392
	512, 513, 514	Depowski, Stanisław -----	218
Caner, B -----	396	Dessler, A. J -----	439, 443
Carmichael, C. M -----	455	Deutsch, E. R -----	483
Carpenter, E. W -----	159	Deutsch, Sarah -----	56
Carron, M. K -----	78	de Vuyst, A -----	390
Carsey, J. B -----	223	Dewey, J. F -----	21
Carson, R. L -----	602	Dicke, R. H -----	59, 101
Carter, Adams -----	273	Dickens, H. B -----	354
Cecchini, Andrè -----	407	Dietz, R. S -----	71, 246
Central Water and Power		Dirac, P. A. M -----	59
Research Station Poona ---	96, 589	Dodson, M. H -----	23
	590, 592	Doell, R. R -----	477
Chantret, Francis -----	7	Dohr, Gerhard -----	584
Chao, E. C. T -----	76	Dooley, J. C -----	317
Chapman, R. M -----	216	Dowling, D. R -----	335
Chapman, Sydney -----	389, 437	Dubin, Maurice -----	70
	438, 442	DuBois, P. M -----	471
Chauveau, Jean -----	555	DuBois, R. L -----	481
Chelidze, T. L -----	94	Duclaux, Françoise -----	403
Cheriton, C. G -----	191	Duff, A. D -----	515
Chinnery, M. A -----	121	Duffus, H. J -----	427
Christoffel, D. A -----	524	Durbin, W. P., Jr -----	303
Cisternas, Armando -----	360	Dzhibladze, E. A -----	105
Clark, J. R -----	17	Dzhibuti, S. S -----	345
Clarke, R. S -----	78		
Claus, George -----	60	Eardley, A. J -----	248
Cohen, A. J -----	72, 87	Eargle, D. H -----	504, 505, 506
Coleman, P. J., Jr -----	443		507, 508, 542
Conley, F. R -----	209	Ekren, E. B -----	189
Consbruch, Claus von -----	421	Elizondo, J. R -----	346
Cook, A. H -----	312	Ellis, G. R. A -----	413
Cook, D. R -----	215	El-Ramly, M. F -----	25
Cook, K. L -----	162, 320	Emery, K. O -----	609
Cook, M. A -----	248	Engineering and Mining Journal-	518
Copeland, R. J -----	322	Everitt, C. W. F -----	456
Coster, F. M -----	195	Evison, F. F -----	473
Cox, A. V -----	477	Ewing, J. I -----	132
Craig, B. G -----	18	Ewing, Maurice -----	132, 599, 607
Craig, Harmon -----	377		
Crary, A. P -----	222, 280	Faradzhev, A. S -----	179
Creer, K. M -----	465, 474, 479	Fatt, Irving -----	208
		Faynberg, F. S -----	460, 484
Dąbrowski, Adam -----	219	Fedotov, S. A -----	110
Dagelayskiy, V. B -----	31, 33	Firsov, F. V -----	343
Dalseide, Helge -----	399	Firsov, L. V -----	4, 11, 45, 46
Dam, J. C. van -----	196	Fischer, Irene -----	244

Abstract

Abstract

Fleming, H. W -----	192	Havemann, Hans -----	264
Foshag, W. F -----	616	Hayakawa, T -----	64
Frassetto, Roberto -----	576	Heezen, B. C -----	607
Fridman, Sh. D -----	535, 549	Heifetz, M. E -----	306
Frischknecht, F. C -----	189, 194	Heine, A. J -----	279
Futi, Hidetaka -----	352	Heiskanen, W. A -----	238
		Helbig, Klaus -----	316
Galushko, P. Ya -----	250	Helliwell, R. A -----	224, 425
Gast, P. W -----	577	Hemon, Charles -----	555
Gayskiy, V. N -----	106	Hess, W. N -----	86
Gel'man, O. Ya -----	12	Hibberd, F. H -----	488
Gerling, E. K -----	38, 49	Hide, Raymond -----	384
Gilbert, C -----	58	Hiersemann, Lothar -----	134
Gilbert, D -----	403	Higazy, R. A -----	25
Giletti, B. J -----	22	Hine, A -----	385
Girdler, R. W -----	457	Hinsley, F. B -----	341
Gjellestad, Guro -----	399	Hintenberger, H -----	64
Glangeaud, Louis -----	359	Hiramatsu, Yoshio -----	595
Glebova-Kul'bakh, G. O -----	36	Hirvonen, R. A -----	242
Glen, J. W -----	272	Hodgson, J. H -----	138
Glendinin, L. E -----	528	Holtedahl, Hans -----	605
Glyuzman, A. M -----	168	Holtedahl, Olaf -----	605
Goldenfeld, I. V -----	8	Holz, H. W -----	353
Goldthwait, R. P -----	274	Honda, Hirokichi -----	422
González Jenaro, Reyna -----	616	Hopfield, H. S -----	282
Gorbenko, V. F -----	211	Horai, Ki-iti -----	342, 352
Gorokhov, I. M -----	37	Hrách, Stanislav -----	520
Gorshkov, G. S -----	256	Hu, Ch'ang-lin -----	348
Gougenheim, M. A -----	146	Hughes, T. D -----	350, 546
Gow, A. J -----	278		
Grabner, L. H -----	576	Ichimura, Takeshi -----	625
Gratsianova, O. P -----	229	Inagaki, Morido -----	326
Green, R -----	130	Ingall, L. N -----	322
Green, Ronald -----	489	Innes, M. J. S -----	74
Gregg, D. R -----	627	Inoue, Hideo -----	54
Griffiths, D. H -----	470, 582	International Geophysical Year Bulletin -----	394, 395
Grigoryev, I. G -----	12	Ionescu, Florian -----	521
Gross, G. W -----	188	Irving, E -----	469, 474, 475, 490
Gugunava, G. E -----	94	Israel, Hans -----	533
Guha, S. K -----	304	Iszak, I. J -----	239
Gupta, U. C -----	534	Ito, Yoshiro -----	623
Gurvich, I. I -----	570	Ivanov, A. I -----	44
Gutenberg, Beno -----	103	Ivanov, L. I -----	560
		Ivanov, O. D -----	522
Hadikusomo, Djajadi -----	626	Ivanov, V. V -----	633
Haefeli, Robert -----	270, 271	Izaki, Akira -----	591
Hales, A. L -----	371		
Hall, J. M -----	453	Jeffreys, Harold -----	85
Hallof, P. G -----	180	Jelen, Miroslav -----	520
Hamilton, A. C -----	313	Jenny, W. P -----	498
Hamilton, W. B -----	247	Jensen, Homer -----	497
Hanson, W. B -----	439	Jesson, E. E -----	277
Harrison, J. C -----	299	Jobert, Nelly -----	407
Hatherton, T -----	111	Jones, E. L -----	606
Hatuda, Zin'itiro -----	530		

	Abstract		Abstract
Jones, H. S -----	141	Komlev, L. V -----	29
Joplin, Germaine -----	467	Kon'no, Enzo -----	125
Jordan, Louise -----	210	Konovalov, M. M -----	569
		Koopmans, L. H -----	160
Kakinuma, Seiichi -----	409	Kopal, Zdeněk -----	79
Kalashnikov, A. G -----	462	Kopf, Manfred -----	572
Kalinin, Yu. D -----	435	Kornev, V. A -----	585
Kalmakov, M. V -----	93	Kovach, R. L -----	367, 368
Kal'varsкая, V. P -----	201	Kovalenko, V. F -----	185
Kamb, W. B -----	598	Kovylin, V. M -----	610
Kanamori, Hiroo -----	352	Kozai, Yoshihide -----	283, 284, 285
Kántás, Karl -----	328	Kozhina, T. K -----	5
Karapetyan, B. K -----	165	Krause, D. C -----	614
Kárník, Vít -----	104	Krausz, A. S -----	597
Karpinskaya, T. B -----	10	Krayev, G. A -----	158
Karrow, P. V -----	17	Krey, Theodor -----	566
Kartevilishvili, K. M -----	293	Krishnan, M. S -----	604
Kasahara, Keichi -----	119	Krylov, A. Ya -----	40, 52
Kataja, Airi -----	95	Kudryavtsev, Yu. I -----	500
Kato, Yoshio -----	422	Kuiper, G. P -----	80
Katok, A. P -----	106	Kukhareenko, N. K -----	539
Kaufman, A. A -----	167	Kul'chikhina, T. N -----	558
Kaula, W. M -----	240	Kulp, J. L -----	16
Kawashima, Takeshi -----	562	Kundorf, W -----	593
Kazakov, A. N -----	49	Kunetz, Gésa -----	563
Kazakov, G. A -----	39	Kuo, Tseng-Chien -----	120
Keating, W. D -----	317	Kuzelov, Yu. V -----	531
Keeling, C. D -----	375	Kuzin, I. P -----	110
Keller, G. V -----	194		
Kendall, P. C -----	438	LaCoste, L. J. B -----	299
Kern, J. W -----	451, 452	LaGow, H. E -----	68
Key, F. A -----	159	Lal, Devendra -----	377
Khanin, A. A -----	203	Lambert, R. S. J -----	22
Kharaz, I. I -----	559	Lambert, W. D -----	237, 286
Kharchenko, F. M -----	574	Landisman, Mark -----	599
Kharchenko, G. Ye -----	574	Langill, F. E -----	138
Khil'tova, V. Ya -----	51	Larochele, A -----	463, 478
Khramov, A. N -----	468	Lazarev, K. F -----	383
Khrebtov, A. I -----	344	LeBorgne, Eugène -----	406, 407, 519
Kim, K. S -----	198	Legget, R. F -----	354
Kim, Y. C -----	198	Legin, V. K -----	531
King, R. F -----	470, 582	Leontyev, V. G -----	379
Kinshakov, A. I -----	207	Levin, B. Yu -----	340
Kinyapina, T. A -----	99	Levyant, V. B -----	568
Kirova, O. A -----	67	Levykin, A. I -----	156
Kisslinger, Carl -----	163	Lew, J. S -----	388
Kivioja, Lassi -----	234	Lewis, W. V -----	272
Kline, R. C -----	282	Lindsay, J -----	467
Kneissl, Max -----	310	Lipskaya, N. V -----	392
Knutson, C. F -----	209	Lipsky, Yu. N -----	84
Kobayashi, Naota -----	82	Liyva, A. A -----	28
Kochan, L. S -----	187	Li-Zhen', U -----	34
Kochegura, V. V -----	468, 485, 487	Lliboutry, Louis -----	583
Kogan, R. M -----	535	Lobach-Zhuchenko, S. B -----	35, 37
Komarov, A. G -----	468	Lock, C. M -----	428

Abstract		Abstract	
Loeb, J -----	150	Meyer, A. J. P -----	461
Long, A -----	16	Migunov, B. B -----	551
Loomer, E. I -----	396	Mikaelyan, Sh. S -----	213
Lossovskiy, Ye. K -----	135	Mikhailov, A. A -----	84
Lovtsyus, A. V -----	379	Mikhalevskaya, A. D -----	29
Lovtsyus, G. P -----	9	Mikumo, Takeshi -----	364
Lozano Calvo, Luis -----	315	Miliayev, N. A -----	398
Lukavchenko, P. I -----	290	Minakami, Takeshi -----	629
Lum, Daniel -----	319	Minzberg, L. V -----	214
Lusova, L. M -----	343	Mitchell, F. J -----	541
L'vov, Yu. A -----	66	Modrinskiy, N. I -----	245
Lyttleton, R. A -----	57	Molochnov, G. V -----	169
Lyubimova, Ye. A -----	338, 339, 343	Monich, V. K -----	44
Lyustikh, Ye. N -----	249, 257, 357	Moody, G. B -----	228
		Moorbath, Stephen -----	22
McCarthy, E -----	317	Moorcroft, E -----	335
McCracken, C. W -----	68, 70	Mooser, F -----	265
MacDonald, G. J. F -----	126, 440	Morgan, W. J -----	101
MacDowall, J -----	408	Mou, Hung-wei -----	349
McEvilly, T. V -----	143	Moxham, R. M -----	504, 505, 506
Mackay, D. G -----	193		507, 508, 542
McKenzie, A. M -----	221	Moyd, Louis -----	538
McLeod, I. R -----	277	Moyd, Pauline -----	538
McMurtie, I. H -----	334	Mufti, Irshad -----	332
Maddern, C. A -----	317	Murai, Isamu -----	624
Maeda, Hiroshi -----	446	Muraishi, Yukihiko -----	409
Mahadevan, C -----	529		
Makarov, A. N -----	202	Nagata, Takesi -----	411, 417
Maldonado-Koerdell, M -----	265	Nagumo, Shozaburo -----	562
Malmqvist, David -----	65	Nagy, Bartholomew -----	60
Manganwidjoyo, A -----	594	Nairn, A. E. M -----	474
Mann, V. I -----	318	Nakamura, Kohei -----	161
Mansurov, S. M -----	412	National Bureau of Standards ---	391
Markhinin, Ye. K -----	618, 621	Natoff, N. C -----	502
Markov, K. K -----	260	Nazarenko, O. V -----	197
Marmo, Vladi -----	19, 227, 231	Nazarov, A. G -----	123
Martin, L. H -----	224	Neprochnov, Yu. P -----	571
Marzahn, Kurt -----	311	Nersesov, I. L -----	108
Mašín, Jan -----	520	Newton, R. R -----	282
Maslenikov, V. A -----	31	Neyelov, A. N -----	48
Mason, Brian -----	62, 63	Niblett, E. R -----	447
Mason, R. G -----	393, 516, 517	Nikolayev, D. S -----	531
Mateker, E. J., Jr -----	143	Nikolayeva, L. A -----	214
Matumoto, Hideteru -----	136	Nimiforov, M. V -----	535
Matumoto, Tosimatsu -----	365	Nishimura, Genrokuro -----	124
Matuzawa, Takeo -----	365	Nishimura, Susumu -----	530
Mavlyanov, A. V -----	212	Noblan, O -----	401
Mayeva, S. V -----	340	Norden, J. A. E -----	164
Mazzon, Cozzado -----	314	Nordyke, M. D -----	86
Maede, R. F -----	380	Northrop, John -----	576
Meador, J. G -----	579		
Mekhtiyeva, V. L -----	381	Odé, H -----	252
Melbye, C. E -----	190	Oeschger, H -----	24
Melchior, P. J -----	142, 143, 144	Offshore -----	578
Metcalf, W. G -----	608	Oka, Yukitoshi -----	595

	Abstract		Abstract
Okada, Atsushi -----	266	Reinharz, M -----	56
Okada, Atusi -----	364	Rel'tov, B. F -----	158
Okano, Kennosuke -----	525	Renne, O. S -----	535
Ol', A. I -----	419	Research Group for	
Olson, E. A -----	376	Explosion Seismology -----	364
Ondoh, T -----	444	Reuter, Helmut -----	553
Onhauser, A. A -----	397	Reyman, V. M -----	107
Onhauser, M. H -----	397	Rikitake, Tsuneji -----	90, 424, 499
Öpik, E. J -----	61, 81	Ritsema, A. R -----	115
Orlova, L. P -----	47	Rivosch, L. A -----	523
O. R. S. T. O. M -----	404, 405	Riznichenko, Yu. V -----	108
Osharov, A. B -----	66	Roberts, B. C -----	178
Oshima, H -----	415	Roberts, P. H -----	384
Ostrovskiy, I. A -----	10	Robertson, W. A -----	490
Otsuka, Michio -----	364	Rodermund, C. G -----	552
Oussarof, G -----	403	Roethlisberger, Hans -----	581
Ovchinnikov, A. M -----	347	Roever, W. L -----	252
Ozawa, Izuo -----	145	Rosenbaum, J. H -----	147
		Röthlisberger, Hans -----	24
Paarma, Heikki -----	227	Rotter, D -----	593
Parasnis, D. S -----	287	Rozova, Ye. A -----	109
Parker, E. N -----	439	Rubinshteyn, M. M -----	1, 12, 41, 42
Paterson, N. R -----	193, 300	Rudich, Ye. M -----	253
Paul, M. K -----	294	Rukavishnikov, V. G -----	547
Pavlenko, A. S -----	47	Rummelen, F. F. F. E. van -----	196
Pekarskaya, T. B -----	6	Runcorn, S. K -----	474
Pemberton, R. H -----	230, 509	Ryss, Yu. S -----	173
Per'kov, N. A -----	204		
Petrova, G. N -----	454, 468	Sable, E. G -----	216
Picciotto, E. E -----	3, 56	Sahasrabudhe, P. W -----	483
Pinayeva, N. I -----	35, 36	Saito, Masanori -----	82, 128
Piskunov, L. I -----	225	Saito, Takao -----	416
Pitulej, W -----	545	Salisbury, J. W -----	88
Poldini, E -----	326	Saltykovskiy, A. Ya -----	357
Polevaya, N. I -----	2, 39	Samosyuk, G. P -----	170
Polkanov, A. A -----	34, 38	Santo, T. A -----	366, 526
Polonskiy, A. M -----	495	Sasa, Yasuo -----	591
Ponomarev, V. N -----	496	Sasajima, Sadao -----	459
Ponomarev, Ye. A -----	423	Sato, Kazuo -----	54
Popovici, Dorin -----	521	Savarenskiy, Ye. F -----	105, 114, 362
Porkka, M. T -----	131	Savel'yev, A. A -----	50
Porstendorfer, Gottfried -----	184	Sawatzky, H. B -----	217
Press, Frank -----	117, 367, 368	Schmidt, Gerhard -----	566
Priyatkina, L. A -----	32	Schmidt, R. G -----	540, 543
Prozorovich, E. A -----	337	Scott, G. G -----	461
Puchkov, S. V -----	102	Scott, R. F -----	355
		Searle, E. J -----	55
Radakrishnamurty, C -----	483	Seelis, K. H -----	566
Raff, A. D -----	516, 517, 606, 612	Sekiya, H -----	622
Ragimov, Sh. S -----	112	Selzer, Édouard -----	400, 407
Rapoport, M. B -----	157	Semenenko, N. P -----	27
Raspet, Rudolph -----	351	Semenov, A. S -----	172, 460, 466
Redpath, B. B -----	580	Semenov, E. I -----	30
Rees, A. I -----	458	Sen'ko-Bulatnyy, I. N -----	548
Reid, A. M -----	72	Sergeyev, I. V -----	611

	Abstract		Abstract
Shalayev, S. V -----	289	Stoner, J. O -----	101
Shanin, L. L -----	10	Stott, B. M. H -----	159
Shaub, Yu. B -----	226	Stott, P. M -----	453, 469
Shechkov, B. N -----	362	Stuart, A. W -----	279
Shel'ting, V. F -----	392	Studt, F. E -----	634
Shengelaya, G. Sh -----	331, 361	Stupnikova, N. I -----	47
Sherratt, A. F. C -----	341	Sudovikov, N. G -----	48
Sheynmann, Yu. M -----	369	Sugiura, Masahisa -----	429
Shima, Etsuzo -----	575	Sukhanov, B. I -----	547
Shima, Michiyasu -----	155	Šumi, Franc -----	183
Shimazu, Yasuo -----	358	Suzuki, Masazi -----	124
Shimozuru, Daisuke -----	632	Svyatlovskiy, A. Ye -----	620
Shmidt, O. Yu -----	233	Swartz, J. H -----	351
Shoemaker, E. M -----	76	Szabo, Bela -----	305
Sholpo, L. Ye -----	449, 485, 486, 487	Takeuchi, Hitoshi -----	82, 128, 374
Shtimmer, A. I -----	166	Tal'-Birskiy, B. B -----	587
Shuleykin, V. V -----	91, 92, 410	Talwani, Manik -----	321
Shulyat'yev, S. A -----	548	Tamao, Tsutomu -----	431
Shumskiy, P. A -----	267, 268	Tanaka, Yutaka -----	630, 631
Shushpanov, A. P -----	343	Tanaoka, Iwao -----	499
Shvank, O. A -----	298	Tarakanov, R. Z -----	110
Sigachev, N. I -----	92	Tazieff, Haroun -----	122
Sikharulidze, D. I -----	97	Tengström, Erik -----	236, 295
Silin, Yu. I -----	40	Teplitskiy, V. A -----	588
Silverman, A -----	16	Terashima, Tsutomu -----	364
Singer, S. F -----	69	Terasmae, J -----	17
Sizov, V. P -----	156	Terekhin, Ye. I -----	166, 167, 179
Slepak, Z. M -----	302	Teupser, Christian -----	133
Śliviński, Zygmunt -----	218	Tharp, Marie -----	607
Smit, J -----	450	Thirlaway, H. I. S -----	316
Smith, G. H -----	199	Thiruvkatachar, V. R -----	151
Smith, R. A -----	493	Thomas, P. D -----	241
Smith, S. W -----	127	Thompson, L. G. D -----	305
Snodgrass, J. M -----	603	Tikhonov, V. I -----	523
Snyder, J. D -----	596	Tilak, V. V. S. S -----	529
Sobotovich, E. V -----	9, 379	Timko, D. J -----	209
Sokhranov, N. N -----	207	Toksöz, M. N -----	117
Solodunov, A. I -----	207	Tomoda, Yoshibumi -----	352
Solomasov, A. I -----	554	Troshkov, G. A -----	289
Sonett, C. P -----	443	Trukachev, G. A -----	66
Space Science -----	89	Trumbull, J. V. A -----	504, 505
Srivastava, P. K -----	534	Trusheim, Ferdinand -----	553
Stacey, F. D -----	453, 467	Tskhakaya, A. D -----	97
Starik, F. Ye -----	382	Tucek, C. S -----	376
Starik, I. Ye -----	9, 40, 52, 53 379, 382, 383, 531	Tugarinov, A. I -----	47, 378
Starikova, G. N -----	343	Tushkanov, L. Ya -----	297
Stavrou, Angelos -----	448	Ullmann, W -----	133
Ștefănescu, S. S -----	521	Umezu, Naganori -----	176, 177
Steinberg, E. P -----	528	Uotila, U. A. K -----	308
Steiner, Franz -----	301	Upton, P. S -----	527
Stevens, P. J -----	428	Urupov, A. K -----	557
Stewart, H. B., Jr -----	606	Utsu, Tokuji -----	364
Stoenescu, Scarlet -----	329, 521	Uyeda, Seiya -----	342, 352
Stoneley, R. S -----	148		

	Abstract		Abstract
Uznadze, E. D-----	12	Wilson, C. R-----	280
Vacquier, Victor-----	515	Wilson, J. T-----	246
Vaisberg, O. L-----	140	Wilson, N. W-----	19
Valentine, J. W-----	380	Wilson, R. L-----	480
Valliant, H. D-----	313	Wilson, W-----	217
VanderHoeven, F. G-----	222	Winter, P. J-----	313
Van Voorhis, G. D-----	491	Wolf, Helmut-----	307
Van'yan, L. L-----	166, 167	Woollard, G. P-----	309
Vartanov, S. P-----	585	World Oil-----	573
Vasil'yev, A. V-----	466	Worzel, J. L-----	321
Vasil'yev, N. V-----	66	Wright, A. E-----	470
Vasil'yeva, L. B-----	100	Wright, J. K-----	159
Vasil'yeva, V. G-----	220	Wright, P. M-----	528
Velikoslavinskiy, D. A-----	49	Yakupov, V. S-----	174
Vening Meinesz, F. A-----	261, 372	Yakzhin, A. A-----	536
Verbaandert, J-----	142, 143, 144	Yamamoto, Giichi-----	422
Verstappen, H. T-----	628	Yanagihara, Kazuo-----	418
Veshev, A. V-----	170, 171,	Yasuhara, M-----	446
Vestine, E. H-----	426	Yegorov, Yu. M-----	392
Vicente, R. O-----	139	Yelizarova, A. N-----	382
Vilkov, N. V-----	205	Yen, Tung-Lu-----	259
Vivet, Roland-----	583	Yeremenko, N. A-----	381
Vogel, Andreas-----	373	Yeroshkina, A. I-----	66
Volarovich, M. P-----	156	Yevstrakhin, V. A-----	537
Vol'vovskiy, B. S-----	586	Yevteyev, S. A-----	275
Vol'vovskiy, I. S-----	586	Yokoyama, Izumi-----	333
Vvedenskaya, A. V-----	114, 118	Yoshimatsu, Takasaburo-----	445
Wakai, Noboru-----	433	Yoshino, Takeo-----	432
Wang, Kuang-Yen-----	258	Yoshiyama, Ryoichi-----	153, 154
Wänke, H-----	64	Yukutake, Takesi-----	386, 387
Ward, M. A-----	469	Yun'kov, A. A-----	291, 292
Ward, S. H-----	181	Zabarinskiy, P. P-----	232
Warren, R. E-----	515	Zabek, Z-----	243
Watkins, N. D-----	494	Zablocki, F. S-----	318
Wawrzik, Martin-----	572	Zaccara, Gaetano-----	327
Wdowiarz, Stanisław-----	218	Zatonskiy, L. K-----	611
Weber, J. R-----	323	Zamyatin, N. I-----	44
Weertman, J-----	269	Zandle, G. L-----	501
Wesley, J. P-----	492	Zharkov, A. P-----	53
Wexler, H-----	281	Zhigalov, L. N-----	420
White, B. L-----	503	Zhirova, V. V-----	52
Wiebanga, W. A-----	594	Zolotov, A. V-----	532
Wijn, H. P. J-----	450		539, 550
Will, Rolland-----	403	Zumberge, J. H-----	577
Williams, L. W-----	317	Zverev, S. M-----	615
Wilson, C. D. V-----	582	Zykov, S. I-----	47, 378

