

# Geophysical Abstracts 185 April-June 1961

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

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

*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***

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## GEOPHYSICAL ABSTRACTS 185, APRIL-JUNE 1961

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 175 (October-December 1958, Bulletin 1086-D) have been compiled into a single list, which may be obtained by writing the U.S. Geological Survey, Washington 25, D. C.

Supplements to this master list have been published in each issue since Geophysical Abstracts 175. The following is an additional supplement that lists references cited in Geophysical Abstracts 185 that have not been listed previously.

Addis Ababa Univ. Coll., Geophys. Observatory Bull. -- Bulletin of the Geophysical Observatory, Addis Ababa University College. Addis Ababa, Ethiopia.

Akad. Nauk Uzbek. SSR Izv., Ser. Geol. -- Akademiya Nauk Uzbekskoy SSR, Izvestiya, Seriya Geologicheskaya [Academy of Sciences of the Uzbek S.S.R., Bulletin, Geological Series]. Tashkent, Uzbek S.S.R.

Annales Astrophysique -- Annales d'Astrophysique. -- Revue Internationale Bimestrielle. Publiée par le Centre National de la Recherche Scientifique et Éditée par Son Service d'Astrophysique [Annals of Astrophysics. International Bimonthly Review. Published by the National Center of Scientific Research and edited by its Astrophysics Service]. Paris, France.

Bol. Tecn. Petrobrás -- Boletim Técnico da Petrobrás. Publicado pelo Centro de Aperfeiçoamento e Pesquisas de Petróleo com a Colaboração dos Órgãos Técnicos de Empresa [Technical Bulletin of Petrobrás. Published by the Center of Petroleum Development and Investigation with the Cooperation of the Technical Organ of the Enterprise]. Rio de Janeiro, Brazil.

Edmonton Geol. Soc. Quart. -- Edmonton Geological Society Quarterly. Edmonton, Alberta, Canada.

[France] Comm. Énergie Atomique Bull. Inf. Sci. Tech. -- Bulletin d'Informations Scientifiques et Techniques. Commissariat à l'Énergie Atomique [Bulletin of Scientific and Technical Information. Atomic Energy Commission]. Paris, France.

- Geog. Rev. Japan -- Geographical Review of Japan [Chirigaku Hyoron]. The Association of Japanese Geographers, Institute of Geography, Faculty of Science, University of Tokyo. Tokyo, Japan.
- Geologica Ultraiectina -- Geologica Ultraiectina. Mededelingen van het Mineralogisch-Geologisch Instituut der Rijksuniversiteit te Utrecht [Bulletin of the Mineralogical-Geological Institute of Rijks University in Utrecht]. Utrecht, Netherlands.
- Inst. Petroleum Rev. -- The Institute of Petroleum Review. London, England.
- Mining Engineer -- Mining Engineer. The Institution of Mining Engineers. London, England.
- Northern Rhodesia Geol. Survey Recs. -- Records of the Geological Survey, Northern Rhodesia Ministry of Labour and Mines. Lusaka, Northern Rhodesia.
- Oceanographia Sinica -- Oceanographia Sinica [Chinese Oceanography]. Private Research Publication in Cooperation with the Overseas Branch of the National Academy of Peiping and Académie et Bibliothèque Sino-Internationales. Taiwan, China.
- Offshore -- Offshore. Industrial Trade Publications. Conroe, Texas.
- Prog. Theoretical Physics -- Progress of Theoretical Physics, Research Institute for Fundamental Physics, Physical Society of Japan. Kyoto, Japan.
- Tokyo Univ. Fac. Sci. Jour. -- Journal of the Faculty of Science, Tokyo University. Tokyo, Japan.

#### 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 H. Faul, E. C. Robertson, A. J. Shneiderov, and H. C. Spicer, as well as by the principal authors. Authors' abstracts are used in many instances. The initials of an abstractor following the notation "Author's abstract" indicates a translation from the original language.

#### AGE DETERMINATIONS

- 185-1. Kulp, J. Laurence, Geologic time scale: Science, v. 133, no. 3459, p. 1105-1114, 1961.

Available pertinent isotopic age measurements are evaluated and the most probable geologic time scale is constructed. Those samples that appear to be most definitive are listed in a table and described briefly in an appendix. In the new time scale the Cenozoic and Cretaceous are much better defined than any other parts. No data exist for the Silurian, and only a few quantitative points are available for the Cambrian, Ordovician, and Triassic. The length of the major periods averages about 60 million years, with surprising uniformity. The division into Early, Middle, and Late clearly does not, on the basis

of biostratigraphic considerations, represent equal or even similar time intervals. The geologic time scale has developed to the place where it can be used for correlation problems in paleontology, orogeny, and mineralization. — D. B. V.

- 185-2. Aldrich, L. T[homas], Wetherill, G[eorge] W., Bass, M[anuel] N., Tilton, G[eorge] R., and Davis, G. L. Mineral age measurements and early history: Carnegie Inst. Washington Year Book 59, p. 208-221, 1960; reprinted in Carnegie Inst. Washington Dept. Terrestrial Magnetism Ann. Rept. of Director for 1959-60, 1960.

Age measurements made by the same method may give information about two fundamental geological questions: (1) Is the mineral-forming process an essentially continuous one, and (2) are there discrete epochs of tectonic activity between quiescent periods? The time distribution of Rb-Sr ages on a world-wide basis, classified by continents, indicates significant epochs at 1,000 and 2,600 million years occurring in nearly all continents. Detailed studies carried out in the past year on basement rocks from Michigan, Ohio, West Virginia, Missouri, Iowa, Finland, and Saudi Arabia are discussed. (See also Geophys. Abs. 185-10.) — V. S. N.

- 185-3. Vinogradov, A. P., and Tugarinov, A. I. Nekotoryye opornyye opredeleniya absolyutnogo vozrasta (k mirovoy geokhronologicheskoye shkale) [Some marker determinations of absolute age (for a world geochronological scale)]: Akad. Nauk SSSR Doklady, v. 134, no. 5, p. 1158-1161, 1960.

The following partial geochronological scale is established on the basis of absolute age determinations of critical samples made in U.S.S.R. laboratories by the lead isotope and K-Ar methods:  $3,500 \pm 300 \times 10^6$  yr, lower boundary of Katarchean (Kolan);  $2,700 \pm 150 \times 10^6$  yr, Katarchean-Archean (Rhodesian);  $1,900 \pm 100 \times 10^6$  yr, Archean-Early Proterozoic (Belomorian);  $1,150 \pm 50 \times 10^6$  yr, Early Proterozoic-Late Proterozoic (Ulkano or Grenville);  $650 \pm 50 \times 10^6$  yr, East Aldan (Katangan);  $430 \pm 20 \times 10^6$  yr, Late Caledonian;  $350 \pm 20 \times 10^6$  yr, Early Hercynian;  $250 \pm 10 \times 10^6$  yr, Late Hercynian. — D. B. V.

- 185-4. Kommissiya po Opredeleniya Absolyutnogo Vozrasta Geologicheskikh Formatsiy. Geokhronologicheskaya shkala v absolyutnom letoischislenii po dannym laboratoriy SSSR na 1960 g. [Geochronological scale in absolute age calculations according to data of laboratories of the U.S.S.R. as of 1960]: Akad. Nauk SSSR Izv. Ser. Geol., no. 10, p. 17-21, 1960.

An absolute geological time scale has been drawn up by the Commission on the Determination of the Absolute Age of Formations of the Academy of Sciences of the U.S.S.R., based on 58 selected K-Ar age determinations made at different U.S.S.R. laboratories. The decay constants  $\lambda_K = 5.57 \times 10^{-11} \text{ yr}^{-1}$  and  $\lambda_\beta = 4.72 \times 10^{-10} \text{ yr}^{-1}$  were used. According to this 1960 time scale, the lower boundaries of the geologic time units are as follows (in millions of years): Pliocene 10, Miocene 25, Oligocene 40, Paleocene 70, Late Cretaceous 100, Early Cretaceous 140, Jurassic 185, Triassic 225, Permian 270, Carboniferous 320, Devonian 400, Silurian (Gotlandian) 420, Ordovician 480, Cambrian 570, Precambrian IV (Riphean, Sinian, Late Precambrian, Proterozoic II) 1,100-1,200, Precambrian III (Proterozoic I) 1,800-1,900, Precambrian II (Archean) 2,600-2,700, and Precambrian I (Katarchean) 3,400-3,500. — D. B. V.

- 185-5. Semenenko, M. [N.] P. Heokhronologichna shkala SRSR [The geochronological scale of the U.S.S.R. (with Russian summary)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 20, no. 6, p. 17-23, 1960.

At the ninth session of the Commission for the Determination of the Absolute Age of Geologic Formations of the U.S.S.R., an absolute geochronological scale was worked out and accepted. Two values for the lower boundary of the Paleozoic figured in the discussions; in the Urals, Caucasus, and Ukraine the boundary is some  $30-60 \times 10^6$  yr younger than in Kazakhstan and Czechoslovakia. The accepted value is  $540-600 \times 10^6$  yr.

The Precambrian is divided into 4 groups with the following lower time boundaries (in millions of years): I—3,400-3,500; II—2,600-2,700; III—1,800-1,900; and IV—1,100-1,200. The entire scale is presented in a folded insert. — D. B. V.

- 185-6. Starik, I. E. [Ye.]. Yadernaya Geokhronologiya [Nuclear geochronology]: Akad. Nauk SSSR, Moscow-Leningrad, 630 p., 1961.

An extensive and detailed summary of the nuclear methods of geologic age determination including much information of historical interest is presented in this book. The following topics are discussed: basic principles of radioactivity; uranium, thorium and lead; emanation; common lead; volumetric, isotope-dilution, and activation methods of argon analysis; determination of potassium by chemical and photometric methods; argon retention in minerals; rubidium and strontium; helium method; ionium method and ocean sediments; carbon-14 and its determination with proportional and liquid scintillation counters; summary of minor methods including discussions of osmium, rhenium, pleochroic haloes, uranium oxidation, beryllium-10, xenon from fission, calcium from potassium decay, radium in manganese nodules, disequilibrium in secondary uranium minerals, age of fossil bones, and age of oolites; the age of the earth and of meteorites; and a summary of geologic time scales including a new list of tie points from the U.S.S.R. A bibliography of almost 1,200 titles and exhaustive indices are provided. — H. F.

- 185-7. Bederke, E. Kritische Betrachtung physikalischer Altersbestimmung [Critical consideration of physical age determination]: Geol. Rundschau, v. 49, no. 1, p. 314-319, 1960.

Possible reasons for discrepancies between the absolute time scales of different authors, due to the limitations of various dating methods, are discussed. — D. B. V.

Fowler, William A., and Hoyle, F. Nuclear cosmochronology. See Geophys. Abs. 185-90.

Gourinard, Yves. On the presence of cosmic spherules in sedimentary rocks. See Geophys. Abs. 185-100.

- 185-8. Hedberg, Hollis D. The stratigraphic panorama (An inquiry into the bases for age determination and age classification of the earth's rock strata): Geol. Soc. America Bull., v. 72, no. 4, p. 499-518, 1961.

The basic purpose of chronostratigraphy is to interpret the history of the earth through the chronologic sequence of its strata. The principal means used to work out chronostratigraphy are the physical interrelations of strata,

the relation of strata to the sequence of organic evolution, and radioactive age determinations. Few of the supplementary lines of evidence can be proved to have had effects that were distinctly recognizable, identical in character, and synchronous over the whole world. Coordinated use of all possible lines of relative and absolute age determination and time correlation offers the best promise for continued progress in chronostratigraphy. The latter part of the paper concerns the related problem of chronostratigraphic classification. — D. B. V.

Ringwood, A. E. Changes in solar luminosity and some possible terrestrial consequences. See *Geophys. Abs.* 185-260.

- 185-9. Stieff, L[orin] R., and Stern, T[homas] W. Graphic and algebraic solutions of the discordant lead-uranium age problem: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 176-199, 1961.

The calculation of possible concordant ages from discordant lead isotope data has been greatly simplified by Wetherill's graphic method (see *Geophys. Abs.* 166-11). The linear relations noted in his procedure have been extended to plots of the mole ratios of total  $Pb^{206}/U^{238}(N_{206}/N_{238})$  versus total  $Pb^{207}/U^{235}(tN_{207}/N_{235})$ ; this modification permits calculation of concordant ages for unaltered samples using only the  $Pb^{207}/Pb^{206}$  ratio of the contaminating common lead.

If isotopic data are available for two samples of the same age,  $x$  and  $y$ , from the same or related deposits or outcrops, graphs of the normalized difference ratios

$$\left[ \frac{(N_{206}/N_{204})_x - (N_{206}/N_{204})_y}{(N_{238}/N_{204})_x - (N_{238}/N_{204})_y} \right] \text{ vs } \left[ \frac{(N_{207}/N_{204})_x - (N_{207}/N_{204})_y}{(N_{235}/N_{204})_x - (N_{235}/N_{204})_y} \right]$$

can give concordant ages corrected for unknown amounts of a common lead with an unknown  $Pb^{207}/Pb^{206}$  ratio. Similar plots of the normalized difference ratios for three genetically related samples will give concordant ages corrected, in addition, for either one unknown period of past alteration or initial contamination by an older generation of radiogenic lead of unknown  $Pb^{207}/Pb^{206}$  ratio.

Algebraic equivalents of these new graphic methods give equations which may be programmed for computing machines. For geologically probable parameters the equations of higher order have two positive real roots that rapidly converge on the exact concordant ages corrected for original radiogenic lead and for loss or gain of Pb or U. Modifications expanded only to the second degree have been derived for use with desk calculators. — D. B. V.

- 185-10. Davis, G. L., Tilton, G[eorge] R., Aldrich, L. T[homas], Wetherill, G[eorge] W., and Bass, M[anuel] N. The ages of rocks and minerals: *Carnegie Inst. Washington Year Book* 59, p. 147-158, 1960; reprinted in *Carnegie Inst. Washington Geophys. Lab. Ann. Rept. of Director for 1959-60*, 1960.

The various nuclear age-dating methods have established the role of long-term diffusion as a process leading toward discordant ages in rocks. The differential losses of  $Pb^{207}$  and  $Pb^{206}$  can be calculated for diffusion processes, and the predicted pattern of age discordances compared with those actually observed. Analyses of discordant age data from metamorphic zones in northern Michigan, from the Karelian basement complex in Finland, from the basement complex of the Appalachian orogenic belt in the Eastern United

States and Canada, and from the Canadian Shield are discussed, and it is concluded that long-term diffusion played an important role in causing discordant uranium-lead ages but is of less importance in determining the other age values. (See also *Geophys. Abs.* 185-2.)—V. S. N.

- 185-11. Picciotto, Edgard E. *Géochimie des éléments radioactifs dans l'océan et chronologie des sédiments océaniques* [Geochemistry of the radioactive elements in the ocean and chronology of the ocean sediments]: *Ciel et Terre*, v. 76, no. 3-4, p. 65-86, 1960.

The radioactive nuclides that occur naturally in the ocean are tritium,  $C^{14}$ ,  $Be^{10}$ ,  $K^{40}$ ,  $U^{238}$ ,  $Th^{230}$  (ionium),  $Rb^{87}$ ,  $Ra^{226}$ ,  $U^{235}$ ,  $Pa^{231}$ ,  $Th^{227}$  (radio-actinium),  $Th^{232}$ ,  $Th^{228}$  (radiothorium), and  $Ra^{228}$  (mesothorium). Their concentrations are extremely low compared to those in the crust, and the Th/U ratio is particularly low (0.01 in the ocean compared to about 3 in rocks). All three radioactive families are out of equilibrium.  $Ra^{226}$  and  $Ra^{228}$  are in excess with respect to their parents,  $Th^{230}$  and  $Th^{232}$ . This situation offers interesting possibilities for tracer studies of ocean circulation.

The radioactive nuclides in pelagic sediments should show equilibrium deficiencies to complement the excesses in the water. The U and Th contents in pelagic clays have been found to be fairly constant and similar to those of granitic rocks. In young surface layers  $Th^{230}$  and  $Pa^{231}$  are definitely in excess with respect to uranium. Migration of  $Th^{230}$ -produced radium has been demonstrated.  $Th^{230}$  concentration decreases with depth in the sediment in a general way.  $Be^{10}$  has been reported in Pacific clays.

The dating methods based on these nuclides are reviewed briefly.  $C^{14}$  dates material up to the order to 25,000 yr old.  $Be^{10}$  is the sole hope at the moment of dating events that occurred  $0.5-10 \times 10^6$  yr ago.  $Th^{230}$  and Pa methods measure to 300,000 and 150,000 yr ago, respectively. Calculations can be made on the basis of the decrease of either element, in which case it is assumed that the uranium concentration in the ocean has remained constant with time; on the basis of the  $Th^{230}/Th^{232}$  ratio, with the assumption that the U/Th ratio has been constant; on the basis of the  $Pa^{231}/Th^{230}$  ratio, which is independent of variations in uranium content of the ocean; and on the basis of the  $Th^{230}/U^{238}$  and  $Pa^{231}/U^{235}$  ratios, where uranium has been separated from its descendants as in aragonite of coral reefs or oolites. The K-Ar and U-He methods can be applied to authigenic minerals or fossils in oceanic sediments. —D. B. V.

- 185-12. Starik, I. Ye., Starik, F. Ye., Petryayev, Ye. P., Lazarev, K. F., and Yelizarova, A. N. *Znachenie migratsii radioelementov iz mineralov dlya opredeleniya ikh vozrasta svinstovym metodom* [Significance of migration of radioactive elements from minerals for the determination of their age by the lead method (with English summary)]: *Internat. Geol. Cong.* 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 15-31, 1960.

Discrepancies between ages determined from different lead isotope ratios are caused mainly by poor preservation of the sample; as a result of alteration various radioactive elements have migrated differently. Therefore, in order to evaluate these age determinations properly, it is necessary to study the migration behavior of all the radioelements as a function of such factors as acidity or the presence of other ions. The limiting value of leaching, which characterizes the portion of radioelements extracted from a mineral, together with the coefficient of emanation can serve as criteria for the suitability of a sample for dating purposes.

The limiting value of leaching of U, Ra, Rn,  $Pb^{206}$ , and  $Pb^{207}$  is found to be greater than that for Th,  $Ra^{224}$ , and  $Pb^{208}$  in monazite; therefore, the  $Pb^{208}/Th^{232}$  age is most probable in the case of monazite. The study of leaching from uraninite, on the other hand, suggests that the  $Pb^{206}/U^{238}$ ,  $Pb^{207}/Pb^{206}$ , and  $Pb^{207}/U^{235}$  ages are more reliable than the  $Pb^{208}/Th^{232}$  age. — D. B. V.

- 185-13. Narbutt, K. I., Laputina, I. P., Shuba, I. D., Kardakov, K. A., and Samoylov, G. P. Isotopnyy sostav rudnogo svintsa i vozrast mineralov, sodержashchikh U, Th i Pb, po mass-spektrometricheskim i rentgeno-spektral'nym dannym [Isotopic composition of ore lead and the age of minerals containing U, Th, and Pb according to mass-spectrometer and X-ray data]: Akad. Nauk SSSR Inst. Geol. Rudnykh Mestorozhdeniy, Petrographii, Mineralogii i Geokhemii, Trudy, no. 28, p. 122-137, 1959.

Mass spectrometer isotopic analyses were made on the lead from 19 galena specimens and 8 radioactive minerals. The uranium, thorium, and lead contents of the radioactive minerals were determined by an X-ray-spectral method using the fluorescence spectrum. The accuracy of this method is  $\pm 5$  percent for concentrations of 1-80 percent of the element concerned, and is  $\pm 10$  percent for concentrations less than 1 percent.

The ages of the radioactive minerals were calculated on the basis of these analyses. The X-ray-spectral method is fully adequate for such minerals as monazite and uraninite but must be supplemented by mass spectrometer analysis of the lead for such minerals as pitchblende, brannerite, and samarskite. — J. W. C.

- 185-14. Houtermans, F. G. Die Blei-Methoden der geologischen Altersbestimmung [The lead methods of geologic age determination]: Geol. Rundschau, v. 49, no. 1, p. 168-196, 1960.

The principles of radioactive age determination in general and of the U-Pb, Th-Pb, Pb-Pb, RaD and ThB ( $Pb^{210}$  and  $Pb^{212}$ ), lead-alpha, and "common" lead methods in particular are reviewed. The chief results are discussed in the light of their bearing on the age of the earth and stoney meteorites and on geologic time scales. — D. B. V.

Russell, R[ichard] D., and Farquhar, R. M. Lead isotopes in geology. See Geophys. Abs. 185-393.

- 185-15. Hintenberger, H. Die Rubidium-Strontium-Methode [The rubidium-strontium method]: Geol. Rundschau, v. 49, no. 1, p. 197-224, 1960.

The principles and techniques of the Rb-Sr dating method are reviewed, and the results obtained on some suitable minerals from various parts of the world are presented. It is concluded that this method has attained at least the same degree of accuracy as the U-Pb and K-Ar methods. The results are enhanced when two or more independent radioactive methods are used on the same rocks. The reliability of the data is particularly high when U-Pb or Th-Pb determinations supplement Rb-Sr and K-Ar data; interesting conclusions concerning the history of a rock can be drawn from any discrepancies between the results. — D. B. V.

- 185-16. Erickson, G. P., and Kulp, J. L[aurence]. Potassium-argon measurements on the Palisades sill, New Jersey: Geol. Soc. America Bull., v. 72, no. 4, p. 649-652, 1961.

The  $\text{Ar}^{40}/\text{K}^{40}$  ratios were determined for whole rock samples from different parts of the Palisades sill, for biotite separated from a concentration near the top of the sill, and for a sample from the first Watchung basalt flow. Comparison with the biotite, which is assumed to have retained all of its argon, shows that the fine and chilled phases of the sill retain all their argon, whereas the medium and coarse phases retain about 85 percent. These retentivities may be a function of mineral composition rather than mere texture. An argon retentivity of 40 percent is indicated for the Watchung basalt.

The results indicate that in some cases the argon retentivity of certain types of basaltic rocks may be as high as that of biotite. A study of the separate minerals in such rocks may support the application of the method to basalts in general. — D. B. V.

- 185-17. Fechtig, H., Gentner, W., and Zähringer, J. Argonbestimmung an Kaliummineralien—VII. Diffusionsverluste von Argon in Mineralien und ihre Auswirkung auf die Kalium-Argon-Altersbestimmung [Argon determination on potassium minerals, pt. 7. Diffusion loss of argon in minerals and its effect on the potassium-argon age determination (with English abstract)]: *Geochim. et Cosmochim. Acta*, v. 19, no. 1, p. 70-79, 1960.

Argon-37 was produced in calcium-containing minerals by means of a  $(n, \alpha)$  reaction, and its diffusion measured as a function of temperature (T). Owing to the high sensitivity of the method it was possible to measure the diffusion constants (D) down to room temperature. For fluorite, anorthite, augite, and margarite the constants at room temperature are  $10^{-21}$ - $10^{-25}$   $\text{cm}^2$  per sec. These results agree with those of K-Ar age determinations. The shape of the D (1/T) curves shows two "knees" that account for discrepancies in values found by extrapolation. — D. B. V.

- 185-18. Zähringer, J. Altersbestimmung nach der K-Ar-Methode [Age determination by the K-Ar method]: *Geol. Rundschau*, v. 49, no. 1, p. 224-237, 1960.

The present state of the K-Ar dating method is reviewed. Decay constants, measuring techniques, and measurement error are discussed briefly, and the problem of argon diffusion and discrepancies between mica and feldspar ages are treated. It is concluded that the argon method is not the most accurate, but that it is practical and widely applicable and when used on micas can provide extremely useful geologic information. Results from some determinations on rocks and minerals from the Schwarzwald, Scandinavia, and the United States, and on iron meteorites are compiled. — D. B. V.

- 185-19. Afanas'yev, G. D., Kozhina, T. K., and Starik, I. Ye. Rezul'taty opredeleniya argonovym metodom vozrasta etalonnnykh prob muskovita, biotita i mikroklina [Results of age determinations of standard samples of muscovite, biotite and microcline by the argon method (with English summary)]: *Internat. Geol. Cong.* 21st, Copenhagen 1960, *Doklady Sovet. Geologov, Problema* 3, p. 9-14, 1960.

This paper is published in English in the *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 3, p. 28-32, 1960 (see *Geophys. Abs.* 183-14). — D. B. V.



- 185-20. Polevaya, N. I., Murina, G. A., Sprintsson, V. D., and Kazakov, G. A. *Opredeleniya absolyutnogo vozrasta osadochnykh i vulkano-gennykh formatsii* [Determination of the absolute age of sedimentary and volcanogenic formations (with English summary)]: Internat. Geol. Cong. 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 32-54, 1960.

The K-Ar ages of some intrusive and extrusive rocks and of glauconite from sediments representing a wide geographic and stratigraphic range in the U.S.S.R. and China are tabulated. It is shown that little argon is lost from glauconite, or from lava as it cools. The conclusion is drawn that volcanic rocks and glauconitic sediments can be dated reliably by the argon method. When these can also be dated in relation to formations of well established biostratigraphic age, their contribution to the establishment of an absolute geologic time scale will be considerable. — D. B. V.

- 185-21. Amirkhanov, Kh. I., Brandt, S. B., and Bartnitskiy, Ye. N. O metodike E. K. Gerlinga opredeleniya energii aktivatsii radiogennykh gazov v mineralakh [On E. K. Gerling's method of determining the activation energy of radiogenic gases in minerals]: Geokhimiya, no. 7, p. 646-649, 1960.

Gerling, E. K. Po povodu stat'i Kh. I. Amirkhanova, S. B. Brandta, i Ye. N. Bartnitskogo "O metodike E. K. Gerlinga opredeleniya energii aktivatsii radiogennykh gazov v mineralakh" [Apropos of the paper by Kh. I. Amirkhanov, S. B. Brandt, and Ye. N. Bartnitskiy "On E. K. Gerling's method of determining the activation energy of radiogenic gases in minerals"]: *ibid*, p. 649, 1960.

It is claimed that Gerling's work on the loss of radiogenic helium and argon from various minerals (see Geophys. Abs. 171-43, 183-13) is not compatible with modern theories of solids. Diffusion from a layer is examined mathematically, and it is shown that the activation energies are not characterized by the slopes of the logarithmic curves of the rate of liberation of radiogenic gases from minerals. Therefore, Gerling's values of activation energies, and the inferred differences in position of radiogenic atoms in the lattice, are completely arbitrary.

Gerling replies that the point of view of Amirkhanov and his colleagues is obsolete and not in accord with modern physical concepts on diffusion along a disturbed crystal lattice. Their use of a curve concerning argon liberation from different positions in the mineral, including an activation energy of zero, is mathematically absurd, as in that case argon could not be retained in the mineral. — D. B. V.

Krylov, A. Ya., Lisitsyn, A. P., and Silin, Yu. I. Significance of the argon-potassium ratio in ocean sediments. See Geophys. Abs. 185-590.

- 185-22. Münnich, K. O. Die  $C^{14}$ -Methode [The  $C^{14}$  method]: Geol. Rundschau, v. 49, no. 1, p. 237-244, 1960.

The principles, techniques, and sources of error of the radiocarbon dating method are reviewed briefly. The results and possibilities of the method are illustrated by a few typical examples. — D. B. V.

- 185-23. Olsson, Ingrid. The  $C^{14}$  dating stations using the  $CO_2$  proportional counting method: Arkiv Fysik, v. 13, no. 3, p. 37-60, 1958.

After a discussion of the principles of radiocarbon dating and the occurrence of  $C^{14}$  in nature, the apparatus and procedure used at the Uppsala (Sweden) dating laboratory are described in full detail. — D. B. V.

National Bureau Standards. Redetermination of the half life of carbon-14. See Geophys. Abs. 185-488.

- 185-24. Daniels, Farrington. Kinetics and thermoluminescence in geochemistry: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 65-74, 1961.

This is the text of the presidential address delivered in 1958 before the Geochemical Society at St. Louis, Mo. After a brief survey of some branches of geochemistry, in which the helpful aspects of physical chemistry are mentioned, two special research fields are discussed in more detail: chemical kinetics, with application to the calcite-aragonite problem; and the thermoluminescence of crystals and its application to age determination. — D. B. V.

- 185-25. Ramdohr, P. Neue Beobachtungen an radioaktiven Höfen in verschiedenen Mineralien mit kritischen Bemerkungen zur Auswertung der Höfe zur Altersbestimmung [New observations on radioactive haloes in different minerals with critical remarks on the evaluation of haloes for age determination]: *Geol. Rundschau*, v. 49, no. 1, p. 253-263, 1960.

The method of age determination by means of pleochroic haloes is often applied to objects that are unsuitable for the purpose; this is true both of the radiating as well as of the discolored mineral. The sources of error lie in non-uniform size of the radioactive inclusions, in variations of activity within the granules (due to zonal structure), in the relative ages of the inclusions and host material, and in the exposure time and susceptibility to coloration of the host material. Age determinations by the pleochroic halo method therefore should be regarded with great caution. — D. B. V.

- 185-26. Ehmann, William D., and Huizenga, John R. A search for long-lived  $Ca^{50}$  and  $Cr^{56}$ : *Kentucky Acad. Sci. Trans.*, v. 21, no. 1-2, p. 1-5, 1960.

The existence of extinct natural radioactivity would have considerable significance in the fields of geochemistry and cosmology. An extinct natural radionuclide is one whose lifetime is too short for detectable amounts to be present from the time of nucleogenesis but is long enough to produce, through radioactive decay, effects that may be identified at present. Its half life falls in the range from  $3 \times 10^7$  yr to  $3 \times 10^8$  yr.  $Pb^{205}$ ,  $Pu^{244}$ , and  $Cm^{247}$  appear to have half lives in this range. Of these only  $Pb^{205}$  with a stable decay product,  $Tl^{205}$ , would be important for isotopic dating.

The search made for the nuclides  $Ca^{50}$  and  $Cr^{56}$  by use of the active daughter extraction technique is described here. Results indicate a lower limit to the half life of  $Ca^{50}$  of approximately  $1 \times 10^3$  yr and for  $Cr^{56}$  of approximately  $1.1 \times 10^4$  yr if they are not both very short lived. The possibility that  $Ca^{50}$  and  $Cr^{56}$  might have half lives in the range for extinct natural radionuclides is not excluded by these results. Much longer irradiation times and larger, highly enriched samples must be used to extend the exclusion limits through this half life range. — V. S. N.

- 185-27. Toulmin, Priestly, 3d. Geological significance of lead-alpha and isotopic age determinations of "alkalic" rocks of New England: Geol. Soc. America Bull., v. 72, no. 5, p. 775-780, 1961.

Recent age determinations indicate that at least two groups of "alkalic" igneous rocks exist in New England, with ages of about 185 and 270 million years. Because of their lithologic and geologic similarities, all these rocks had previously been grouped with the White Mountains plutonic-volcanic series of New Hampshire. Until reliable petrographic or geologic criteria become available for distinguishing these age groups, caution should be exercised in assigning any undated body of "alkalic" rock to one or the other group. — Author's abstract

- 185-28. Giletti, Bruno J., and Damon, Paul E. Rubidium-strontium ages of some basement rocks from Arizona and northwestern Mexico: Geol. Soc. America Bull., v. 72, no. 4, p. 639-643, 1961.

Results of 11 Rb-Sr age determinations on basement rocks from Arizona and northern Mexico are tabulated. The Precambrian age range is  $1,200-1,500 \times 10^6$  yr. The "1,350 million year orogeny" is extended into northwestern Arizona (Chloride granite) and southern Arizona (Oracle granite) near Tucson. Cretaceous-Tertiary ages were obtained for basement rocks in southern Arizona and northern Sonora, Mexico. — D. B. V.

- 185-29. Fairbairn, H[arold] W., Hurley, P[atrick] M., and Pinson, W[illiam] H. [Jr.]. Mineral and rock ages at Sudbury-Blind River, Ontario: Geol. Assoc. Canada Proc., v. 12, p. 41-66, 1960.

The Sudbury-Blind River complex is a part of the area along the north shore of Lake Huron that is bounded by two more stable regions of contrasting age: on the north and northwest by granitic rocks and metasediments mostly  $2.5-2.7 \times 10^9$  yr old, and on the southeast by Grenville gneisses and granites  $900-1,000 \times 10^6$  yr old. The reconnaissance study reported here is part of a larger study to determine the degree to which each of the more stable shield areas has affected the isotopic ages within the north shore belt.

Eighty-three isotopic age analyses on biotite, potassium feldspar, and whole-rock samples from 45 localities were made by both K-Ar and Rb-Sr methods on igneous rocks and on a few metasediments. The dates obtained form an age spectrum from 1.0 to 2.2 billion years, and both K-Ar and Rb-Sr results give evidence of orogenic events at approximately 1.0, 1.2, and 1.6 billion years. Whole-rock analyses of igneous material, which show higher ages than do coexisting minerals, are believed to yield close approximations to the true age.

Data are summarized in tables and histograms, and a map shows the location of samples and the generalized geology of the Sudbury-Blind River area. — V. S. N.

- 185-30. Gross, G[ordon] A. Iron-formations and the Labrador geosyncline: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Paper 60-30, 7 p., 1961.

The geology and structure of the Precambrian formations and associated iron-bearing members of the Labrador geosyncline are described briefly. Potassium-argon determinations on micas from 2 older Precambrian metamorphic units give ages of  $2,365 \times 10^6$  yr, and  $1,635-1,935 \times 10^6$  yr. Ages range from 440 to  $1,580 \times 10^6$  yr for younger Precambrian units within the geosyncline. — V. S. N.

- 185-31. Moorbath, S., Webster, R. K., and Morgan, J. W. Absolute age determination in south-west Greenland. The Julianehaab granite, the Ilímaussaq batholith and the Kûngnât syenite complex: [Denmark] Medd. om Grønland, v. 162, no. 9, p. 5-13, 1960.

Rubidium-strontium age measurements for the Julianehaab granite and for the Ilímaussaq batholith give values of  $1,590 \pm 70 \times 10^6$  yr and  $1,086 \pm 19 \times 10^6$  yr, respectively (using a value of  $5.0 \times 10^{10}$  yr for the half life of rubidium). These represent the maximum and minimum values for the age of the Gardar formation, which is thus Precambrian. The results furthermore show that the Ketilidian basement rocks (pre-Julianehaab granite) of southwest Greenland are themselves Precambrian. A Rb-Sr determination from the Kûngnât syenite complex also gives a Precambrian age ( $1,240 \pm 150 \times 10^6$ ) indicating possible contemporaneity with the Ilímaussaq batholith. Two K-Ar age measurements are reported and are found to be in broad agreement with the Rb-Sr data. — Authors' abstract

- 185-32. Baadsgaard, H[alfdan], Folinsbee, R. E., and Lipson, J[oseph]. Potassium-argon dates of biotites from Cordilleran granites: Geol. Soc. America Bull., v. 72, no. 5, p. 689-701, 1961.

Biotites from 20 plutons of the North American Cordillera, mostly from British Columbia, have been dated by the K-Ar method. Most dates confirm geologic age interpretations. The Cordillera underwent 5 periods of granitic intrusion (in millions of years): Devonian (Acadian), 350-360; Early Mesozoic, 186 and 163; Middle Cretaceous (the major Cordilleran intrusion), 95-100; Late Cretaceous, 80; and Eocene (Rocky Mountain orogeny), 50-60. Small bodies intruded in the Cascade Range  $18 \times 10^6$  yr ago (Miocene) are believed to be the youngest exposed batholiths in North America. — D. B. V.

- 185-33. Rouse, Glenn E., and Mathews, W. H. Radioactive dating of Tertiary plant-bearing deposits: Science, v. 133, no. 3458, p. 1079-1080, 1961.

Four K-Ar determinations from Tertiary rocks in the interior of British Columbia have yielded dates ranging from 45 to 49 million years. This suggests contemporaneity of three separate localities within the Middle Eocene epoch. Abundant plant micro- and macro-fossils support this conclusion and indicate a flora quite different from floras of comparable age in western United States. — Authors' abstract

- 185-34. Pittioni, Richard. Der Beitrag der Radiokarbon-Methode zur absoluten Datierung urzeitlicher Quellen. 2. Bericht [Contribution of the radiocarbon method to the absolute dating of primitive sites. 2d report]: Forschungen u. Fortschritte, v. 33, no. 7, p. 200-206, 1959.

This second compilation of radiocarbon data for Europe and North America lists results published since the first report (see Geophys. Abs. 172-3). Geologic and archeologic dates are given in separate tables, together with a bibliography of sources and an alphabetical list of sites. — D. B. V.

- 185-35. Shepard, Francis P. Rise of sea level along northwest Gulf of Mexico, in Recent sediments, northwest Gulf of Mexico: Tulsa, Okla., Am. Assoc. Petroleum Geologists, p. 338-344, 1960.

Carbon-14 determinations on nearshore and shallow-bay macro-organisms from the relatively stable Texas coast date the post-glacial rise of sea level from 300 feet below the present at 17,000 yr B. P. to about 40 feet at 8,000 B. P. The rise apparently has continued very slowly during most of the remaining time although unidentified fluctuations are possible. Fluctuations during the 17,000-8,000 B. P. interval, indicated by eastward-sloping drowned barriers, appear to correspond with some of the readvances of the continental ice sheets.

The history of rise along the Texas coast agrees with that along other stable coasts. Records from the Mississippi Delta area, however, indicate an independent subsidence of that area on the order of about 1 ft per century. A rapid downwarping in a portion of the Gulf Coast geosyncline is indicated rather than subsidence due solely to compaction of the delta sediments or to isostatic sinking under load. — V. S. N.

- 185-36. Rosholt, J[ohn] N., Emiliani, C[esare], Geiss, J[ohannes], Koczy, F[ritz] F., and Wangersky, P. J. Absolute dating of deep-sea cores by the  $\text{Pa}^{231}/\text{Th}^{230}$  method: *Jour. Geology*, v. 69, no. 2, p. 162-185, 1961.

Dating by the  $\text{Pa}^{231}/\text{Th}^{230}$  method of two deep-sea cores from the Caribbean separated by about 60 km has given a set of dates that are internally consistent, identical within the limits of error in stratigraphically equivalent levels of the two cores, and coincident with  $\text{C}^{14}$  chronology. These dates provide an absolute time scale from the present to about 175,000 yr ago.  $\text{Pa}^{231}/\text{Th}^{230}$  and  $\text{C}^{14}$  measurements on deep-sea cores,  $\text{C}^{14}$  measurements on continental material, paleotemperature analysis of deep-sea cores, and correlation of the temperature record of the cores with continental events provide the following Pleistocene time scale: Postglacial, 0-10,000 yr; Late and Main Würm, 10,000-30,000 yr; Main Würm-Early Würm interval, 30,000-50,000 yr; Early Würm, 50,000-65,000 yr; Riss/Würm interglacial, 65,000-100,000 yr; Riss, 100,000-130,000 yr; and Mindel/Riss interglacial, 130,000-175,000 yr.

$\text{Pa}^{231}/\text{Th}^{230}$  dating of a deep-sea core from the North Atlantic gave ages consistently greater by 30,000 yr than dates from the Caribbean cores and the  $\text{C}^{14}$  chronology. This is believed to result from contamination by reworked clay. Sedimentation studies indicate that rates of sedimentation during the last 11,000 yr were lower than during previous time intervals. A generalized temperature curve, calibrated in terms of the  $\text{C}^{14}$ - $\text{Pa}^{231}/\text{Th}^{230}$  chronology, is presented. — V. S. N.

- 185-37. Koldewijn, B. W. Sediments of the Paria-Trinidad shelf [with Dutch summary]: *Amsterdam Univ. Fys.-Geog. Lab. Pubs.*, no. 1, 109 p., 1958.

Carbon-14 ages are reported for 13 samples taken from 9 sediment cores along the Paria-Trinidad shelf. The oldest plant remains dated were  $17,820 \pm 600$  yr old. Estimates of the rate of deposition are made for various sites based on the carbon-14 dates and also on the thickness of the clay deposit. It is concluded that clay sedimentation started about 12,000 yr ago.

The relief and slope of the Paria-Trinidad shelf are factors of some influence in the deposition of the sediments. The most striking fact about this shelf is the extreme irregularity of the surface even though the steepest slopes hardly exceed one degree. The presence of three diverging orogenic belts in the vicinity, one of which is still active, supports the idea that the morphology of the shelf north of the Paria Peninsula and around Trinidad is strongly influenced by tectonics. — V. S. N.

- 185-38. Schreiner, G. D. L. Comparison of the  $^{87}\text{Rb} \rightarrow ^{87}\text{Sr}$  ages of the red granite of the Bushveld complex from measurements on the total rock and separated mineral fractions: Royal Soc. [London] Proc., ser. A, v. 245, no. 1240, p. 112-117, 1958.

Rubidium-strontium age determinations were made on a portion of total crushed rock and on the feldspar fraction of each of four widely separated samples of the red granite of the Bushveld complex, and on biotite separated from one sample. These nine determinations yielded a mean age of  $2.41 \times 10^9$  yr for a half life value of  $6.3 \times 10^9$  yr, or  $1.92 \times 10^9$  yr using a half life value of  $5.0 \times 10^9$  yr. There are no variations between individual determinations that are significant at the 99 percent confidence level. For the unweighted mean age the 99 percent confidence limits are  $\pm 0.13 \times 10^9$  yr. Despite the low enrichment of  $\text{Sr}^{87}$  the total rock method shows 99 percent confidence limits of  $\pm 0.22 \times 10^9$  yr for the mean of four determinations. — D. B. V.

- 185-39. Allsopp, H. L. Rb-Sr age measurements on total rock and separated-mineral fractions from the Old Granite of the Central Transvaal: Jour. Geophys. Research, v. 66, no. 5, p. 1499-1508, 1961.

The ages of 5 total rock samples and 13 separated mineral fractions from granites and pegmatites of the Old Granite exposed between Johannesburg and Pretoria in the Transvaal were determined by the Rb-Sr method. The techniques employed are described briefly. The total-rock samples yield concordant results; the age of emplacement of the granite is found to be  $3,200 \pm 65 \times 10^6$  yr and the primary abundance of  $\text{Sr}^{87}$  to be  $0.07006 \pm 0.00030$ . The apparent ages deduced from the separated minerals differ widely, and are both higher and lower than the total-rock age. The discordance is considered to be due to diffusion of radiogenic strontium from mineral to mineral probably about  $2,000 \times 10^6$  yr ago. — D. B. V.

- 185-40. Bésairie, H[enri]. Le socle cristallin de Madagascar [The crystalline basement of Madagascar], in *Asociacion de Servicios Geologicos Africanos: Internat. Geol. Cong.*, 20th, Mexico City, 1956, p. 47-62, 1959.

The constitution of the metamorphic series and the different systems of the crystalline basement of Madagascar are described. The chronology is as follows: Androyan Graphite System,  $2,600 \times 10^6$  yr; Vohibory System,  $2,140 \times 10^6$  yr; magmatic epochs at 1,800, 1,660, 1,520 and 1,140 ( $\pm 350$ )  $\times 10^6$  yr; Cipolin Series and magmatism,  $1,125 \times 10^6$  yr; magmatic epoch at  $700 \times 10^6$  yr; many pegmatites,  $485 \times 10^6$  yr; Quartzite Series (Devono-Carboniferous); and pre-Karoo orogenesis. (See also Geophys. Abs. 183-22.) — D. B. V.

- 185-41. Roubault, Marcel, and Durand, Georges L. Âges absolue de divers minéraux uranifères français déterminés par la méthode au plomb [Absolute ages of different French uranium minerals determined by the lead method]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 3, p. 367-370, 1961.

The ages of 4 pitchblendes, 1 gummite, and 1 pitchblende-gummite mixture from different parts of France and of 1 uranothorianite and 1 samirésite from Madagascar were determined by the lead method. Discordance of  $\text{Pb}^{207}/\text{Pb}^{206}$  ages with respect to those calculated from the  $\text{Pb}^{206}/\text{U}^{238}$  and  $\text{Pb}^{207}/\text{U}^{235}$  ratios for the French pitchblendes and gummites shows that these minerals were formed  $260 \pm 5 \times 10^6$  yr ago (Permian, terminal phase of the Hercynian orogeny) and were reworked  $70 \pm 5 \times 10^6$  yr ago (beginning of the Alpine orogeny). — D. B. V.

- 185-42. Verger, Fernand, and Florschütz, Frans. Sur l'existence à Fromentine (Vendée) d'une couche de tourbe du début de l'atlantique [On the existence of a peat bed from the beginning of the Atlantic at Fromentine (Vendée)]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 6, p. 891-893, 1960.

Radiocarbon dating of a peat found 9.50 m deep in two borings at Fromentine, France, as  $5,230 \pm 100$  yr B.C. confirms paleobotanic evidence that it was formed at the beginning of the Atlantic stage. — D. B. V.

- 185-43. Ferrara, G., Stauffer, H[einz], and Tongiorgi, E[zio]. Analisi isotopica del piombo in sedimenti uraniferi delle Alpi Orientali [Isotopic analysis of lead in uraniferous sediments of the East Alps]: Accad. Naz. Lincei Atti Cl. Sci. Fis., Mat. e Nat. Mem., Sess. 2, no. 2, p. 67-81, 1960.

The lead in samples from the continental "Val Gardena Sandstones" collected in the Val Rendena in the East Alps was analyzed isotopically. Results are tabulated and discussed.

Only two samples (silicified wood containing about 1 percent U) were suitable for age determinations by the RaD ( $Pb^{210}$ ) method; these indicate an age of  $220 \times 10^6$  yr for the original rock. Ages obtained on other samples suggest that secondary enrichment ( $U > 10$  percent) occurred  $70-95 \times 10^6$  yr ago. Comparison with results obtained in the West Alps suggests that the mobilization of heavy elements in the East Alps occurred at about the same time as in the Val d'Aosta, and that the uraniferous sediments of the East and West Alps could have been deposited contemporaneously. — D. B. V.

- 185-44. Brinkmann, R., Münnich, K. O., and Vogel, J. C. Anwendung der  $C^{14}$ -Methode auf Bodenbildung und Grundwasserkreislauf [Application of the  $C^{14}$  method to soil formation and ground water circulation]: Geol. Rundschau, v. 49, no. 1, p. 244-253, 1960.

The circulation of water in the ground can be followed closely by means of the carbon isotopes. Carbon-14 in particular makes it possible to understand better the formation of carbonate precipitations, and to determine the absolute age of calcareous crusts and of groundwater. Apparently, numerous calcareous crusts formed in the Mediterranean region during the Quaternary. Groundwaters yield ages up to 10,000 yr depending on their depth level. The significance of the method in the problem of cycles of juvenile-vadose water, deep groundwater, and fossil groundwater is indicated. — Authors' summary, D. B. V.

- 185-45. Watznauer, A. Bemerkungen zur physikalischen Altersbestimmung an sächsischen Graniten und Gneisen [Remarks on the physical age determination on granites and gneisses of Saxony]: Geol. Rundschau, v. 49, no. 1, p. 278-288, 1960.

For several years physical age determinations have been made in order to date more accurately the magmatic processes in the Saxon-Thuringian zone of the Variscan mountains. They concern the Lausitz granite complex, the Dohna granite, that of Karlsbad-Eibenstock and its mineral deposits, a number of Bohemian granites, and gneisses and schists from Saxony. The values given in tables and discussed in the text suggest that present physical methods of age determination are not yet unambiguous enough in the case of magmatic rocks to allow definite conclusions. The investigations are being continued. — Author's summary, D. B. V.

- 185-46. Neumann, Henrich. Apparent ages of Norwegian minerals and rocks: *Norsk Geol. Tidsskr.*, v. 40, no. 3-4, p. 173-191, 1960.

Apparent ages determined on Norwegian rocks and minerals by different laboratories are compiled from various sources, including unpublished personal communications. Many recalculations are necessary in order to make the results mutually comparable and thus permit a more thorough and detailed analysis. However, these preliminary results clearly indicate that there were two important Precambrian epochs, one about  $900-950 \times 10^6$  yr ago and the other about  $1,100 \times 10^6$  yr ago. Surprisingly, there is as yet no evidence of the 1,400- and 1,800-million-year-old events that are so prominent elsewhere in the world. It is also noteworthy that the three Precambrian "formations" of southern Norway appear to have been formed by a number of penecontemporaneous and generally similar geologic events; differences in the resulting products depend mostly on variations in temperature and pressure and chemical environment. — D. B. V.

- 185-47. Magnusson, Nils H. Age determinations of Swedish Precambrian rocks: *Geol. Fören. Stockholm Förh.*, v. 82, no. 4, p. 407-432, 1960.

The Precambrian history of Sweden is discussed in some detail in the light of the compiled results of available age determinations. Some 60 rocks have been dated by the K-Ar method, and 2 of these by the Rb-Sr method in addition. Seven samples were dated by two different potassium-argon laboratories in the U. S. S. R. The age data are tabulated.

The essential problems in the Swedish Precambrian are the regeneration processes and their effect on apparent ages. Many complementary determinations are necessary to elucidate details in different areas. — D. B. V.

- 185-48. Lundqvist, Gösta]. C14-Daterade tallstubbar från fjällen [C<sup>14</sup>-dated pine stumps from the mountains (with English summary)]: *Sveriges Geol. Undersökning, Årsb.* 53, no. 3, (ser. C, no. 565), 21 p., 1959.

The results of radiocarbon dating of pine stumps from the mountains of western Sweden show that the pine immigrated soon after ice retreat, probably from the west. The oldest dated stumps are more than 4,000 yr old. The "fossil" timberline occurs at the intersection of the land uplift curve and the climatic curve; the effect of land uplift on the altitude of the timberline was greatest in the early stages and has decreased up to the present time. — D. B. V.

- 185-49. Krummenacher, Daniel, and Evernden, Jack F[oord]. Déterminations d'âge isotopique faites sur quelques roches des Alpes par la méthode Potassium-Argon [Isotopic age determinations made on some Alpine rocks by the potassium-argon method]: *Schweitzer. Mineralog. Petrog. Mitt.*, v. 40, no. 2, p. 267-277, 1960.

Nine rocks from various parts of the Alps were dated by the K-Ar method on micas, and the results agree well with geologic data. The rocks of the Aiguilles-Rouges and Mount Blanc massifs yield ages that appear to be too young; this indicates loss of argon. The loss may be due to an accelerated rate of diffusion during hydrothermal and metamorphic activity of the Alpine orogeny. The size of the minerals used for dating appears to have an influence on the ages obtained; the diffusion of gas in the mineral is an inverse



function of grain size. The age found for the Grand-Paradis massif is somewhat older than that assigned to the Alpine orogeny. This is due either to the retention of radiogenic argon produced before the orogeny or to the Alpine orogeny being actually older than has been supposed. — J. W. C.

- 185-50. Gross, Hugo. Zur Frage der Gliederung und Chronologie der Letzten Eiszeit (Würm oder Weichsel) in Mitteleuropa [On the problem of the subdivision and chronology of the Last Glaciation (Würm or Weichsel) in central Europe]: *Forschungen u. Fortschritte*, v. 33, no. 11, p. 332-336, 1959.

The geologic and  $C^{14}$  data show that the short Würm chronology supported by Narr is false, and that the longer chronology, subdivided into three main intervals (Early Würm, Gottweig Interstadial, and Main Würm), is correct. — D. B. V.

- 185-51. Narr, Karl J. Nochmals:  $C^{14}$ -Daten und die Gliederung des Jungpleistozäns [Once more:  $C^{14}$ -dates and the subdivision of the late Pleistocene]: *Forschungen u. Fortschritte*, v. 34, no. 3, p. 90-91, 1960.

Gross' objections to Narr's subdivision of the late Pleistocene (see Geophys. Abs. 178-10, 185-50) are shown to be not well founded. — D. B. V.

- 185-52. Polkanov, A. A., and Gerling, E. K. Geokhronologiya dokembriya baltiyskogo shchita [Geochronology of the Precambrian of the Baltic shield (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov, Problema 3*, p. 57-82, 1960.

This paper has been published in English in the *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 9, p. 183-191, 1960 (see Geophys. Abs. 183-31). — D. B. V.

- 185-53. Vinogradov, A. P., Komlev, L. V., Danilevich, S. I., Savonenkov, V. G., Tugarinov, A. I., and Filippov, M. S. Absolyutnaya geokhronologiya Ukrainskogo dokembriya [Absolute geochronology of the Ukrainian Precambrian (with English summary)]: *Internat. Geol. Cong.*, 21st., Copenhagen 1960, *Doklady Sovet. Geologov, Problema 3*, p. 83-111, 1960.

This paper has been published in English in the *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 9, p. 116-132, 1960 (see Geophys. Abs. 183-35). — D. B. V.

- 185-54. Semenenko, N. P., Burkser, Ye. S., and Ivantishin, M. N. Vozrastnyye gruppy mineralizatsii porod Ukrainy v absolyutnom letoschislenii [Age groups of mineralization of rocks of the Ukraine in absolute age calculations (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov, Problema 3*, p. 112-131, 1960.

The evidence for each of the igneous and metamorphic cycles that have been established for the Ukrainian Precambrian on the basis of absolute age determinations (see Geophys. Abs. 183-34, and 184-44) is discussed. The lower boundary of the Cambrian is set at 570 million years. — D. B. V.

- 185-55. Vinogradov, A. P., Tugarinov, A. I., Knoore, K. G., Bibikova, Ye. V., and Lebedev, V. I. O vozraste kristallicheskogo osnovaniya Russkoy platformy [On the age of the crystalline basement of the Russian platform (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 132-148, 1960.

The results of absolute age determinations on cores from the crystalline basement underlying the thick Paleozoic-Mesozoic cover of the Russian platform show that the Voronezh massif in the region of the Kursk magnetic anomaly is about  $1,800 \times 10^6$  yr old, the same as the ancient formations of the Baltic and Ukrainian shields. The next magmatic cycle,  $1,600-1,700 \times 10^6$  yr old, is contemporaneous with the rapakivi intrusions of the southern Baltic shield and the intrusions in the Lower Proterozoic syncline between the Baltic and Ukrainian shields and the Voronezh massif. Intensive activity occurred in the area of the Pachelm depression and the Stalingrad slope of the Caspian depression about  $1,400 \times 10^6$  yr ago, and the last Proterozoic cycle, about  $900-1,100 \times 10^6$  yr ago, produced intrusions along the margins of the Baltic depressions and in the Volga region. The tectonic and magmatic activity of the Donets Basin, originating in the Early Proterozoic, was subsequently regenerated even as late as in Hercynian time. Recent tectonic movements in the Russian platform have occurred along ancient mobile zones that have been periodically reactivated throughout geologic history. — D. B. V.

- 185-56. Afanas'yev, G. D., Abdullayev, R. N., Bagdasaryan, G. P., Knorre, K. G., Rubinshteyn, M. M., and Studenikova, Z. V. Itogi geokhronologicheskikh issledovaniya magmaticheskikh gornykh porod Kavkaza [Results of geochronological investigations of magmatic rocks of the Caucasus (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 161-194, 1960.

The results of argon age determinations made on igneous and a few metamorphic rocks from different structural units of the Caucasus are compiled and the geologic history of the region inferred from the results. The significance of discrepancies between the ages of micas and alkali feldspars from the same specimens is discussed. — D. B. V.

- 185-57. Ovchinnikov, L. N., and Garris [Harris], M. A. Absolyutnyy vozrast geologicheskikh obrazovaniy Urala i Priural'ya [Absolute age of geologic formations of the Urals and Pri-Urals (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 195-207, 1960.

The English version of this paper has been published in the Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 3, p. 33-45, 1960 (see Geophys. Abs. 183-39). — D. B. V.

- 185-58. Komlev, L. V. Absolyutnyy vozrast granitnykh intruziy tsentral'nogo i severnogo Kazakhstana i shkala geologicheskogo vremeni [The absolute age of the granitic intrusions of central and northern Kazakhstan and the geologic time scale (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 208-221, 1960.

On the basis of absolute age determinations by different methods on granitic rocks from northern and central Kazakh S.S.R., the following time scale is established (in millions of years): end of the Paleozoic, 260; Permian-Car-

boniferous boundary, 300; end of the Viséan (Middle Carboniferous), 360; Early Devonian, 420; end of Middle Ordovician, 500; early Caledonian cycle, 500-?; late Caledonian cycle, 420-480; early Hercynian cycle, 340-380; and late Hercynian cycle, 260-320. — D. B. V.

- 185-59. Semenov, A. I., and Shuvalov, Yu. M. O vozraste Kryk-Kudukstoy intruzii v severnom Kazakhstane [On the age of the Kryk-Kuduk intrusion in northern Kazakhstan]: Akad. Nauk SSSR Doklady, v. 137, no. 2, p. 397-399, 1961.

The age of the Kryk-Kuduk intrusive massif in northern Kazakh S.S.R. has been established on the basis of field relations, degree of metamorphism, and K-Ar dating ( $500 \times 10^6$  yr) as middle Llandeilan or older. — D. B. V.

- 185-60. Semenenko, M. P. [N. P.], and Tsarovskiy, I. D. Zistavlennyya heoloho-strukturnykh danykh z rezul'tatamy vyznachennyya absolyutnoho vîku luzhnykh porîd Pryazov'ya [Comparison of geologic-structural data with the results of absolute age determinations on the alkaline rocks of the Azov region (with Russian summary)]: Akad. Nauk Ukrayin. R.S.R. Heol. Zhur., v. 19, no. 6, p. 3-11, 1959.

The alkaline rocks of the Azov region of the Ukrainian S.S.R. occur structurally as centers with radial systems of metasomatically alkalinized silicic rocks and as linear bodies related to fracture systems. Potassium-argon determinations show that these structures are not contemporaneous, the former giving ages of  $800-1,260 \times 10^6$  yr and the latter of  $250-280 \times 10^6$  yr. — D. B. V.

- 185-61. Khamrabayev, I. Kh. Ob absolyutnom vozraste granitoidnykh intruzivov i postmagmaticheskikh obrazovaniy Zapadnogo Uzbekistana [Absolute age of granitic intrusives and postmagmatic deposits of western Uzbekistan]: Akad. Nauk Uzbek. SSR, Izv., Ser. Geol., no. 1, p. 77-87, 1957.

The granitic intrusions and postmagmatic ore deposits of western Uzbek S.S.R. are geologically older than the Middle Carboniferous and younger than the Upper Carboniferous-Permian continental deposits. The most reliable absolute age for both the granites and ore deposits is 180-200 million years, which corresponds to the end of the Carboniferous and the beginning of the Permian. Contemporaneity of igneous activity and mineralization is thus demonstrated. None of the age methods was successful in distinguishing individual phases of intrusion. This is explained by the interval between phases being less than 1 million years, which lies below the threshold of accuracy of the methods. The discrepancy between the geologic age and the absolute age may be caused by imperfections in the argon method and by inaccurate geologic dating. — J. W. C.

- 185-62. Krylov, A. Ya. Absolyutnyy vozrast porod tsentral'nogo Tyan'-Shanya i primeneniye argonovogo metoda k metamorficheskim i osadochnym porodam [Absolute age of rocks of the central Tien Shan and application of the argon method to metamorphic and sedimentary rocks (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 222-244, 1960.

Total rock age determinations were made on a wide range of rocks from the central Tien Shan by the argon method. Three cycles are distinguished on the

basis of 62 samples of granitic rocks (in millions of years): Proterozoic, 540; Caledonian (the most important), 370; and Hercynian, 280. The volcanic rocks represent three cycles: Caledonian, Hercynian, and a Tertiary cycle 55 million years ago. The last metamorphism was Caledonian.

During decomposition of granitic rocks, the Ar/K ratio changes in two stages. Argon is lost before potassium, but the difference disappears in the final weathered products. Study of the retention of argon in granitic gravel, sands, sandstones, clays, and silts showed that the proportion of radiogenic argon is generally the same as in the original feldspar. Therefore, the argon method may be used to estimate the age of the source material of clastic sediments and thus to solve several paleogeographic problems, such as the dispersal of glacial material from Fennoscandia and the source of terrigenous deposits carried to the Black Sea (see Geophys. Abs. 176-14, 181-50, 182-12). — D.B.V.

- 185-63. Krylov, A. Ya., and Silin, Yu. I. Vremya metamorfizma drevnykh otlozheniy severnoy zony Tyan'-Shanya [Time of metamorphism of the old sediments of the northern zone of the Tien Shan]: Akad. Nauk SSSR Doklady, v. 122, no. 5, p. 889-891, 1958.

Results of argon age determinations on 36 metasedimentary rocks from the Proterozoic and Lower Paleozoic of the northern zone of the Tien Shan and on 2 from the Lower Paleozoic of the southern zone are tabulated. The metamorphism apparently is Caledonian ( $330-360 \times 10^6$  yr) in the northern Tien Shan; there are no perceptible Hercynian and Alpine metamorphic effects. The samples from the southern Tien Shan, on the other hand, were metamorphosed  $280-295 \times 10^6$  yr ago, in the Hercynian. — D. B. V.

- 185-64. Krylov, A. Ya., Silin, Yu. I., and Lovtsyus, A. V. Vozrast granitoidov severnoy zony Tyan'-Shanya [Age of granites of the north zone of Tien Shan]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 197-204, 1958 (1960).

Sixty absolute ages of granites of the northern and central Tien Shan are reported. The principal cycles of intrusion were Proterozoic at  $465-560 \times 10^6$  yr, Caledonian at  $310-385 \times 10^6$  yr, and Hercynian at  $240-280 \times 10^6$  yr. — A.J.S.

- 185-65. Bykovskaya, Ye. V., and Polevaya, N. I. Absolyutnyy vozrast vulkanogennykh obrazovaniy Badzhal'skogo i Bureinskogo khrebtov [Absolute age of volcanogenic formations of the Badzhal' and Burein ranges]: Akad. Nauk SSSR Izv. Ser. Geol., no. 10, p. 86-91, 1960.

The results of K-Ar age determinations on 12 samples of igneous rocks from the Upper Burein region (Badzhal' and Burein ranges) in Siberia are tabulated. The ages range from 75 million years (Late Cretaceous) to 193 million years (Triassic) and are consistent with the stratigraphic evidence. The consistency of results in the case of a granite 86 million years old which intrudes a liparite-dacite 93 million years old and is in turn overlain by a vitroliparite 75 million years old is significant; evidently argon loss has been negligible in both the intrusive and extrusive rocks. Although K-Ar data cannot yet be used as a basis for stratigraphic subdivision, igneous masses can definitely be correlated by this method. — D. B. V.

- 185-66. Krasnyy, L. I., and Polevaya, N. I. Absolyutniy vozrast nekotorykh magmaticheskikh porod Dal'nego Vostoka [Absolute age of some magmatic rocks of the Far East (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 245-251, 1960.

Results of argon age determinations on igneous rocks from the Far Eastern Region of the U. S. S. R. (Amur, Khabarovsk) show that the Stanovoy-Dzhugdzur Proterozoic folded region on the southeast edge of the Aldan shield has been intruded by large granite bodies up to late Mesozoic time. In the Mongol-Okhotsk folded region, where a geosyncline was present mainly in Paleozoic and Mesozoic time, the intrusions are early and late Paleozoic and Mesozoic in age. In the Sikhote Alin young folded region, a geosyncline was present from late Paleozoic to Paleogene time. A preliminary regional time scale for the area is given in a chart. — D. B. V.

- 185-67. Mahadevan, C., Sastry, A. V. R., and Aswathanarayana, U. Some aspects of nuclear geology in India: Pan Indian Ocean Sci. Cong., 3d, Tananarive, Proc., Sec. C, p. 33-37, 1957 (1960).

Available age data indicate orogenic cycles in India at  $2,300 \pm 100$ ,  $1,625 \pm 75$ ,  $1,300 \pm 150$ ,  $955 \pm 40$ , and  $735 \pm 5$  million years. The distribution of radioactivity has also been studied for various rock types and for modern marine sediments off the east coast. — J. W. C.

- 185-68. Katsui, Yoshio, and Murase, Tsutomu. Some considerations on the activity of the Shikotsu Volcano [in Japanese with English abstract]: Geol. Soc. Japan Jour., v. 66, no. 781, p. 631-638, 1960.

Carbon-14 dating of carbonized trunks of *Picea jezoensis* found buried in pumice deposits places the formation of Shikotsu caldera, southwest Hokkaido, Japan, at 20,000 yr ago. Field study of the caldera and associated pumice deposits indicates that the eruption forming the caldera resembled the 1883 eruption of Krakatau, although on a larger scale. — V. S. N.

- 185-69. Hurley, P[atrick] M., Fisher, N. H., Pinson, W[illiam] H., Jr., and Fairbairn, H[arold] W. Geochronology of Proterozoic granites in Northern Territory, Australia. Pt. 1: K-Ar and Rb-Sr age determinations: Geol. Soc. America Bull., v. 72, no. 5, p. 653-662, 1961.

K-Ar and Rb-Sr age measurements on granitic rocks intrusive into two subdivisions of the Lower Proterozoic in Northern Territory, Australia, show well grouped ages averaging  $1,440 \times 10^6$  yr and  $1,630 \times 10^6$  yr. The geologic evidence as well as the concordance between the Rb-Sr and K-Ar measurements suggest that these are close to the true values, marking the end of two disturbances which produced intracratonic basins of sedimentation. — D. B. V.

- 185-70. Walpole, B. P., and Smith, K. G. Geochronology of Proterozoic granites in Northern Territory, Australia. Pt. 2: Stratigraphy and structure: Geol. Soc. America Bull., v. 72, no. 5, p. 663-668, 1961.

The stratigraphy and structure of the Precambrian rocks of Northern Territory, Australia, are summarized in the light of the age determinations reported in the first part of this report (see Geophys. Abs. 185-69). The older group of granites marks the top of the lower subdivision of the Lower Proterozoic and the younger group marks the top of the Lower Proterozoic. — D. B. V.

- 185-71. Russell, R[ichard] D., Ulrych, T. J., and Kollar, F. Anomalous leads from Broken Hill, Australia: Jour. Geophys. Research, v. 66, no. 5, p. 1495-1498, 1961.

Seven Thackaringa-type leads from veins at Broken Hill, Australia, have been analyzed isotopically. The points representing these leads lie along a straight line on a  $Pb^{207}/Pb^{204}$  versus  $Pb^{206}/Pb^{204}$  plot, proving beyond serious doubt that these are anomalous leads. The isotopic analyses indicate that these leads were deposited not earlier than  $1,190 \pm 50 \times 10^6$  yr ago and that the source material for the anomalous radiogenic lead component came into existence not before  $1,970 \pm 50 \times 10^6$  yr ago but not later than  $1,190 \pm 35 \times 10^6$  yr ago. Approximate values for the Th/U ratios of the anomalous lead sources are included. — D. B. V.

- 185-72. Wilson, Allan F., Compston, W., Jeffery, P. M., and Riley, G. H. Radioactive ages from the Precambrian rocks in Australia: *Geol. Soc. Australia Jour.*, v. 6, pt. 2, p. 179-195, 1960.

The oldest rocks of the Australian Precambrian basement occur in Western Australia where huge tracts of granitic rocks have been dated at about 2,700 million years by the Rb-Sr and K-Ar methods. They also show metamorphism at 2,400 million years. This shield area is flanked and cut by younger Precambrian rocks—on the southeastern side by pegmatized basic charnockites, 1,300 million years; on the southern side by rocks pegmatized at 1,400 million years; and on the west by rocks showing regional magmatic activity at 900-1,100 million years and vigorous recrystallization at about 650 million years. A long east-west 1,000 million year belt in central Australia may continue westward to divide the central nucleus of the shield. Granites in northern Australia are at least 1,650 million years old with uranium mineralization at 500 million years, and in South Australia periods of uranium mineralization at 500 and 1,500 million years are recognized. Major age divisions in Canada and Australia appear to be closely comparable. — V. S. N.

- 185-73. Gage, Maxwell. New Zealand glaciations and the duration of the Pleistocene: *Jour. Glaciology*, v. 3, no. 29, p. 940-943, 1961.

Recent work in New Zealand has resulted in recognition of an additional glaciation preceding the Waimaunga glaciation in the late Pleistocene. This new period followed the mid-Pleistocene climax of the earth movements responsible for most of the present mountainous relief of New Zealand and an interval of time long enough for the construction and subsequent deep dissection of the Banks Peninsula shield volcano. This suggests an interval of several hundred thousand years between the earliest late Pleistocene glaciation and the early Pleistocene Ross glaciation and a length of at least one million years for the entire Pleistocene period. This estimate for the Pleistocene does not fit well with the datings of major climatic conditions based on carbon-14, radium/ionium, and oceanic sedimentation rates. — V. S. N.

- 185-74. Nicolaysen, L. O., Burger, A. J., Tatsumi, T., and Ahrens, L[ouis] H. Age measurements on pegmatites and a basic charnockite lens occurring near Lützow-Holm Bay, Antarctica: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 94-98, 1961.

Rb<sup>87</sup>-Sr<sup>87</sup> age measurements were carried out on large biotite crystals from 3 granitic pegmatites and a basic charnockite lens occurring near Lützow-Holm Bay, Queen Maud Land. The mean age obtained (~515 million years) probably refers to the last major metamorphic episode in this region. The age data are also significant for the interpretation of paleomagnetic results reported from this area. — Authors' abstract

- 185-75. Starik, I. Ye., Krylov, A. Ya., Ravich, M. G., and Silin, Yu. I. *Vozrast gornykh porod vostochnoy Antarktidy* [The age of rocks from eastern Antarctica (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 149-157, 1960.

Absolute ages determined by the argon method for 80 samples of granitic and metamorphic rocks collected in eastern Antarctica in 1956-58 are tabulated. The decay constants used were  $\lambda_K = 5.57 \times 10^{-11} \text{yr}^{-1}$ ,  $\lambda_\beta = 4.72 \times 10^{-10} \text{yr}^{-1}$ . The rocks fall into eight age groups (in millions of years): Tertiary, 20; Mesozoic, 185; middle Paleozoic, 335; early Paleozoic, 460; late Proterozoic, 585; middle Proterozoic, 735; early Proterozoic, 1,090; and late Archean, 1,440. The last regional metamorphism was in the early Paleozoic. The oldest rocks yet found are the granites of the Langensset oasis, 1,525 million years old. This is the first attempt to subdivide East Antarctic rocks chronologically. (See also Geophys. Abs. 177-20, 183-46.) — D. B. V.

Stauffer, Heinz. Cosmogenic argon and neon in stone meteorites. See Geophys. Abs. 185-94.

Goles, Gordon G., and Anders, Edward. The record in the meteorites. 6. On the chronology of the early solar system. See Geophys. Abs. 185-91.

Wänke, H. Exposure ages for iron meteorites. See Geophys. Abs. 185-93.

Marshall, Royal R., and Hess, David C. Lead from some stone meteorites. See Geophys. Abs. 185-86.

#### COSMOGONY

- 185-76. Krinov, E. L. Principles of meteoritics: London, Pergamon Press Inc., 535 p., 1960.

This book is a translation of the original Russian edition published in 1955(?) that has been checked and brought up to date by Professor Krinov. The aim of the volume is to present the principles underlying meteoritics and to point out the most important problems confronting the science. The text includes eight chapters as follows: meteoritics as a branch of science, motion and fall of meteorites, morphology of meteorites, chemistry of meteorites, mineralogy and petrography of meteorites, physical properties of meteorites, tektites and silica-glass, and the origin of meteorites. A catalogue of meteorites of the U.S.S.R. as of January 1, 1959, a list of meteorites of rare type, and a classification of surface structure of fusion crusts of meteorites are given in three appendices. A reference list of 207 citations is included. — V. S. N.

- 185-77. Krinov, E. L. The nature of micrometeorites: Am. Jour. Sci., v. 259, no. 5, p. 391-395, 1961.

Meteorite showers are due to the fragmentation of one large meteorite during its movement through our atmosphere at cosmic velocity and not to the invasion of our atmosphere by swarms of meteoritic bodies as formerly believed. Included in the material resulting from such a break-up are entire clouds of microscopic dustlike fragments that fall on the earth as individual samples of meteorite showers. These minute fragments have the fusion crust and morphological properties of meteorites in general. They differ from cosmic dust in that the cosmic dust particles are practically unaltered by impact with our atmosphere. — V. S. N.

- 185-78. Brown, Harrison. Addendum: The density and mass distribution of meteoritic bodies in the neighborhood of the earth's orbit: Jour. Geophys. Research, v. 66, no. 4, p. 1316-1317, 1961.

The total rate of fall upon the earth appears to be about 560 meteorites per year. All of the computed impact frequencies of meteorites upon the earth and moon, given in an earlier paper (see Geophys. Abs. 182-61) should be multiplied by a factor of 3.4. — D. B. V.

- 185-79. Fisher, David E. Space erosion of the Grant meteorite: Jour. Geophys. Research, v. 66, no. 5, p. 1509-1511, 1961.

An upper limit to the erosion of iron meteorites in space is calculated, based on the cosmic exposure age of the Grant meteorite and the measured depth variation of cosmogenic  $\text{Ne}^{21}$  in this meteorite. A value for  $E_{\text{max}}$  of  $\sim 1.1 \times 10^{-8}$  cm per yr is found. A previous estimate based on the Sikhote-Alin meteorite is discussed. — Author's abstract

- 185-80. Urey, Harold C. Criticism of Dr. B. Mason's paper on "The origin of meteorites": Jour. Geophys. Research, v. 66, no. 6, p. 1988-1991, 1961.

The simple outline of events proposed by Mason (see Geophys. Abs. 181-53) to explain the origin of chondrites cannot be correct; much more complicated histories are required. Simple heating of carbonaceous chondrites will not produce the metal structures of the chondritic meteorites. Mason also suggested that chondrites were always small bodies. It seems probable, however, that only objects at least as large as asteroids could be heated to high temperatures with the escape of appreciable amounts of volatiles and still remain as celestial bodies; nor has any physically possible source of the heat needed for heating small objects yet been suggested.

Misunderstandings of this problem are due to the fact that geologists and geochemists deal essentially with an open system in the case of terrestrial rocks. The variability in composition of all the classes of meteorites makes it difficult to conclude definitely whether they are adequate samples of a closed system. Urey assumes that the planets are not a closed system because of their variable densities, and that the chondritic meteorites are only an approximate sample of primordial matter. — D. B. V.

- 185-81. Stacey, F. D., Lovering, J. F., and Parry, L. G. Thermomagnetic properties, natural magnetic moments, and magnetic anisotropies of some chondritic meteorites: Jour. Geophys. Research, v. 66, no. 5, p. 1523-1534, 1961.

Thermomagnetic analyses, thermal demagnetization of natural and laboratory-induced remanent magnetic moments, and measurements of magnetic anisotropy have been carried out on a number of chondritic stone meteorites. Alpha-phase iron-nickel (kamacite) containing 5-6 percent Ni was found to be responsible for 80-90 percent of the saturation magnetic moments and for most of the observed remanence and magnetic anisotropy. The natural magnetic moments of the Mount Browne, Homestead, and Farmington chondrites had two components of quite different origins; in each case the important component appears to have been induced thermally in an extraterrestrial field. The Mokoia carbonaceous chondrite had only a small moment, consistent with isothermal induction in the earth's field. The magnetic anisotropies of eight chondrites were related to the degree of metamorphism indicated by their porosities.



The magnetic evidence is consistent with the supposition that the chondrites once formed parts of the mantle of a body with a fluid metal core which produced a magnetic field of terrestrial type. — D. B. V.

- 185-82. Honda, M[asatake], Shedlovsky, J. P., and Arnold, J[ames] R. Radioactive species produced by cosmic rays in iron meteorites: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 133-154, 1961.

The radioactive isotopes  $\text{Be}^{10}$ ,  $\text{Al}^{26}$ ,  $\text{Cl}^{36}$ ,  $\text{K}^{40}$ , and  $\text{Mn}^{53}$  have been measured in the Grant, Williamstown, Odessa, and Canyon Diablo iron meteorites. Each sample was recycled to constant activity, using a different chemistry for each recycle wherever possible. The samples were counted with a low-level  $\beta$ -counter, except for  $\text{Mn}^{53}$  for which X-rays were measured. These samples are probably the first sources of  $\text{Mn}^{53}$  that have been counted. Results are tabulated.

Except for  $\text{Mn}^{53}$  where a depth effect is apparent, the isotope ratios were approximately constant for each meteorite. The cosmic-ray age, depth effect, and time variation of cosmic-ray intensity will be discussed in a subsequent paper. — D. B. V.

- 185-83. Sheline, R. K., and Hooper, J. E. Probable existence of radioactive manganese-53 in iron meteorites: *Nature*, v. 179, no. 4550, p. 85-87, 1957.

Sheline and Hooper believe that the half life of  $\text{Mn}^{53}$  is much longer than previously thought, and that the amount of  $\text{Mn}^{53}$  activity produced in iron meteorites exposed to cosmic ray fluxes in solar space for a million years or more within the past few million years should be easily detectable. The search for  $\text{Mn}^{53}$  in meteorites at the very least would give additional information on cosmic-ray intensity in solar space. If activity is found, the determination of its intensity in concentric shells as a function of depth should yield information on the intensity of low-energy cosmic radiation within the solar system. If certain problems can be overcome it should be possible to date the fall of meteorites by their  $\text{Mn}^{53}$  content; such dating could presumably go back several million years.

The relative amounts of  $\text{H}^3$  and  $\text{Mn}^{53}$  in recently fallen meteorites should tell something about the constancy of cosmic-ray intensity over periods of about one million years. Finally, if appreciable amounts of  $\text{Mn}^{53}$  could be found on the earth's surface (the possibility of its accumulation in the polar regions has been suggested), it might constitute an important tool with which to date the time of burial of terrains back to a few million years. — D. B. V.

- 185-84. Feller-Kniepmeier, M., and Uhlig, H. H. Nickel analyses of metallic meteorites by the electron-probe microanalyzer: *Geochim. et Cosmochim. Acta*, v. 21, no. 3/4, p. 257-265, 1961.

Nickel analyses of separate phases in 9 metallic and 1 stone meteorite were obtained by means of the electron-probe microanalyzer. The composition was uniform throughout the kamacite phase; however, the nickel content was appreciably lower near a schreibersite inclusion. Taenite showed a marked composition gradient which increased at the taenite-kamacite interface. The nickel content of fine plessite was intermediate; it also showed a concentration gradient that was continuous with that of adjacent taenite.

These results are in agreement with slow cooling of the original body or bodies to a temperature of  $300^\circ\text{C}$  or lower during a long period of time; however, the time was short of that required to produce a uniform composition for taenite or for kamacite near schreibersite inclusions. — D. B. V.

- 185-85. Reed, G[eorge] W., Kigoshi, K., and Turkevich, A[nthony]. Determinations of the concentrations of heavy elements in meteorites by activation analysis: *Geochim. et Cosmochim. Acta*, v. 20, no. 2, p. 122-140, 1960.

Barium, mercury, thallium, lead, bismuth, and uranium contents and isotopic compositions of some stone meteorites and of the troilite phase of iron meteorites have been determined by neutron activation analysis. Two groups of chondrites were observed. The group including the enstatite and carbonaceous chondrites has orders of magnitude more of the chalcophilic elements studied than do the other chondrites. Barium and uranium do not show this variation. The lead in this group is primordial in its  $Pb^{208}/Pb^{204}$  isotopic composition, as might be expected from the Pb/U ratio. Some of the nuclear and geochemical implications of these results are suggested.

The Nuevo Laredo meteorite is interesting because it is the only one in which the absolute amounts of lead, thorium, and uranium are consistent with an observed isotopic composition of the lead (see *Geophys. Abs.* 157-131). The age of  $4.5 \times 10^9$  yr that has been deduced for it is probably trustworthy; in other meteorites for which lead-lead ages have been quoted there is a question whether there is enough uranium and thorium to be compatible with the amount of the radiogenic lead, and the ages must be considered suspect. The  $Bi^{209}$  content of Nuevo Laredo also gives a lower limit of  $1.6 \times 10^7$  yr for the time that must have elapsed since the formation of the elements and their segregation into the matter that forms the meteorite. This lower limit is shorter than the  $>4 \times 10^8$  yr deduced from the  $Xe^{129}$  content (see *Geophys. Abs.* 163-150, 171-8) but may be more reliable as it does not depend on the retention of a noble gas. — D. B. V.

- 185-86. Marshall, Royal R., and Hess, David C. Lead from some stone meteorites: *Jour. Chem. Physics*, v. 28, no. 6, p. 1258-1259, 1958.

The isotopic composition of lead (extracted by a volatilization process) from two stone meteorites was determined. For the Richardton chondrite,  $Pb^{206}/Pb^{204}=27.57$ ,  $Pb^{207}/Pb^{204}=22.13$ , and  $Pb^{208}/Pb^{204}=48.51$ ; for the Holbrook chondrite the corresponding ratios are 17.52, 15.52, and 38.93, respectively. The Richardton lead is considerably more radiogenic than terrestrial lead. In Holbrook the U/Pb ratio is lower than that of crustal lead, and thorium is relatively higher. The lead-lead ages deduced from these isotopic compositions are both  $4.7 \times 10^9$  yr, agreeing within the limits of error with other investigations.

Although the amount of lead present is not more than a few tenths of a ppm, it is 1.5-3 times as much as it should be according to the measured uranium concentrations; this relative excess of lead may be characteristic of stone meteorites. — D. B. V.

- 185-87. Hess, D[avid] C., and Marshall, R[oyal] R. The isotopic compositions and concentrations of lead in some chondritic stone meteorites: *Geochim. et Cosmochim. Acta*, v. 20, no. 3/4, p. 284-299, 1960.

The isotopic compositions of lead from the Richardton, Holbrook, Beardsley, and Plainview chondrites have been analyzed. The technique used is described. The isotopic compositions were found to range from highly radiogenic (in Richardton) to substantially less radiogenic than average lead in the earth's crust (in the other three). From recent concentration determinations

by the isotopic dilution method, it seems that the amount of lead in Beardsley is about 0.13 ppm and in Richardton about 0.06 ppm. The leads in these meteorites are consistent within a factor of about 2 with the lead-lead ages and the independently measured uranium and thorium concentrations. The lead-lead age for Richardton is the same as that found by Patterson for Nuevo Laredo (see *Geophys. Abs.* 167-5),  $4.6 \times 10^9$  yr. The lead concentration in Forest City is 0.09 ppm, while that in Holbrook is 0.28 ppm. Holbrook is quite anomalous in containing 2.5 times more radiogenic lead than can be explained by the accumulation of decay products in place. The total amount of lead on the surface of a meteorite appears to be comparable to the total amount inside. The isotopic composition of this surface lead indicates that it is principally terrestrial lead. — D. B. V.

- 185-88. Marshall, R[oyal] R., and Hess, D[avid] C. Lead from troilite of the Toluca iron meteorite: *Geochim. et Cosmochim. Acta*, v. 21, no. 3/4, p. 161-164, 1961.

The isotopic composition of silver from troilite of the Toluca (Xiquipilco) iron meteorite was found in 1957 (see *Geophys. Abs.* 185-89) to be similar to that of terrestrial silver; lead from the same sample was found to be different from the primeval lead observed by Patterson and others (see *Geophys. Abs.* 160-144 and 162-171) in the Canyon Diablo and Henbury iron meteorites. The simplest explanation of the fact that the Toluca troilite lead is nearly as radiogenic as average modern lead at the earth's surface is that this troilite may contain uranium and thorium. Assuming that the original lead isotopic composition was the same as that of Patterson's primeval lead, the lead-lead age of the meteorite would be about  $4.7 \times 10^9$  yr, about the same as that of the stone meteorites.

Should analyses reveal only very small concentrations of uranium and thorium in the Toluca troilite, however, the latter would be similar to the Holbrook chondrite in having a peculiar excess of radiogenic lead (see *Geophys. Abs.* 185-86, -87). In that event another possible explanation would be the addition of lead more recently than  $4.7 \times 10^9$  yr ago. A model age of  $0.77 \times 10^9$  yr is calculated on this assumption. If the iron meteorite formed only about  $10^9$  yr ago, variation in the isotopic composition of silver would be quite unlikely.

Although the concentration and isotopic composition of the lead reported here need not be characteristic of all or even most of Toluca, it may be an important clue to the history of the meteorite. — D. B. V.

- 185-89. Hess, David C., Marshall, Royal R., and Urey, Harold C. Surface ionization of silver; silver in meteorites: *Science*, v. 126, no. 3286, p. 1291-1292, 1957.

The isotopic composition of silver in meteorites may reveal part of the early history of the solar system. Troilite from the Toluca (Xiquipilco) iron meteorite was found to contain no more than 1.6 ppm of silver, and a fragment of the Canyon Diablo iron meteorite (free of visually obvious troilite) no more than 1 ppm of silver. The  $\text{Ag}^{107}/\text{Ag}^{109}$  ratios of meteoritic silver and terrestrial silver were found to agree within the limits of experimental error. — D. B. V.

- 185-90. Fowler, William A., and Hoyle, F. Nuclear cosmochronology: *Annals Physics*, v. 10, no. 2, p. 280-302, 1960.

The radioactive decays of uranium and thorium are applied in cosmochronology, in much the same manner as in geochronology, to two models representing different views as to the immediate source of the material that now constitutes the solar system.

In Model 1 (the autonomous galaxy) consideration of the decay of  $\text{Th}^{232}$ ,  $\text{U}^{235}$ , and  $\text{U}^{238}$  leads to the conclusion that the age of the galaxy is  $15^{+5}_{-3} \times 10^9$  yr. Similar considerations according to Model 2 (steady state cosmology and galactic-intergalactic exchange of matter) lead to the conclusion that the expansion time scale of the universe is  $11 \pm 6 \times 10^9$  yr. The error can be reduced to  $\pm 2 \times 10^9$  yr if the present Th/U ratio is chosen to give a  $\text{Pb}^{208}/\text{Pb}^{206}$  age for the solar system that is concordant with that given by  $\text{Pb}^{207}/\text{Pb}^{206}$ , namely  $4.5 \times 10^9$  yr. Application of radioactive decays to the chronology of the galaxy can no longer be made in a simple manner; however, the age found in the Model 1 calculations would seem to be a lower limit. — D. B. V.

- 185-91. Goles, Gordon, G., and Anders, Edward. The record in the meteorites. 6. On the chronology of the early solar system: *Jour. Geophys. Research*, v. 66, no. 3, p. 889-898, 1961.

An attempt is made to account for the differences between the isotopic composition of terrestrial and meteoritic xenon reported by Reynolds (see *Geophys. Abs.* 183-66, -67). The two chief mechanisms (other than the decay of  $\text{I}^{129}$  to  $\text{Xe}^{129}$ ) are the production of  $\text{Xe}^{131-136}$  by spontaneous fission of now extinct nuclides in the earth, and the production of  $\text{Xe}^{124-128}$  by nuclear spallation reactions in the early history of the solar nebula. About 9.6 percent of the  $\text{Xe}^{136}$  in the earth's atmosphere appears to have been derived from the spontaneous fission of  $\text{Pu}^{244}$ . The  $\text{Pu}^{244}$ - $\text{Xe}^{136}$  decay interval of the earth is  $290 \times 10^6$  yr, and its  $\text{I}^{129}$ - $\text{Xe}^{129}$  decay interval may be estimated as  $\geq 210 \times 10^6$  yr. Thus, the earth appears to be  $100$ - $200 \times 10^6$  yr younger than the meteorites. Possible errors in these determinations are discussed. A dating method based on the two decay systems  $\text{I}^{129}$ - $\text{Xe}^{129}$  and  $\text{Pu}^{244}$ - $\text{Xe}^{136}$  is proposed, and the appropriate equations are given. The initial solar-system ratios of  $\text{I}^{129}/\text{I}^{127}$  and  $\text{Pu}^{244}/\text{U}^{238}$ , which can be determined by this method, would provide a crucial test of models of nucleosynthesis. — D. B. V.

- 185-92. Reynolds, John H. The age of the elements in the solar system: *Sci. American*, v. 203, no. 5, p. 171-174, 176, 178, 180, 1960.

Measurements of the U/He and K/Ar ratios in the noble gases trapped in the crystal lattices of meteoritic stone and iron show that the cold planetary bodies of the solar system all crystallized at about the same time - some 4.5 or 4.6 billion years ago. Moreover, measurement of the cosmic-ray produced  $\text{He}^3$ , rather than just the  $\text{He}^4$  which terminates the decay of uranium, makes it possible to determine the age and biography of the meteorite as a fragment of some larger parent body. The exposure or break-up ages of common stone meteorites are a few tens of millions of years, but those of iron meteorites are about 600 million years. A "contour map" of the distribution of  $\text{He}^3$ , in a cross-section of a meteorite makes it possible to determine the original shape of the fragment.

An upper limit is placed on the age of the elements in the solar system by the existence now of  $\text{U}^{235}$  with its half life of 700 million years as compared to the half life of  $\text{U}^{238}$  of 4.5 billion years. If the original ratio of these isotopes was unity, then they were formed not more than approximately 6.6 billion years ago. The use of the I/Xe ratios to provide ultimately a reliable time scale for events at about the time the solar system was formed is discussed. Results to date with this method confirm the  $\text{U}^{235}$  evidence that the time interval between nucleogenesis and the formation of the minerals in the meteorites is relatively short. (See also *Geophys. Abs.* 183-66, -67, -68.) — V. S. N.

- 185-93. Wänke, H. Exposure ages for iron meteorites: *Nature*, v. 188, no. 4756, p. 1101-1102, 1960.  
 Schaeffer, Oliver A. Exposure ages for iron meteorites: *ibid*, p. 1102, 1960.

Wänke points out that the exposure ages calculated by Schaeffer and Fisher (see *Geophys. Abs.* 182-73) cannot be correct, as they are based on two assumptions that cannot withstand examination: that the mean energy of particles producing spallations decreases with depth from the surface, and that the  $\text{He}^3/\text{Ar}^{38}$  ratio is a measure of the mean energy of the particles.

Schaeffer replies that the exposure ages were not based on assumptions, but on experimental observations which indicate a relation between the  $\text{He}^3/\text{Ar}^{38}$ ,  $\text{He}^3/\text{He}^4$ , and  $\text{He}^4/\text{Ar}^{38}$  ratios and the production rate of the radioactive nuclides  $\text{Cl}^{36}$  and  $\text{Ar}^{39}$  by cosmic rays. — D. B. V.

- 185-94. Stauffer, Heinz. Cosmogenic argon and neon in stone meteorites: *Jour. Geophys. Research*, v. 66, no. 5, p. 1513-1521, 1961.

The abundance and isotopic composition of argon and neon in six chondrites and an achondrite have been measured. The results of previous investigations are confirmed, namely Ar/K ages from 1.3 to 4.6 billion years and exposure ages from 4 to 24 million years. It is shown that the differences of the ratios  $\text{Ar}^{36}/\text{Ar}^{38}$  are due mainly to small amounts of trapped primordial or atmospheric argon. Using the corrected  $\text{Ar}^{38}$  abundances, a value of 9.0 with a total spread of  $\pm 20$  percent is found for the corrected  $\text{Ne}^{21}/\text{Ar}^{38}$  ratios. The possibility of diffusive losses of cosmogenic rare gases is discussed. — Author's abstract

- 185-95. Goles, Gordon G., and Anders, Edward. Iodine content of meteorites and their  $^{129}\text{I}$ - $^{129}\text{Xe}$  ages: *Jour. Geophys. Research*, v. 65, no. 12, p. 4181-4184, 1960.

Iodine and tellurium abundances in chondritic meteorites were determined by neutron activation analysis. For 6 bronzite and hypersthene chondrites, iodine abundances range from 37 to 104 ppb, and for 9 enstatite and carbonaceous chondrites the range is from 127 to 560 ppb; the tellurium abundances range from 0.42 to 0.73 ppm and 1.23 to 3.4 ppm respectively.

Using the continuous nucleosynthesis model, the  $^{129}\text{I}$ - $^{129}\text{Xe}$  decay intervals, measured from the cessation of nucleosynthesis, were calculated to be  $119^{+8}_{-8} \times 10^6$  yr for Richardton,  $97^{+17}_{-10} \times 10^6$  yr for Indarch,  $106^{+9}_{-8} \times 10^6$  for Murray, and  $>190 \times 10^6$  yr for Beardsley. The iodine content of Richardton is about a factor of 20 less than that assumed by Reynolds (see *Geophys. Abs.* 183-68), so that the decay interval is considerably shorter than his original estimate. The apparent difference in values for Richardton and Indarch is not statistically significant. — D. B. V.

- 185-96. Read, William F. The Saxeville meteorite: *Wisconsin Acad. Sci., Arts, and Letters Trans.*, v. 49, p. 191-198, 1960.

The Saxeville meteorite was found many years ago about 5 miles southwest of Saxeville, Waushara County, Wis. The original mass is said to have weighed 3.6 kg but only 687 g can be accounted for now in major collections. This study is based on 236 g in the collection at Lawrence College. The metallic portion of the meteorite is mainly granular-octahedral Ni-Fe with scattered blebs of schreibersite and troilite; the stoney portions are a crystalline mosaic of 46 percent pyroxene, 32 percent olivine, 0.5 percent plagioclase, and 21.5 percent Ni-Fe and troilite. The metal is in veins intruded along fractures in the stoney material and replacing it to a limited extent. — V. S. N.

- 185-97. Krinov, E. L. The Kaaliyarv meteorite craters on Saaremaa Island, Estonian S. S. R.: *Am. Jour. Sci.*, v. 259, no. 6, p. 430-440, 1961.

An investigation of one large and six small meteorite craters in Estonia is reported. It is concluded that the large crater is the result of an explosion caused when a large meteorite traveling at remaining cosmic velocity collided with the earth. The smaller craters, formed by the same meteorite shower, are impact craters formed by smaller fragments which had been slowed by the atmosphere until all cosmic velocity was lost and thus could not produce an explosion at the point of impact. No fragments of meteorites are associated with the small craters in contrast to the many associated with the large crater.

Comparison is made with similar crater groups in Sikhote-Alin, U.S.S.R.; Henbury, Australia; and Brenham, Kan. — V. S. N.

- 185-98. Thiel, Edward, and Schmidt, Richard A. Spherules from the Antarctic ice cap: *Jour. Geophys. Research*, v. 66, no. 1, p. 307-310, 1961.

A study of spherules contained in Antarctic ice cores leads to improved values for the size distribution and annual mass deposit of these distinctive extraterrestrial particles. Previous estimates of the annual deposit based on collections from air and from ocean sediments have varied from 8 metric tons to 2,000,000 metric tons per year. The figure derived from the present study is 184,000 metric tons per year. — Authors' abstract

- 185-99. Pettersson, Hans. Cosmic spherules and meteoritic dust: *Sci. American*, v. 202, no. 2, p. 123-126, 128, 130-132, 1960.

The amount of extraterrestrial material that is contributed to the earth by meteor-falls is estimated from a study of cosmic spherules in deep ocean sediments and of meteoritic dust in the atmosphere to be about five million tons per year. Deep sea cores from the Pacific, containing sediments 7.5 to 15 million years old in the lowest parts, show a cosmic spherule count that varies from point to point on the ocean floor and from one period to another down the length of the core; in general, however, the count is higher in the upper, more recent sediments and lower in the more ancient sediments. Cores from other oceans show this same tendency. To estimate the amount of meteoritic material falling on the earth today, a collection of meteoritic dust is being made. Collections are made from high mountains in areas relatively uncontaminated with terrestrial dust; cosmic dust is distinguished from terrestrial dust by the presence of nickel. If five million tons of meteoritic dust fall to the earth each year of which 2.5 percent is nickel, the amount of nickel added to ocean sediments would be .017 percent of the total red clay deposited in a year. This is well within the 0.44 percent nickel content of deep-sea sediments and makes the five-million-ton per year figure seem conservative; the figure of 14 million tons actually arrived at from dust collections may be more accurate. (See also *Geophys. Abs.* 172-145, 173-234, 184-83.) — V. S. N.

- 185-100. Gourinard, Yves. Sur la presence de sphérules cosmiques dans des roches sédimentaires [On the presence of cosmic spherules in sedimentary rocks]: *Acad. Sci. [Paris] Comptes Rendus*, v. 251, no. 22, p. 2558-2560, 1960.

Cosmic spherules have been recovered from Pliocene clays near Algiers that are about the same age as the oldest Pacific sediments examined by Pettersson (see *Geophys. Abs.* 185-99). Their average size is smaller than that of the Pacific spherules (most are 10-20  $\mu$ ), but they are more abundant

(100-400 spherules per kg). An Upper Bajocian calcareous marl from Tagremaret (Oran) also furnished spherules, but in less abundance with respect to total mass of rock (some tens per kg at most).

If it can be shown on the basis of absolute age data that the abundance and size distribution of cosmic spherules has varied in the course of geologic time, they would constitute exceptionally good stratigraphic horizon markers, which are strictly contemporaneous and of worldwide distribution. — D. B. V.

- 185-101. Taylor, S. R., Sachs, Maureen, and Cherry, R. D. Studies of tektite composition-I. Inverse relationship between  $\text{SiO}_2$  and the other major constituents: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 155-163, 1961.

The relation of  $\text{SiO}_2$  to the other major constituents in tektites has been studied (see also *Geophys. Abs.* 183-78). It is concluded that a significant inverse relationship exists between  $\text{SiO}_2$  and the other constituents, and that  $\text{Al}_2\text{O}_3$ ,  $\text{FeO}$ ,  $\text{MgO}$ ,  $\text{CaO}$ ,  $\text{Na}_2\text{O}$ , and  $\text{K}_2\text{O}$  display positive correlations among themselves. — D. B. V.

- 185-102. Cherry, R. D., and Taylor, S. R. Studies of tektite composition-II. Derivation from a quartz-shale mixture: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 164-168, 1961.

The inverse relation between  $\text{SiO}_2$  and the other major constituents of tektites (see *Geophys. Abs.* 185-101), together with the presence of lechatelierite, is explained on the basis of a physical mixing process. A close match to the average composition of tektites is produced by a mixture of 25 percent quartz and 75 percent nonvolatile (at  $1,700^\circ\text{C}$ ) constituents of shale. (See also *Geophys. Abs.* 183-78). — D. B. V.

- 185-103. Salisbury, John W. An introduction to the moon: U.S. Air Force Research Division, Geophysics Research Directorate, TN 60-456, 30 p., 1960.

Present knowledge and theories concerning the origin of the moon and the lunar surface structures are summarized primarily for the use of laymen, schools, and teachers. The following chapters are included: introduction, origin of the moon, lunar interior, lunar surface, and lunar experiments. In conclusion, a brief list of references is given. — V. S. N.

- 185-104. LeRoy, L. W. Lunar features and lunar problems: *Geol. Soc. America Bull.*, v. 72, no. 4, p. 591-604, 1961.

The major features of the moon (mares, highlands, craters, fractures) are briefly reviewed to encourage geologists to participate in the solution of lunar problems—problems involving the interpretation of varied land forms, the rock types and their distribution, potential ore deposits, and lunar tectonics. Special attention is given to fracture systems, the origin of the lava filling many closed craters, and the origin of the central peak complexes. — Author's abstract

- 185-105. Bolt, Bruce A. Spheroidal oscillations of the moon: *Nature*, v. 188, no. 4757, p. 1176-1177, 1960.

Periods of natural vibration of three spherical gravitating models of the moon have been calculated on an IBM 7090 electronic computer. The values provide basic information for lunar space research concerned with the design

of experiments to investigate the structure of the moon. Each model is completely solid and has a radius of 1,738 km and mean density of  $3.33 \text{ g per cm}^3$ . Model I is a homogeneous sphere with P- and S-wave velocities of 8.2 and 4.7 km/sec, respectively; Model II has a density distribution close to that calculated by Jeffreys (1937) for the self-compression of a moon composed of ultrabasic rock with a surface density of nearly  $3.28 \text{ g per cm}^3$ ; and Model III has a rather extreme density distribution, with a surface value of  $2.60 \text{ g per cm}^3$ , near that of granite.

The results, which are tabulated, indicate that the deviation of the moon from homogeneity can be measured using observations of the long-period spectrum of free vibrations. An ultra-long period seismometer or tidal gravimeter placed on the moon, designed to record periods up to 16 min, should provide more detailed information on the deep interior than the short-period seismometer suggested by Press and others (see Geophys. Abs. 183-88). — D.B.V.

- 185-106. Watson, Kenneth, Murray, Bruce, and Brown, Harrison. On the possible presence of ice on the moon: *Jour. Geophys. Research*, v. 66, no. 5, p. 1598-1600, 1961.

It is argued that water is far more stable on the lunar surface than  $\text{SO}_2$  or noble gases because of its extremely low vapor pressure at low temperatures, and that it may well be present in appreciable quantities in shaded areas in the form of ice. The fraction of lunar surface that is in permanent shade is estimated to be  $1.2 \times 10^{-4}$ ; if so, the area of exposed ice would be  $4.5 \times 10^{13} \text{ cm}^2$  and the escape rate would be  $1.9 \times 10^{-18} \text{ g per cm}^2 \text{ per sec}$ . Over the life span of the moon this would correspond to a loss of  $0.28 \text{ g per cm}^2$ . If the moon evolved as the earth did,  $3.0 \times 10^4 \text{ g per cm}^2$  of water would have been liberated on the surface; in addition,  $8.3 \times 10^{-21} \text{ g per cm}^2 \text{ per sec}$  is added by sporadic meteorite impact, and some is liberated from lunar crustal material as the result of impact. When suitable instruments can be placed in the dark areas to determine the presence or absence of ice, the result may reveal much concerning early lunar history. — D. B. V.

- 185-107. MacDonald, G[ordon] J. F. Interior of the moon: *Science*, v. 133, no. 3458, p. 1045-1050, 1961.

Present knowledge and theories concerning the physical and thermal state of the moon and of its stress history and dynamic history are reviewed. Despite the abundance of observations, the origin of many of the surface features remains in doubt. Very few data relate to the nature of the moon's interior. Direct observations, either from orbiting lunar satellites or from instruments on its surface (seismic stations, tidal gravimeters, heat flow measuring apparatus), would do much to reduce the present uncertainty. — D. B. V.

- 185-108. Bülow, Kurd von. Fundamentaltektonische Parallelen zwischen Mond und Erde [Fundamental tectonic parallels between moon and earth]: *Forschungen u. Fortschritte*, v. 33, no. 1, p. 1-4, 1959.

Comparison of the known features of earth and moon shows that the two bodies are alike in their fundamental structural style, suggesting parallels in their structural history. — D. B. V.

- 185-109. Bülow, Kurd von. Zur Deutung der Lunik-Aufnahmen von der Rückseite des Mondes [On the interpretation of the Lunik photographs of the back of the moon]: *Forschungen u. Fortschritte*, v. 34, no. 3, p. 65-66, 1960.



This is a brief description, with sketch, of the features visible in the Russian photographs of the back of the moon. — D. B. V.

Schrader, C. D., and Stinner, R. J. Remote analysis of surfaces by neutron-gamma-ray inelastic scattering technique. See *Geophys. Abs.* 185-511.

## EARTH CURRENTS

- 185-110. Roberts, P. H., and Lowes, F. J. Earth currents of deep internal origin: *Jour. Geophys. Research*, v. 66, no. 4, p. 1243-1254, 1961.

The current system flowing in the earth's core that is responsible for the dipole geomagnetic field is toroidal and does not appreciably extend into the mantle. However, the mechanism supporting these currents almost certainly generates in addition a poloidal current system that does extend into the mantle and that could, in principle, be measured at the earth's surface. In this paper the current distribution in the mantle is examined for several assumed distributions of conductivity in the mantle. The effect of the oceans is also briefly considered. It is found that the potential gradient at the surface of the earth associated with these deep earth currents may be of the order of a mv per km if thermoelectric emf's at the core boundary contribute appreciably to the magnetic field, but will be smaller if the primary emf's are inside the core. — Authors' abstract

- 185-111. Garland, G. D. Earth currents, in *Methods and techniques in geophysics*, v. 1: New York, Interscience Publishers, Inc., p. 277-307, 1960.

Electric currents that are on a sufficient scale to be useful in study of the earth as a whole are considered in this paper. The emphasis is on the general instrumental requirements for specific applications rather than on technical details, because much of the instrumentation required for measurement of earth currents is well understood. The following are discussed: measurement of earth currents, general nature of earth-current records, electromagnetic induction in the earth, and particular applications of earth-current measurements. It is suggested that apart from the study of crustal structures, earth current observations should lead to a better understanding of difference in properties from place to place in the upper mantle. In conjunction with magnetic observations they should assist in determining the nature of the sources of disturbance for effects of various periods. Finally, there is the possibility of locating components of the measured currents that are not the result of induction by an external varying magnetic field; this could be highly important if the currents could be shown to be related to a toroidal magnetic field in the core or to mantle-core currents. — V. S. N.

- 185-112. Fournier, Hugo. Sur une polarisation sélective remarquable des courants telluriques enregistrés à Garchy [On a remarkable selective polarization of telluric currents recorded at Garchy]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 4, p. 562-564, 1961.

Earth currents of "intermediate" period recorded at the Nivernais Geophysical Station at Garchy, France, are distinctly channeled in an approximately north-south direction. The polarization becomes perceptible for periods of 5 sec, is most distinct in those of about 5 min, and ceases to be perceptible for periods of the order of 3 hr. Channeling of earth currents is

known elsewhere; what is remarkable here is its selective character. It evidently occurs in the intermediate layers of the crust, in which the intermediate-frequency currents flow. — D. B. V.

- 185-113. Tárczy-Hornoch, A[ntal]. Bericht des observatoriums bei Nagycenk (Ungarn) über die Ergebnisse der Erdstromregistrierungen in den beiden Halbjahren 1958 [Report of the observatory near Nagycenk (Hungary) on the results of earth current recordings in both halves of 1958]: Acad. Sci. Hungaricae Acta Tech., v. 30, no. 3-4, p. 337-422, 1960.

Earth current data obtained at the Nagycenk observatory in Hungary in 1958 are presented in extensive tables and graphs. — D. B. V.

Porstendorfer, G[ottfried]. Experiments with the use of stray currents in geophysical prospecting. See Geophys. Abs. 185-182.

#### EARTHQUAKES AND EARTHQUAKE WAVES

- 185-114. Lotze, Franz. Aktuogeologische Charakteristik des Jahres 1958 [Actuogeologic characteristics of the year 1958]: Neues Jahrb. Geologie und Paläontologie Monatsh., no. 12, p. 529-545, 1959.

In 1958 in central Europe 816 definite earthquakes were registered. Their monthly distribution is tabulated. Epicenters were determined for 59 percent of them; of these, 65 were in Europe and the Mediterranean area, 3 in Africa, 23 in the Atlantic and Arctic Oceans, 28 in India and Indonesia, 259 in the western and northwestern half of the Pacific Ocean, and 56 in its southeastern half. There were 82 shocks of magnitude 6 or more, 7 with  $M \geq 7$ , and 1 with  $M=8$ ; their regional distribution is given. There were more than twice as many shocks with focal depths greater than 50 km than in 1957; they were distributed as follows: 14 at 50-90 km, 24 at 100-190 km, 10 at 200-350 km, and 16 at 400-650 km. Their geographic distribution is given.

Volcanic activity in 1958 included the further development of Ilha Nova (Cape-linhos) in the Azores, and eruptions of Goma and another volcano in the Belgian Congo, Etna and Stromboli in Europe, Aso and Asama in Japan, and Ma-nâm in New Guinea. — D. B. V.

- 185-115. Due Rojo, Antonio. Notas sísmicas de 1958 [Seismic notes, 1958]: Rev. Geofísica, v. 18, no. 70, p. 207-215, 1959.

Progress in seismology in 1958 is reviewed briefly; and mention is made of the numerous International Geophysical Year activities all over the world, development of very long-period seismographs, calculations of the shape of the earth's core, studies of the relation between microseisms and seismicity of the areas where they were registered, and studies of waves generated by nuclear explosions. The world distribution of epicenters of 1958 earthquakes is shown on a map, and macroseismic data concerning the most noteworthy shocks are reviewed by region (Europe, Asia, North and South America, and Oceania). — D. B. V.

- 185-116. Due Rojo, Antonio. Notas sísmicas de 1959 [Seismic notes for 1959]: Rev. Geofísica, v. 19, no. 74, p. 183-188, 1960.

Earthquake activity in various parts of the world during 1959 (Europe, Asia, Africa, America, and Oceania) is reviewed briefly. A table shows the distribution of magnitudes and focal depths, and a map gives the geographic position of the 1,192 epicenters determined for 1959. — D. B. V.

- 185-117. Berg, Joseph W., Jr. Earthquakes near Nephi, Utah, on November 28, 1958, and December 1, 1958: Utah Acad. Sci. Proc., v. 37, p. 77-79, 1960.

One earthquake occurred November 28, 1958 and three on December 1, 1958, near Nephi, Utah. The shocks ranged between 4 and 5 in maximum intensity on the Modified Mercalli Scale. Instrumental determinations for the epicenters were not possible, and all epicenters were assumed to be at one location, lat  $39^{\circ}42.7' N.$ , long  $111^{\circ}50.0' W.$  Body shear waves traveled the 115.6 km to Salt Lake City at an average velocity of  $3.5 \pm 0.1$  km/s. — V. S. N.

- 185-118. Schulz, R[udolf]. Breve descripción de los terremotos de Chile de Mayo de 1960 [Brief description of the earthquakes in Chile in May 1960]: El Salvador Servicio Geol. Nac. Bol. Sismol., v. 6, p. 23, 1960.

The time of occurrence and magnitude of the Chilean earthquakes of May 21-22, 1960 and the damage and topographic changes wrought are described very briefly. The occurrence of three strong shocks ( $M=7 \frac{3}{4}$ ,  $7 \frac{3}{4}$ , and  $8 \frac{1}{2}$ ) within a few minutes of each other—particularly the last two, which were only a half minute apart—provoked very slow oscillations of the whole surface of the globe of more than 1 cm amplitude, which were recorded by long-period seismographs. — D. B. V.

- 185-119. Pfluke, John H. Agadir earthquake of February 29, 1960—seismicity and geology of the area: Earthquake Notes, v. 31, no. 4, p. 46-50, 1960.

The Agadir earthquake of February 29, 1960 occurred in a well-defined belt of earthquakes that extends the length of Morocco and branches off the large Alpine belt which forms a loop about the Western Mediterranean. Seismic activity in Morocco seems to follow mountain ranges; beginning where the Alpine belt divides the Moroccan branch, continues down the Middle and High Atlas ranges with a sub-branch following the Rif mountain range. A striking alignment of epicenters occurs along the Atlas ranges. Epicenters are located along two lines—one directed N.  $25^{\circ}$  E. and paralleling the trend of Hercynian folding, and the other directed N.  $55^{\circ}$  E. and paralleling the trend of the Alpine tectonic axis. The epicenter of the Agadir earthquake was located on the latter alignment. A fault plane solution by the P-wave first motion method is attempted for the Agadir earthquake. The fault strike of the first solution closely parallels the strike of surface faults in the area. To eliminate the ambiguity, the two P-wave solutions are compared with the polarization of S-waves observed at a number of seismic stations. From this it seems probable that the fault break may have occurred on a downward extension of either the Casbah or Tildi fault. — V. S. N.

- 185-120. Sahlström, K. E., and Båth, M[arkus]. Jordskalv i Sverige 1951-1957 [Earthquakes in Sweden, 1951-57 (with German summary)]: Sveriges Geol. Undersökning, Årsb. 52, no. 5, (Ser. C, no. 562) 19 p., 1958.

Twenty-two earthquakes were observed macroseismically in Sweden in the period 1951-57. The strongest, with an intensity of 4-5 (Rossi-Forels scale), occurred on August 26, 1956 in northern Hälsingland and was felt over an area of  $4,500 \text{ km}^2$ . Two others, of intensity 4, were felt over wider areas: March 5, 1953 over  $14,000 \text{ km}^2$  in western Wärmaland, Dalsland, and northern

Bohuslän; and January 21, 1956 over 6,000 km<sup>2</sup> around Arjeplog in Lappland. Seven shocks were felt in 1956, 5 in 1955, 3 each in 1953 and 1957, 2 in 1951, and 1 each in 1952 and 1954. Epicenters are shown on a map. Each shock is described briefly. — D. B. V.

Yevseyev, S. V. The earthquake of February 20, 1951 and the structure of the earth's crust in the Transcarpathian region. See *Geophys. Abs.* 185-356.

- 185-121. Kukhtikova, T. I., and Yeferina, G. P. O polozhenii epitsentra Stalinabadskogo zemletryaseniya 1952 g. [On the location of the epicenter of the Stalinabad earthquake of 1952]: *Akad. Nauk Tadzhik SSR, Inst. Seysmostoykogo Stroitel'stva i Seysmologii Trudy*, v. 6, p. 151-170, 1960.

On the basis of study of instrumental data on the Stalinabad earthquake of 1952, the epicenter was found to be located within the Bassar valley close to the zone of maximum seismicity. — A. J. S.

- 185-122. Petrushevskiy, B. A. K geologicheskoy obstanovke Gan'suyskogo zemletryaseniya 1920 g [On the geologic conditions of the Kansu earthquake of 1920]: *Akad. Nauk SSSR Doklady*, v. 129, no. 2, p. 412-415, 1959.

The earthquake of December 19, 1920 in Kansu province in northwestern China was one of the strongest registered anywhere during the period 1904-56. Its magnitude (m) was 7 3/4 and its intensity 11-12 points. Although the epicenter was far from any large cities, there were 100,000-250,000 casualties.

The epicentral zone of this earthquake was visited by Petrushevskiy in December 1958. At first glance it is impossible to detect any of the geologic features usually associated with high seismicity. There seem to be no major faults at or near the surface. There has been no recent structural reorganization nor is there any abrupt change in structural plan. Recent tectonic movements have no distinct surface expression; were it not for the numerous earthquakes, some of them strong, such movements would be considered to be negligible. The area is an epi-Hercynian platform, the general geologic conditions of which are reminiscent of the Kazakh folded region where basement rocks of an epi-Hercynian platform crop out; the latter is practically aseismic, however. An investigation of the seismicity of Kansu province, planned for the near future by Chinese seismologists, should be of great seismo-geologic interest. — D. B. V.

- 185-123. Hsieh, Yü-show. The Kuo-Hsien earthquake of October 8, 1952 (in Chinese with English abstract): *Acta Geophys. Sinica*, v. 7, no. 2, p. 83-90, 1958.

A destructive earthquake occurred on October 8, 1952 in the Hu-tuo River valley near Kuo-Hsien, Shansi Province, China. The hypocenter was at lat 38°53' N., long 112°51' E. The magnitude was only 5.3 but the epicentral intensity attained a value of 8; the S-P interval of several aftershocks was only 2 sec; and the Nanking and Zi-Ka-Wei seismograms showed relatively small amplitudes of body waves. From these facts it was concluded that the focal depth was shallower than usual. The rising earthquake intensity at places along the river is illustrated; it shows clearly the effect of ground condition and water table on earthquake destructiveness. The destructiveness of the earthquake was large because of the unconsolidated nature of the river valley sediments. — V. S. N.

- 185-124. Aver'yanova, V. N., Fedotov, S. A., and Ferchev, M. D. Predvaritel'nyye dannyye o zemletryasenii i tsunami 6 noyabrya 1958 g. [Preliminary data on the earthquake and tsunami of November 6, 1958]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 9, p. 88-99, 1961.

The earthquake of November 6, 1958 at 22<sup>h</sup>58<sup>m</sup> (G.m.t.) occurred on the west slope of the Kurile deep sea basin off Iturup (Etorofu) island and caused a tsunami. The magnitude, according to Moscow, Pulkovo, Irkutsk, and other stations, was  $M=8.0$ ; focal depth was 80 km according to SP-P differences. The SP phase was clearly recorded at Klyuchi, Vladivostok, Moscow, Pulkovo, and other U.S.S.R. stations and correlated well from station to station. Origin time was calculated as 22<sup>h</sup>58<sup>m</sup>14<sup>s</sup>, using the method of least squares according to the Wadati formula. Provisional epicentral coordinates are  $\phi=44.25^\circ$  N.,  $\lambda=149.0^\circ$  E. Numerous aftershocks occurred through December. The strongest of these ( $M=7$ ) was on November 12 at 20<sup>h</sup>; its epicenter was close to that of the main shock.

The earthquake was felt for 500 km along the Kurile Islands from Kunashiri to Uruppu, with almost equal intensity (about 8 points), indicating its great depth and energy. Macroseismic effects are described briefly. The tsunami produced by the earthquake is discussed in more detail. Its relatively small size can be explained by the great depth of focus and by the fact that the southern Kurile Islands are bordered by a broad shallow-water zone on the ocean side. — D. B. V.

- 185-125. Lee, S. P. A practical magnitude scale [in Chinese with English abstract]: Acta Geophys. Sinica, v. 7, no. 2, p. 98-102, 1958.

A practical magnitude scale is suggested to estimate the magnitude of ancient earthquakes for which only simple historical records are available. An empirical formula,  $M=0.58 I_0+1.5$  (where  $M$  is magnitude and  $I_0$  is intensity at epicenter), is derived from instrumental and field observations of 35 recent earthquakes in China. Using this formula, a practical magnitude scale in tabular form is constructed. It is concluded that the resulting estimates of magnitude for the ancient earthquakes are accurate to within half-a-scale of magnitude. — V. S. N.

- 185-126. Kvale, Anders. Earthquakes, in Geology of Norway: Norges Geol. Undersøkelse Skr., no. 208, p. 490-506, 1960.

Seismic activity in Norway is greater than in the other Scandinavian countries and epicenters that have been located with sufficient accuracy are located on known or inferred fault zones. Seismological research since 1887 when written records were first instituted, the number and distribution of earthquakes, the regions of seismic activity, location of epicenters and their relation to tectonics, depth of hypocenters, thickness of crustal layers, the earthquake of October 23, 1904, and the causes of earthquakes in Norway are discussed.

It is concluded that post-glacial uplift is not the cause of all Norwegian earthquakes. Faulting has occurred in Norway since Precambrian times, and some of these faults are still active as loci of earthquakes. Faults of Silurian, Devonian, and Permian origin are also known and the greatest historic earthquake (1904) occurred on one of the latter. It is unlikely that present movements inside and outside the coastal areas of Norway should have a cause different from movements on the same faults in Tertiary times, especially as Tertiary movements are still continuing in other parts of the North Atlantic. — V. S. N.

- 185-127. Panasenko, G. D. Zemletryaseniya Kol'skogo poluostrova i Severnoy Karelii i ikh svyaz' s sovremennymi dvizheniyami Baltiyskogo shchita [Earthquakes of the Kola Peninsula and northern Karelia and their relation to recent movements of the Baltic shield]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 200-205, 1960.

The Baltic shield is an area of intensive recent crustal movement. In the Kola Peninsula and northern Karelia there is not only geologic and geomorphic evidence of the movement, but perceptible earthquakes also occur. Most of these do not exceed 4 points in intensity, but a few reach 6 or more. Instrumental observations, begun in 1956, show that very weak earthquakes are very numerous. The distribution of epicenters and the seismic zoning are shown on a sketch map. The earthquake zones are apparently related to large-scale fractures produced or rejuvenated by upwarping of the Baltic shield. — D. B. V.

- 185-128. Kirillova, I. V., and Sorskiy, A. A. Tektonika i seysmichnost' Kavkaza [Tectonics and seismicity of the Caucasus (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 158-170, 1960.

The distribution of seismic activity in the Caucasus is irregular in space and time. In a general way, it is greater in the eastern part, where recent differential vertical movements are more pronounced, than in the western part. Longitudinal and transverse zones of higher activity can be distinguished against a general background of rather high seismicity. Two main seismogenic zones are delineated, a deep horizon where mass displacements produce transverse geotectonic zoning and deep-focus earthquakes with generally north-south displacements, and an upper horizon in which mass displacements produce longitudinal zoning and shallow earthquakes.

The most active areas lie where deep faults of Caucasian (northwestern) trend are intersected by transverse deep faults. Such "seismic nodes" are typical of the southeastern Caucasus (Shemakha area) and parts of Armenian S.S.R. and Georgian S.S.R. Areas with reactivated unidirectional deep faults are characterized by relatively moderate seismicity. Areas of low seismicity are those lacking deep faults, in which tectonic movements are slight. — D. B. V.

- 185-129. Hamamatsu, O. Seismicity of shallow earthquakes in and near Japan during 1926-1956 [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 3, p. 97-107, 1960.

Formulas are given to show the relationship between the annual number and the magnitude of shallow earthquakes occurring in Japan as a whole, in northeast Japan, and in southwest Japan from 1926 through 1956. — V. S. N.

- 185-130. Ichikawa, M. On the relation between earthquake magnitude and maximum value of epicentral distance at limit of perceptibility [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 3, p. 83-87, 1960.

The following formulas are presented for estimating the magnitude of a shallow earthquake in or near Japan from the distance between epicenter and limit point of perceptibility:  $M = 2.7 \log \Delta - 1.0$  or  $M = 2.7 \log \Delta + 0.000063 \Delta - 0.96$ . Modifications are given for adapting the formulas to earthquakes in northeast Japan and in central and southwestern Japan. — V. S. N.

- 185-131. Tazieff, Haroun. À propos de la signification tectonique des importants glissements de terrains provoqués par le grand séisme du Chili de mai 1960 [Concerning the tectonic significance of large landslips provoked by the great Chilean earthquake of May 1960]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 20, p. 2204-2206, 1960.

At 200 km from the submarine epicenter of the Chilean earthquake of May 22, 1960, numerous landslide phenomena were produced in a vast area extending over almost two degrees of latitude in the spurs of the Andes Cordillera. Some avalanches of loose material descended hundreds of meters in altitude and acquired a force capable of propelling the mass far over the subhorizontal valley bottom, as is the case in avalanches of powdery snow. In some places, however, masses ranging from some tens of thousands to several million cubic meters of material were stripped from locations only 40-100 m above the valley floor and displaced long distances over the flat bottom; gravity acceleration alone could not have produced horizontal movement of this order. Evidently a mechanism analogous to that of a shaking table can operate during a single shock and cause material to be carried several kilometers. This concept might throw light on certain aspects of tectonics, particularly Alpine tectonics, that have not yet been satisfactorily explained. — D. B. V.

- 185-132. Ritsema, A. R., and Veldkamp, J. Fault plane mechanisms of southeast Asian earthquakes: Koninkl. Nederlands Meteorol. Inst. Mededel. en Verh., no. 76, 63 p., 1960.

Fault plane solutions are presented for 48 earthquakes in southeast Asia. Methods used are discussed and solutions are given in tables which are followed by an analysis of each earthquake. It is concluded that (1) the mechanism at the focus of the earthquakes treated here differs little from the assumed "single-couple" theory; (2) the fault motion and principal earthquake generating stresses are in a more or less vertical plane for deep shocks and in a more or less horizontal plane for shallow shocks; (3) fault motion is generally directed either about perpendicular to or about parallel with the direction of the geological structures at the surface; (4) B-axes are generally situated in a vertical plane through the tectonic structural lines; (5) fault motions of large earthquakes,  $M > 7\frac{1}{2}$ , show a tendency to be directed in NNW-SSE azimuths independent of the seismic zone to which the shocks belong; (6) combined normal and reverse fault earthquakes are 25 percent higher in the "Mediterranean" zones of Sumatra, Sunda arc, Celebes, and the Philippines than in the "Pacific" zones of the Solomon Islands and New Guinea; (7) positions of principal stress components of shocks do not suggest clearly a common stress field for all earthquakes in any one zone; and (8) a geographical distribution of earthquake types is shown if the area is divided into smaller parts of seismic zones about 2,000 km long, such as the Sumatra-Sunda Strait, Java-Timor, N. Celebes, Philippines, Solomon Islands, E. New Guinea, W. New Guinea, and Moluccas regions. — V. S. N.

- 185-133. Kukhtikova, T. I. Dinamicheskaya kharakteristika nurekskikh zemletryaseniy [The dynamic characteristics of the Nurek earthquakes]: Akad. Nauk Tadzhik SSR, Inst. Seysmostoykogo Stroitel'stva i Seysmologii Trudy, v. 6, p. 141-150, 1960.

The results of determinations of dislocations in the source region of the Nurek earthquakes are reported, and conclusions are drawn on the stability of the dislocation mechanism in the first shock and in the strong aftershocks. A similarity is noted between the strike of the ruptures on the surface and the orientation of faults at the earthquake sources. — J. W. C.

- 185-134. Mikumo, Takeshi. Generation mechanism of local earthquakes in Waykayama region [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 2, p. 65-77, 1960.

This is a shorter version of the paper previously published in Kyoto Univ. Coll. Sci. Mem., ser. A, v. 29, no. 2, p. 221-240, 1959 (see Geophys. Abs. 180-54). — V. S. N.

- Scheidegger, A[drian] E[ugen]. Faults and earthquakes. See Geophys. Abs. 185-287.

- 185-135. Oulianoff, Nicolas. Problème du Flysch et géophysique [The flysch problem and geophysics]: Eclogae Geol. Helvetiae, v. 53, no. 1, p. 155-160, 1960.

The conditions under which flysch deposits form are examined. It is concluded that waves, most marine currents, and gravity slumping are inadequate to explain the transport of sediments, particularly on the gentle slopes of the continental platform, and that turbidity currents are too sporadic and localized to be the chief mechanism. Universal and perpetual vibration of the entire crust, the effect of countless shocks of different origins, is responsible for carrying sediments toward basins of accumulation. These shocks are due not only to earthquakes (which occur on the average of nearly 3,000 per day) but to microseismic agitation of local and regional origin such as tides, hurricanes, violent rains, atmospheric pressure variations, and abrupt temperature changes. The distribution of vibrations over the earth varies with space and time. — D. B. V.

- 185-136. Gutenberg, B[eno]. PKIKP and pseudo-PKIKP phases at distances of less than 140°: Royal Astron. Soc. Geophys. Jour., v. 3, no. 2, p. 250-257, 1960.

In several attempts to establish from observations the traveltime curve for PKIKP (called P' or P'' by some authors) the beginning of this curve has been drawn with a relatively strong curvature corresponding to a decrease of  $dt/d\theta$  from roughly 4 sec per degree at  $\theta=110^\circ$  to about 2 sec per degree at  $130^\circ$ . Apparently, traveltimes of different wave types had been combined. Actually, the observed traveltime curve of PKIKP is nearly a straight line in agreement with calculations. Near an epicentral distance of  $115^\circ$  the amplitudes of PKIKP increase by a factor of roughly 5. This probably indicates the transition from the diffracted to the direct PKIKP. The portions of the traveltime curves with a slope corresponding to  $dt/d\theta$  near 4 sec per degree which erroneously had been attributed to PKIKP belong to several wave types which seem to follow P, pP, and sP or precede PP, each at roughly constant time intervals. Among causes for such multiplicity of phases are effects of irregularities in the earth, of discontinuities, and of diffraction. — Author's summary

- 185-137. Bullen, K. E. A new method of deriving seismic velocity distributions from travel-time data: Royal Astron. Soc. Geophys. Jour., v. 3, no. 2, p. 258-269, 1960.

A law of the form  $v = ar^{\frac{1}{2}}$  gives a useful first approximation to the seismic velocity distribution in various parts of the earth. A method is devised here for finding the corrections to numerical values given by the law which are needed to fit a given set of seismic traveltime data. The method provides an alternative to the classical Herglotz method of determining velocity distribu-



tions and can be especially powerful in regions where the proportionate deviations from the above velocity law are small or moderate. The method is exact in spite of the nonlinear form of the first approximation.

Auxiliary notes are given that facilitate computation in particular cases. As an illustration, the method is applied to determining the P velocity distribution for the whole region E of the earth. The method illustrates anew the importance of the parameters  $\xi$  and  $\alpha$  in ray theory. These parameters are defined as follows:

$$\eta = \frac{r}{v}; \xi = \frac{d \log v}{d \log r}; \alpha = \frac{2}{1-\xi} = \frac{2d \log r}{d \log \eta}$$

where  $v$  is the velocity at distance  $r$  from the center of the earth. — D. B. V.

- 185-138. Cagniard, Louis. Rigidité du Noyau et dualité des ondes sismiques qui s'y propagent [Rigidity of the core and quality of the seismic waves that propagate there]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 7, p. 1045-1047, 1961.

Because an electrical "double layer" lies between the core and mantle (see Geophys. Abs. 185-418) the equations of propagation are not at all the same as if the two mediums were found in direct contact. This results in the paradoxical behavior of seismic waves propagating across the core. The core is rigid and the K-waves are distortional. Condensation waves propagating in the core give rise to emergent waves that should not be imputed to diffraction of P-waves. — Author's abstract, D. B. V.

- 185-139. Yoshiyama, Ryoichi. Maximum amplitude and epicentral distance. — Proposed a theoretical elucidation of empirical formulas and some development: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 389-404, 1959.

Empirical formulas for maximum amplitude of an earthquake as a function of epicentral distance are of three types:  $\log A = a - m \log \Delta$ ,  $\log A = a - m \log \Delta - k$ , and  $\log A = a - m \log \Delta - f(T) \Delta$ , where  $A$  = observation of maximum amplitude,  $\Delta$  = epicentral distance,  $T$  = period, and  $a$ ,  $m$ , and  $k$  are constants. Differences among these formulas are shown by purely mathematical analysis and by their application to observations of 7 destructive Japanese earthquakes.

One of the most important problems is to determine which of the formulas is most appropriate for a given earthquake. Toward this end, the formulas are deduced from a presumed fundamental law of wave attenuation. Three assumptions involved in this treatment are discussed. Then the spectrum of the earthquake wave at its origin  $[B(t)]$  and the period ( $T$ ) of the maximum amplitude in two earthquakes are calculated from the observed  $A \sim \Delta$  relation, assuming the same fundamental law of attenuation; differences in the resulting expressions for  $B(t)$  correspond to differences in magnitude. — D. B. V.

- 185-140. Katsumata, M. The effect of seismic zones upon the transmission of seismic waves [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 3, p. 89-95, 1960.

A correlation is shown to exist between the seismicity of an area and the velocity and attenuation of the seismic waves. In an analysis of data from deep earthquakes which have occurred in central Honshu it is found that seismic waves traveling through the area of active seismicity to the northeast have greater velocities and attenuate more slowly than waves traveling through the area of low seismicity to the southwest. — V. S. N.

- 185-141. Caloi, Pietro. Sui tempi di tragitto delle onde sismiche nell'inter-no della Terra, con particolare riguardo al mantello terrestre [On the traveltimes of seismic waves in the interior of the earth, with particular reference to the earth's mantle]: *Accad. Naz. Lincei Atti, Cl. Sci. Fis., Mat. e Nat. Rend.*, v. 26, no. 2, p. 130-136, 1959.

Formulas, based on Gutenberg's velocity values, are derived for the determination of traveltimes of seismic waves that traverse the mantle over epicentral distances corresponding to given angles of incidence. The dependence of  $\rho$  on  $\phi^2$  found in a previous paper (see *Geophys. Abs.* 144-12557) is expressed in a more rigorous form, permitting greater precision in the calculations.

Application of these formulas to the Aegean earthquakes of April 24 and 25, 1957, gives a traveltime of 944 sec to the Tolmezzo seismic station; this is 9 sec more than the observed traveltime and suggests that the focal depth was deeper than normal, or about 70 km. — D. B. V.

MacDonald, Gordon J. F., and Ness, Norman F. A study of the free oscillations of the earth. See *Geophys. Abs.* 185-343.

- 185-142. Shurbet, D. H. Determination of sedimentary thickness in the Mexican geosyncline by Rayleigh wave dispersion: *Jour. Geophys. Research*, v. 66, no. 3, p. 899-902, 1961.

Dispersion of short-period Rayleigh waves is studied in an effort to measure sedimentary rock thickness in the Mexican geosyncline. The measurement is approximate, but the study indicates uniformity of crustal structure over a very large area, including the Mexican geosyncline. Therefore the study suggests an economical method of measuring crustal thicknesses over the entire area. The study indicates that the average sedimentary thickness across the Mexican geosyncline is about 8 km. — Author's abstract

Choudhury, Mansur Ahmed. On the general structure of the earth's crust in western Europe. See *Geophys. Abs.* 185-352.

- 185-143. Bisztricsány, Ede, and Kiss, Zoltán. Kéreg átlagvastagságának számítása eurásiai útra a Love-hullám diszperziós görbéje alapján [Computation of the mean crustal thickness on a Eurasian path based on Love wave dispersion curves (with English summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 147-150, 1960.

Analysis of Love wave dispersion for two earthquakes in southern China (January 21, 1931 and December 15, 1934) as recorded at Budapest gives an average crustal thickness of only 33 km, in spite of the fact that one third of the path is through high mountain areas. — D. B. V.

- 185-144. Payo Subiza, Gonzalo. Estudio sobre las ondas superficiales Lg, Rg y Li en los registros del Observatorio de Toledo [Study of the surface waves Lg, Rg, and Li in the records of the Observatory of Toledo]: *Rev. Geofísica*, v. 19, no. 75, p. 227-256, 1960.

The location of the Toledo (Spain) observatory in southwestern Eurasia is particularly favorable for the study of short-period waves (Lg, Rg, and Li) that have traveled purely continental paths. Such waves have been analyzed in the records of 80 selected earthquakes that occurred during 1941-59. Lg is clearly divided into two types: Lg1 ( $v=3.61\pm0.09$  km/s) and Lg2 ( $v=3.36\pm0.09$  km/s); Lg1 may in turn consist of two other waves. Velocities and periods

are calculated and compared with those determined by others. There is little variation in velocity when Li crosses mountain chains, and as in the case of Lg and Rg, the phase disappears when the path crosses oceanic structure. Recent theories of the mechanism of transmission of surface waves are discussed. — D. B. V.

- 185-145. Teupser, Christian. Zur Abstimmung und Eichung von elektrodynamischen Verrückungsmessern [On the tuning and calibration of electrodynamic displacement-measuring instruments (with English summary)]: *Gerlands Beitr. Geophysik*, v. 69, no. 5, p. 269-289, 1960.

A moving-coil electrodynamic seismograph gives a true response to ground displacement over a wide period range if a long-period pendulum with the usual damping is connected to a short-period, supercritically damped galvanometer. The best adjustment is obtained when the pendulum damping is 0.5 and the galvanometer damping is half as great as the ratio of the natural periods of the pendulum and galvanometer. The response characteristics of ground displacement, ground tilts, phase displacement, and the  $(\phi_s, \phi_g)$  curves are given for different tunings of the apparatus. The tapping test is suitable for determining the damping of the pendulum and the reaction factor. The necessary calibration functions are given in tables and approximate formulas. — D. B. V.

- 185-146. Gudzin, M[artin] G., and Hamilton, J[ack] H. Wichita Mountains Seismological Observatory: *Geophysics*, v. 26, no. 3, p. 359-373, 1961.

The physical plant and equipment of the new seismological observatory in the foothills of the Wichita Mountains, about 15 miles northwest of Lawton, Okla., are described, with photographs and schematic diagrams. The equipment includes short-period vertical, short-period horizontal, long-period (three-component), board-band (three-component), and narrow-band (three-component) seismometers located in 10 earth-covered vaults. Phototube amplifiers are housed in an intermediate building, and control and recording equipment are in a central recording building.

Background noise is low at this site. The location is at a convenient distance from California and Mexico earthquakes and should provide a significant contribution to the science of detecting and identifying underground nuclear explosions and earthquakes. — D. B. V.

- 185-147. Tokarev, P. I. Kozyrevskaya seismicheskaya stantsiya [The Kozyrevsk seismic station]: *Acad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta.*, no. 29, p. 54-55, 1960.

A second station for the study of volcanic earthquakes and tremors in Kamchatka was completed at the settlement of Kozyrevsk in September 1958. The location and equipment (3 Kharin regional seismographs with GK-6 galvanometers and RS-P recorder) are described briefly, and the constants of the instruments are tabulated. — D. B. V.

## ELASTICITY

- 185-148. Phinney, Robert A. Leaking modes in the crustal waveguide. Part 1. The oceanic PL wave: *Jour. Geophys. Research*, v. 66, no. 5, p. 1445-1469, 1961.

The problem of the seismic signal associated with the earliest P-wave is treated by application of normal mode theory, in which the signal is regarded as a quasi-surface wave coupled both to the motion of the earth's layered surface and to body waves propagating in the underlying mediums. Predictions made for this model are relevant to explosion and earthquake sources. The oscillatory "tail" following the initial P motion is explained.

Rosenbaum's transient solution for leaking mode propagation in an acoustic waveguide (see *Geophys. Abs.* 181-152) is generalized to describe propagation in an elastic halfspace overlain by a liquid layer. The early-arriving PL modes known from earthquake studies are computed for several theoretical models to test the effect of the elastic constants on their dispersion and attenuation, many features of which cannot be predicted by physical reasoning based on harmonic plane wave models. The analogy between PL waves and normal modes in the case treated by Pekeris (see *Geophys. Abs.* 135-10569) is exploited; it is also believed that PL waves are related to an attenuated pseudosurface wave of a free solid halfspace. Late-arriving quasi-standing waves are treated briefly; they may play a role in the propagation of seismic noise in oceanic regions. — D. B. V.

- 185-149. Byatt, W. J., and DeVault, G. P. An iteration-variation method for wave propagation problems: *Jour. Geophys. Research*, v. 66, no. 6, p. 1793-1797, 1961.

In a medium in which the index of refraction varies in one space coordinate only, transform methods are convenient for reducing an inhomogeneous scalar wave equation to an ordinary differential equation in which the square of the space-dependent index of refraction appears explicitly. An iteration-variation method for obtaining approximate expressions for the dispersion relations within the medium is discussed. The ordinary differential equation is converted to an integral equation, the solution of which is begun by iteration. The individual terms in the series thereby formed, which we shall call iterates, then form the basis of a trial function for use in a variational principle. The method is illustrated by an example. — Authors' abstract

- 185-150. Scholte, J. G. J. Propagation of waves in inhomogeneous media: *Geophys. Prosp.*, v. 9, no. 1, p. 87-115, 1961.

A method is developed for determining the propagation of a wave of arbitrary shape in an inhomogeneous medium in which both the density and the velocity change with depth according to an arbitrary continuous function. The solution is obtained by means of successive approximations. The successive terms in this approximation correspond to the direct wave, single reflections, and multiple reflections of successive order. The general formulas are then applied to three particular types of transition layer. — Author's abstract

- 185-151. Hervás Burgos, Pablo. Leyes de propagación de las ondas sísmicas en medios de anomalía elástica [Laws of propagation of seismic waves in elastically anomalous mediums]: *Rev. Geofísica*, v. 19, no. 74, p. 121-169, 1960.

This is a general theoretical study of the propagation of waves in imperfectly elastic mediums. In the first part, the dynamic equations of motion are derived for viscous fluids, firmo-elastic bodies, bodies in the zone of retarded elastic action, plastic bodies, and surface rocks. In the second part, the absorption coefficients and phase velocities for longitudinal and transverse waves in each of these mediums are calculated. The third part analyses seismograms

or spectrums of selected earthquakes in the light of these calculations. It is concluded that the visco-elastic theory explains the phenomena of absorption, dispersion, and hysteresis of terrestrial materials along wave paths. — D.B.V.

- 185-152. Coloma Pérez, Antonio. Sobre el tensor elástico [On the elastic tensor (with English summary)]: *Rev. Geofísica*, v. 19, no. 75, p. 223-226, 1960.

The possibility of deducing the tension tensor is established, given the existence of the elastic tensor, its linear relation with the tensor of pure deformation, as well as the existence of P- and S-waves. Not knowing, a priori, the nature of the elastic tensor, its symmetry is proved. Finally, its expression is worked out and found to coincide with that already known. — Author's summary, D. B. V.

- 185-153. Emura, Kinya. Propagation of the disturbances in the medium consisting of semi-infinite liquid and solid: *Tohoku Univ. Sci. Repts.* ser. 5, v. 12, no. 2, p. 63-100, 1960.

Exact solutions for the two-dimensional propagation of transient disturbances in a medium consisting of a semi-infinite liquid and solid are obtained by means of the Laplace transform techniques developed by Garvin. Approximate solutions for the steady state problem based on the method of saddle points or steepest descent are also given. Disturbances at the surface of the semi-infinite liquid are comparable with those in Lamb's problem, produced by a force acting vertically downward at a line in the surface of the solid in the absence of the liquid. The aspect of the diminution of the refracted wave  $P_1P_2P_1$  with distance is different in the exact transient solution from that in the steady state solution.

The modified Rayleigh wave accompanies the disturbance in the liquid as it travels along the surface of the solid with the Rayleigh wave velocity in the absence of liquid, but unlike the Rayleigh wave in Lamb's problem its amplitude decreases with distance along the interface. The accompanying disturbance in the liquid behaves as a refracted wave whose critical angle of incidence is determined by the velocities of sound in the liquid and of the Rayleigh wave in the solid. The sign of particle motion of the reflected wave is reversed for angles of incidence in the ranges  $31.6^\circ$ - $34.7^\circ$  and  $84.6^\circ$ - $90.0^\circ$ . — D. B. V.

- 185-154. Takeuchi, Hitoshi, and Saito, Masanori. On the torsional oscillation of the earth (Pt. 2) [in Japanese with English abstract]: *Zisin*, ser. 2, v. 13, no. 3, p. 141-149, 1960.

The free periods of torsional oscillations are calculated for two earth models using the variational calculus method. The periods are calculated for a fluid core and for a rigid core assuming (1) a homogeneous mantle and core, and (2) a mantle structure inferred by Jeffreys and Bullen. In the fluid core, the periods are determined also when the coupling between mantle and core is perfect or zero. The observations of free periods must be made with an accuracy of several tens of seconds in order for the information obtained to be of use. (See also *Geophys. Abs.* 178-93.) — V. S. N.

- 185-155. Jobert, N[elly]. Calcul de la dispersion des ondes de Love de grande période à la surface de la Terre [Calculation of the dispersion of long-period Love waves at the surface of the earth (with French, English, and Russian summaries)]: *Annales Géophysique*, v. 16, no. 3, p. 393-413, 1960.

This constitutes the full report on a study of long-period Love wave dispersion previously treated in three short papers published in the Acad. Sci. [Paris] Comptes Rendus, v. 249, no. 11, p. 1014-1016, 1959; v. 250, no. 5, p. 890-892, 1960; and v. 250, no. 22, p. 3693-3695, 1960 (see Geophys. Abs. 179-126, 182-130, 183-157). — D. B. V.

- 185-156. Tazime, Kyozi. Transition from dispersive Rayleigh waves to sound waves in a layer over a half space absolutely rigid: Jour. Physics of Earth [Tokyo], v. 7, no. 1, 1959; reprinted from Hokkaido Univ. Fac. Sci. Jour., ser. 7, v. 1, no. 3, p. 163-179, 1959.

In his investigation of dispersive Rayleigh waves in a layer over a rigid half space, Giese (see Geophys. Abs. 172-68) ignored  $M_2$  waves, assuming that their amplitude was much smaller than that of  $M_1$  waves, nor did he refer to any higher order of M-waves. This paper shows that Giese's assumption concerning the amplitude of  $M_2$  waves is not valid and calculates dispersion curves for various values of Poisson's ratio ( $\sigma$ ). The results show that the process of transition from solid to liquid is very complicated. When  $\sigma$  approaches 0.50, the zeroth order of liquid waves consists approximately of many higher orders of  $M_n^{(2)}$ -waves, and the first order of liquid waves consists approximately of many higher orders of  $M_n^{(1)}$ -waves. — D. B. V.

- 185-157. Suzuki, Ziro, and Sato, Yasuo. Condition for the existence of Love waves in heterogeneous media: Tohoku Univ. Sci. Repts., ser. 5, v. 12, no. 1, p. 36-43, 1960.

In the mathematical deduction of Love waves in heterogeneous mediums, the assumption that density and rigidity tend toward zero or increase indefinitely as depth  $z \rightarrow \infty$  leads to the conclusion that there exists a kind of Love wave in which there is no definite relation between velocity and frequency. The existence of these "extraordinary waves" is examined, based on the boundary condition stress=0 at infinite depth; the result is compared with that obtained under the condition displacement=0.

"Extraordinary waves" are introduced when stress=0 but displacement is infinite at  $z=\infty$ , or conversely, when displacement=0 and stress $\neq$ 0. The condition for eliminating this kind of waves, therefore, is that both stress and displacement must disappear at infinite depth. — D. B. V.

- 185-158. Peselnick, Louis, and Meister, Robert. Acoustic relaxation in chromium: Jour. Geophys. Research, v. 66, no. 6, p. 1957-1961, 1961.

The temperature and frequency dependence of the ultrasonic velocities in polycrystalline chromium from  $-65^\circ\text{C}$  to  $+60^\circ\text{C}$  and from 5 to 35 megacycles per sec were measured. The attenuation associated with the dilatational wave was measured at 15 megacycles per sec from  $-25^\circ\text{C}$  to  $+25^\circ\text{C}$ . Anomalies in the attenuation and velocity for the dilatational waves were found at  $-19^\circ\text{C}$ . The compressibility and Poisson's ratio were calculated and from these values the anomalous specific heat was determined. A dispersion in the dilatational velocity was found at  $-19^\circ\text{C}$ , and the limiting high frequency velocity and relaxation time were estimated on the basis of a single relaxation process. From these calculations the magnitude of the attenuation was predicted; this agreed within a factor of 2 with the measured attenuation. These results are pertinent to the study of phase transitions within the earth. — D. B. V.

- 185-159. Hayakawa, M[asami], and Balakrishna, S. An explanation for the high ultrasonic velocity in Indian rocks: *Geophys. Prosp.*, v. 9, no. 1, p. 74-85, 1961.

In an attempt to explain the high ultrasonic velocities of Indian granites compared to those from other countries, the initial internal pressure and initial velocity at the time of formation of granites have been calculated, using published experimental results on variation of velocity with pressure in Indian, American, Japanese, and Russian rocks. The effect of time of formation at specific depths is also calculated.

Results show that under high pressure (great depth) the process of formation requires more time than at low pressure (shallow depth), and that under high pressure much stress energy can be stored; in other words, initial velocity is higher in rocks formed at great depth than in those formed at shallow depth. The elastic behavior of rocks with pressure thus may provide a clue to their petrogenic history and approximate age. — D. B. V.

- 185-160. Balakrishna, S. Ultrasonic velocities in relation to the degree of metamorphism in limestones: *Indian Acad. Sci. Proc.*, sec. A, v. 50, no. 6, p. 363-365, 1959.

Longitudinal and torsional ultrasonic velocities were measured on a number of Indian limestones using the total internal reflection method. It is concluded from the results, which are tabulated, that in general the ultrasonic velocity increases as the degree of metamorphism increases. Certain fine-grained unmetamorphosed limestones, however, behave like marbles. — D. B. V.

- 185-161. Central Water and Power Research Station Poona. Young's modulus of elasticity for rocks, Head Race tunnel and power house site, Koyna HE project: India Ministry of Irrigation and Power, Central Water and Power Research Sta. Poona, *Ann. Research Mem.*, p. 216-218, 1959.

Estimates of Young's modulus of elasticity for the rocks constituting the weak zones of tuff breccia in the Head Race and other tunnels of the Koyna hydroelectric project were made in place in order to assess the stress concentrations likely to be encountered in these weak zones under operating conditions. Indirect estimates were made from the compressional wave velocity as measured in place by both the seismic and ultrasonic methods.

Young's moduli for this tuff breccia with zeolites obtained by the seismic method lie between  $0.34$  and  $2.34 \times 10^{11}$  d per  $\text{cm}^2$ , and those obtained by the ultrasonic method between  $0.62$  and  $3.59 \times 10^{11}$  d per  $\text{cm}^2$ . In any particular locality the values obtained by the two methods agree fairly well. The average value of Young's modulus for the tuff breccia with zeolites is  $1.80 \times 10^{11}$  d per  $\text{cm}^2$ ; this is about one-fourth the value characteristic of an average massive basalt. Values obtained for all stations are shown in a table. — V. S. N.

- 185-162. Shimozuru, D. Elasticity of rocks and some related geophysical problems: *Japanese Jour. Geophysics*, v. 2, no. 3, 85 p., 1960.

Previous results are reviewed and new results are reported on laboratory measurements of the elasticity of rocks. Wave velocities of rocks are determined and analyzed for the effects of porosity, anisotropy, and temperature.

Results of several hundred laboratory measurements by Shimozuru and others of resonant frequency and of ultrasonic wave velocity are computed and plotted as dilatational ( $V_p$ ) and shear ( $V_s$ ) wave velocities versus density. An

empirical expression relating  $V_p$  to porosity is evolved from the increase in  $V_p$  with density increase observed in measurements on 50 sandstone samples. The effect of anisotropy is found to range from 0 to 5 percent; however,  $V_p$  measurements perpendicular and parallel to the bedding of a sandstone differ by 70 percent. Measurements of  $V_p$  on samples of granite and dunite at temperatures to 870°C showed a decrease in  $V_p$ , but despite a large change between 550°C to 600°C, it is concluded that the data do not support Yoder's hypothesis that a low  $V_p$  in the lower crust of the earth is due to the  $\alpha$ - $\beta$  quartz inversion.

A series of high temperature measurements made on hyalopilitic dacite from Usu Volcano showed an anomalous increase in  $V_p$  with temperature increase. — E. C. R., V. S. N.

Matthews, D. H. Lavas from an abyssal hill on the floor of the North Atlantic Ocean. See Geophys. Abs. 185-587.

185-163. Willis, D[avid] E. Some observations on the attenuation of seismic waves: Earthquake Notes, v. 31, no. 4, p. 37-45, 1960.

Spectral analyses using variable pass-band filters were made on records of a number of quarry blasts recorded on magnetic tape by low frequency seismometers. Empirical equations are derived for P- and surface-waves that describe fairly well the decrease in maximum signal level and the change in vertical ground particle velocity versus frequency as a function of distance. Parameters such as method of firing, depth of burial, or type of rock in which the explosive is detonated are shown to have a significant influence on the spectrums of waves generated by explosive blasts. — V. S. N.

Grachev, Yu. N., Dekhnich, M. Ya., Litvinenko, I. V., Nekrasova, K. A., and Sosnovskaya, A. V. Deep geophysical investigations in the territory of the Baltic shield. See Geophys. Abs. 185-354.

185-164. Lombard, David B. The Hugoniot equation of state of rocks: Univ. California, Lawrence Radiation Lab. Pub., UCRL-6311, 28 p., 1961.

In determining peaceful applications for nuclear explosions detonated underground, it must be possible to predict the effects of the shocks on the surrounding medium. Predictions are based partly on the Hugoniot equation of state. The equations of state of rock salt, granite, tuff, marble, dolomite, limestone, basalt, and other rocks were studied experimentally; measurements were made at pressures ranging from 70 to 900 kb. A comparison of data from limestone and basalt is of particular interest because, despite dissimilar compositions, their equations of state agree well at pressures above 230 kb. An instrument was developed that employs pin-contactors to measure shock velocity and free-surface velocity at locations in a rock medium not far from the explosion. The instrument has performed satisfactorily in tests employing actual nuclear explosions, and it is hoped that stresses from below 100 kb to over 1 mb can be measured. — V. S. N.

#### ELECTRICAL EXPLORATION

185-165. Roman, Irwin. Apparent resistivity of a single uniform overburden: U.S. Geol. Survey Prof. Paper 365, 99 p., 1960.

The interpretation of resistivity observations can be facilitated by the development of theoretical formulas and corresponding curves. A development



for a single overburden of uniform thickness has been made and formulas derived that involve infinite series. The series have been evaluated for the geophysical case in which the measuring configuration is located on the surface of the earth. A set of curves that can be superimposed on the field observations has been prepared to permit direct determination of the resistivity and thickness of the overburden, and the resistivity of the underlying medium. Auxiliary tables are given to simplify the numerical evaluations for configurations not covered by the prepared curves. — Author's abstract

- 185-166. Cook, Kenneth L., and Gray, Russell L. Theoretical horizontal resistivity profiles over hemispherical sinks: *Geophysics*, v. 26, no. 3, p. 342-354, 1961.

An album of 40 sets (about 200 different curves) of theoretical horizontal resistivity profiles over and near outcropping hemispherical sinks (a few samples of which are reproduced here) shows the effects of sink diameter, reflection factor  $k$ , and distance of the traverse from the center of the sink on the magnitude and shape of the apparent resistivity curves. Values of apparent resistivity for both Lee and Wenner configurations were computed, using a digital computer. In general, the larger the sink, the larger the magnitude of the apparent resistivity anomaly up to a sink diameter of about  $8a$  ( $a$ =electrode separation), for which diameter the apparent resistivity over the central part of the sink is essentially equal to the resistivity of the sink irrespective of the reflection factor. For sink diameters equal to  $a$ , large apparent resistivity anomalies result from "pseudofocusing" effects. The major peaks for the apparent resistivity curves can be used to detect the edges of sinks. The album is also of general use in qualitative interpretation of resistivity anomalies over other features such as faults (for large sinks), dikes, and grabens. — D. B. V.

- 185-167. Wait, James R. Propagation of electromagnetic pulses in a homogeneous conducting earth: *Appl. Sci. Research*, sec. B, v. 8, no. 3, p. 213-252, 1960.

A general analysis for the electromagnetic response of conducting mediums due to pulse excitation is presented. The treatment is based on the Laplace transform theory. After a survey of previous work, pointing out its scope and limitations, the theory of propagation of a plane wave pulse in an infinite homogeneous conducting medium is reviewed. The relative importance of the conductivity and dielectric constant can be evaluated from the form of these results.

For sufficiently large times in the transient response, displacement currents may safely be neglected for sea water and most geological mediums. Under this assumption, the waveform of the electric field in a conducting medium is illustrated for the case where the source is an electric dipole energized by a step-function current; results are also presented for exponential and bell-shaped source functions. The pulse shape of the field components is profoundly modified as they propagate through the medium. It is suggested that this property may be utilized in measuring distances in the earth's crust.

The more difficult problem of propagation in noninfinite conducting mediums is also considered. An involved analytical expression for the transient fields is required to account for the presence of the interface in a conducting half space (homogeneous flat ground). Certain special cases, such as a horizontal electric dipole at the interface, are illustrated numerically. The transient excitation of a wire loop lying on the surface of a homogeneous ground is also considered. Finally, a transient coupling between pairs of parallel insulated wires grounded at their end points is treated as an extension of the earlier results. — D. B. V.

- 185-168. Frankena, H. J. Transient phenomena associated with Sommerfeld's horizontal dipole problem: *Appl. Sci. Research*, sec. B, v. 8, no. 4, p. 357-368, 1960.

A horizontal electric dipole, located above the plane interface of two non-conducting mediums, has a dipole moment which is an arbitrary but given function of time when  $t > 0$  and which is zero when  $t < 0$ . Traveling electromagnetic waves, generated by this dipole, are calculated with the aid of a modification of Cagniard's method. For the electric field vector above and at the interface we obtain expressions for the direct and reflected waves in the case that the velocity of light in the medium containing the source is the larger one. — Author's summary

- 185-169. de Hoop, A. T., and Frankena, H. J. Radiation of pulses generated by a vertical electric dipole above a plane, non-conducting, earth: *Appl. Sci. Research*, sec. B, v. 8, no. 4, p. 369-377, 1960.

A technique developed by de Hoop, based on his simplification of Cagniard's method (see *Geophys. Abs.* 184-219), is used here to determine the electromagnetic field radiated by a vertical electric dipole located at a height  $h$  above a plane nonconducting earth. Attention is confined to the field in the air; unless  $h=0$ , determination of the field in the earth is much more difficult. The result is given in the form of a definite integral over a finite interval; this integral can easily be computed numerically. — D. B. V.

- 185-170. Senior, T. B. A. Impedance boundary conditions for imperfectly conducting surfaces: *Appl. Sci. Research*, sec. B, v. 8, no. 5-6, p. 418-436, 1960.

It is shown how the exact electromagnetic boundary conditions at the surface of a material of large refractive index can be approximated to yield the usual impedance or Leontovich boundary conditions. These conditions relate the tangential components of the electric and magnetic fields (or normal components of their normal derivatives) via a surface impedance which is a function only of the electromagnetic properties of the material. They are valid for surfaces whose radii of curvature are large compared with the penetration depth, and also for materials which are not homogeneous but whose properties vary slowly from point to point. As the refractive index (or conductivity) increases to infinity, the conditions go over uniformly to the conditions for perfect conductivity. — Author's abstract

- 185-171. Senior, T. B. A. Impedance boundary conditions for statistically rough surfaces: *Appl. Sci. Research*, sec. B, v. 8, no. 5-6, p. 437-462, 1960.

It is shown that for an electromagnetic field incident on a perfectly conducting surface having small geometrical irregularities which are distributed at random but in a statistically uniform and isotropic manner, the boundary condition can be replaced by a generalized impedance condition applied at a neighboring mean surface. The boundary condition is applicable to curved surfaces providing the radii of curvature are large in comparison with the wavelength. This approach is of value in studying the effect of minor surface roughness on scattering of electromagnetic waves. — V. S. N.

- 185-172. Kertz, Walter. Leitungsfähiger Zylinder im transversalen magnetischen Wechselfeld [Conducting cylinder in the transverse alternating magnetic field (with English summary)]: *Gerlands Beitr. Geophysik*, v. 69, no. 1, p. 4-28, 1960.

The distribution and magnetic field of the electric currents induced when an infinite cylinder is acted on by a two-dimensional transverse magnetic field are analyzed and found to be functions of the frequency of the alternating magnetic field, the conductivity, and the radius of the cylinder. The study is pertinent to problems of geomagnetic variations and to interpretation of electrical exploration data obtained by alternating current procedures. — D. B. V.

- 185-173. Orellana Silva, Ernesto. Algunas cuestiones de prospección geoelectrica [Some questions of geoelectrical prospecting]: Rev. Geofísica, v. 19, no. 73, p. 13-28, 1960.

The choice of electrical methods suitable for a given area is much wider than in the case of gravimetric or magnetic prospecting and should be based on thorough knowledge and ample experience in interpretation. The penetration achieved by different techniques, particularly by various electrode configurations, and the significance of empirical methods of interpretation are discussed at some length. In comparison with interpretations based on the use of standard theoretical curves, those based on empirical methods often give erroneous results. Certain methods using fixed current electrodes can use the same set of standard curves as other methods using movable current electrodes; examples of this correspondence are given. In general, resistivity methods are found preferable for vertical investigations and potential methods for lateral investigations. — D. B. V.

- 185-174. Vedrintsev, G. A. K teorii elektricheskikh zondirovaniy v usloviyakh gorizonta'no-neodnorodnykh sred [Theory of electrical sounding under conditions of horizontal heterogeneous mediums]: Vyssh. Ucheb. Zavedeniy Izv., Geologiya i Razvedka, no. 5, p. 125-127, 1960.

In connection with investigations of the electric field of a direct current in a vertically layered medium underlain by an insulator or by an absolute conductor at a depth  $h$  by means of integration of a LePlace equation, an expression was obtained in a general form for potentials created by points and dipole sources at any point on the surface of a cross-section. As a product of the investigations, formulas were obtained by which theoretical curves were constructed for various types of probes. A total of 150 curves were calculated, of which 2 are illustrated. — J. W. C.

- 185-175. Nikitina, V. N. K difraktsii na poluploskosti v pogloshchayushchikh sredakh [On diffraction at a half-plane in absorbing mediums]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1442-1449, 1960.

The problem of diffraction of electromagnetic waves at the edge of a half-plane in a homogeneous conducting medium is discussed. The branched function of a plane wave for a complex wave number is investigated on the basis of the Sommerfeld's theory of branched functions, and the diffracted electromagnetic field is constructed. The relative intensity of the diffracted electric field is studied in terms of the absorption properties of the medium. The investigation is intended for application to diffraction of an alternating electromagnetic field at the edge of an ore body. — A. J. S.

- 185-176. Kozulin, Yu. N. Elektromagnitnoye pole izluchatelya pri bol'shikh parametrah [The electromagnetic field of an emitter for large parameters]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1504-1506, 1960.

This is a study of the behavior of the electromagnetic field of an emitter located on the surface of a horizontally layered structure having a large modulus value  $p$ , which is the product of the complex wave number for the upper layer of the medium times the spread of the arrangement in electromagnetic sounding by the frequency method. The components of the dimensionless electromagnetic field of a vertical magnetic dipole, located on the surface of a many-layered medium, are represented by a series of integrals which for large values of  $p$  are approximated by finite sums in terms of functions. The application of the formulas derived to interpretations of field data obtained by the frequency method of electromagnetic sounding of two- and three-layered mediums shows a satisfactory agreement with the theory. — A. J. S.

- 185-177. Shaub, Yu. B. O napravlennom priyeme vtorichnykh signalov v e-lektrorazvedke metodom vrashchayushchegosya magnitnogo polya [On the directed reception of secondary signals in electrical exploration by the rotating magnetic field method]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1608-1611, 1960.

Directed reception of secondary signals of a rotating magnetic field is analyzed, and diagrams for directional determination of various parameters are plotted. Formulas are derived for the active and reactive components of the disbalancing signal (four-leaf rose graphs  $45^\circ$  different in phase), for the modulus of the signal (graph is a circle), and for the phase of the signal (graph is a cardioid). The derivation of direction diagrams allows directed reception in surface and borehole electrical exploration. — A. J. S.

- 185-178. Hayashi, Yoshio. Perturbation theory of the electromagnetic fields in anisotropic inhomogeneous media: Japan Acad. Proc., v. 36; no. 9, p. 547-549, 1960.

A mathematical analysis is presented of the electromagnetic fields in anisotropic inhomogeneous mediums. A simple, rigorous, and general development of the perturbation theory of the fields is made with the assumption that the deviations of the anisotropy and inhomogeneity are not large. — V. S. N.

- 185-179. Hayashi, Yoshio. General analyses of the forced oscillations in a wave-guide and in a cavity: Japan Acad. Proc., v. 36, no. 9, p. 550-554, 1960.

Mathematical analyses are made of the equations  $\nabla \times E = -i\omega \mu H - k_H$ , and  $\nabla \times H = (\sigma + i\omega \epsilon)E + k_E$  that satisfy the electromagnetic fields  $E$  and  $H$  in a homogeneous and isotropic medium with medium constants  $\epsilon$ ,  $\mu$  and  $\sigma$ , and also satisfy the fields in an anisotropic medium, discussed from the view point of perturbation theory, in which  $k_E$  and  $k_H$  are the perturbed terms. Analyses of fields in a waveguide the axis of which is parallel to the  $z$  axis, in a cavity which is a finite domain enclosed by a waveguide and two planes of conductors perpendicular to the axis of the waveguide, in a circular waveguide, and in several other mediums are given. — V. S. N.

- 185-180. Lyu, Sin-Khan. Depth of prospecting of an ellipsoid of rotation with the method of isolines [in Chinese with Russian summary]: Acta Geophys. Sinica, v. 7, no. 2, p. 108-115, 1958.

A study was made of anomalies in potential of a uniform polarizing ellipsoid of rotation in a field of uniform current. A rule is found for the change in these anomalies with changes in depth of the ellipsoid; this rule is analyzed, and it is demonstrated to what depth the method of isolines is effective. — J. W. C.

- 185-181. Burr, S. V. The self-potential method for the prospector: Canadian Mining Metall. Bull., v. 53, no. 583, p. 866-872, 1960; also in Canadian Inst. Mining Metallurgy Trans., v. 63, p. 590-596, 1960.

The self-potential method is advocated here as the most rapid and economical geophysical method for ground reconnaissance over areas suspected of having good conductors, or to detail known conductors. The history, recommended equipment and prospecting procedure, and limitations and advantages of the method are discussed. The method can save heavy drilling costs by detecting the presence of graphite and indicating whether the conductor may be exposed easily for examination. Several prospected areas in northern Quebec are cited as examples of application of the method. — V. S. N.

- 185-182. Porstendorfer, G[ottfried]. Versuche zur Ausnützung vagabundierender Ströme in der geophysikalischen Prospektion [Experiments with the use of stray currents in geophysical prospecting (with English abstract)]: Geophys. Prosp., v. 9, no. 1, p. 128-143, 1961.

Experimental recording of the three components of the diurnal intensity of stray industrial currents in a mine shaft outside the area of mining activity at Freiberg showed the uninterrupted presence of such currents with periods ranging from a few minutes to a few hours. It is demonstrated theoretically and by model experiments that these currents can be used for prospecting purposes when the ratio between the distance from their source and the size of the surveyed area exceeds a critical value that depends on the accuracy of the measurements. Classic telluric measuring techniques must be replaced by a vectorial recording method in order to make the procedure economically feasible.

A field example from a vein deposit shows that stray currents of random direction and also earth currents are channeled by veins of anomalous conductivity. Other examples are given of underground measurement of stray currents. — D. B. V.

- 185-183. Paczyński, Bronisław. Stosowanie metody potencjałów własnych dla określenia parametrów hydrogeologicznych przy próbnym pompowaniu [Use of the self-potential method for determination of hydrogeologic parameters in test pumping (with English summary)]: Przegląd Geol. v. 9, no. 4, p. 210-214, 1961.

Use of the self-potential method in geological investigations of ground water is generally limited to determination of the direction of flow in undisturbed circulation systems. On the basis of theoretical considerations and field experiments there is the possibility of using this method to study artificially produced forms of ground water level such as depression cones and distribution of liquid during water-flooding of wells. Several examples are given of the use of the self-potential method under conditions of a disturbed ground water regimen. — J. W. C.

- 185-184. Tretyak, O. N. Zastosuvannya metodu kombinovanoho elektroprofilyuvannya pry rozshukakh zon tektonichnykh porushen' [Application of the method of combined electrical profiling in investigations of zones of tectonic disturbances]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 20, no. 3, p. 72-76, 1960.

Combined electrical profiling under various geologic conditions in the Transcarpathian region in 1952-57 is described. The combined 3-electrode

set-up, one of the most sensitive profiling methods, is particularly valuable in the folded areas of mountainous regions where local bodies have a very small horizontal extent (0.5-5 m). The character of the resistivity anomalies obtained by this method over zones of tectonic disturbance (such as mineralized fractures in crystalline rocks, igneous intrusions in sections of sedimentary and pyroclastic rocks, and easily deformed argillaceous sediments) was found to be very intimately related to their origin, form, and attitude. With an electrode configuration of the type AA'MNC  $\rightarrow \infty$ , BB'NMC  $\rightarrow \infty$ , not only the existence but also the direction of dip of a disturbing body could be established. — D. B. V.

- 185-185. Kunori, Shoichi, and Yokoyama, Hidekichi. Experimental studies for electromagnetic prospecting (pt. 2) [in Japanese with English abstract]: Tohoku Kozan, v. 7, no. 1, p. 9-14, 1960.

Some model experimental results of "in-phase" and "out-of-phase" variations of the secondary magnetic field induced by the two-coil method are described. These results are applicable to the interpretation of data from field surveys using the electromagnetic method. (See also Geophys. Abs. 183-230.) — V. S. N.

- 185-186. Bergmann, H. J. Horizontal loop equipment in ground survey: Canadian Mining Jour., v. 81, no. 12, p. 57-61, 1960.

A brief description of the Ronka horizontal loop electromagnetic equipment and its field operation is given. By measuring the two components of the secondary field with this instrument it is possible to obtain a measure of the relative conductivity and in many cases to discriminate between conductors of different characteristics. It is also possible to distinguish between the responses from topographical effects and those from a conductive body. Information may be obtained on dip, width, and depth of the conductors. The equipment is particularly well adapted for ground surveys following an airborne survey because of its mobility and readily interpretable results; data may be interpreted in the field. — V. S. N.

- 185-187. Bobrovnikov, L. Z. K teorii usiliteley postoyannogo toka s elektromekhanicheskim preobrazovatelem [To the theory of d-c amplifiers with an electromechanical converter]: Prikladnaya Geofizika, no. 26, p. 78-89, 1960.

A broad-band d-c amplifier based on the principle of accumulation of signal strength in the incoming circuit is discussed and analyzed mathematically. The analysis used in the magnetic stabilization method is valid for signals with frequencies much lower than the conversion frequency. At high frequencies the signal becomes quantized, leading to lower amplification; in this case the transmission coefficient of the incoming circuit must be modified to discount the quantization. — A. J. S.

- 185-188. King, A[nthony] J. Geophysical investigations at Manyeghi hot springs: Tanganyika Geol. Survey Recs., v. 8 (1958), p. 99-104, 1960.

A brief account is given of preliminary electromagnetic potential-drop-ratio, and resistivity surveys carried out at Manyeghi, Singida district, Tanganyika. The geophysical methods proved inadequate in locating structures that control the helium-bearing springs because of the abnormally low surface resistivities which prevent effective penetration of either direct or alternating current. It is concluded that reliance must be placed on exploratory drilling. — V. S. N.

- 185-189. Lerici, Carlo Maurilio. Esplorazione geofisica nella zona archeologica di Sibari [Geophysical exploration in the Sybaris archaeological area (with English, French, and German summaries)]: *Ricerca Sci.*, v. 30, no. 8, p. 1107-1145, 1960.

Resistivity sounding and profiling were used in conjunction with aerial photographs and drilling in the plain of Crati in Italy in the search for archeological sites, particularly of the city of Sybaris. The methods and techniques used are described. Two zones of interest were found. The horizontal electrical measurements proved to be most useful. — D. B. V.

- 185-190. Pomper, Johannes, and Fröhlich, Lothar. Einsatz der Geoelektrik zur Erkundung glazialdynamisch gestörter Tone [Extension of electrical surveying to the investigation of glaciodynamically deformed clays (with English and Russian summaries)]: *Zeitschr. Angew. Geologie*, v. 6, no. 8, p. 387-390, 1960.

Owing to extensive deformation of the clay deposits in the Bad Schmiedeberg area of East Germany by glacier action, a borehole spacing of 50 m was required for demonstrating B reserves for the stoneware industry. When the electrical resistivity method (Wenner configuration) was used in conjunction with drilling in some of the larger survey areas, a 100-m borehole spacing was found to be adequate. The cost of exploration by drilling alone was three times greater per unit area than that of a combined electrical and drilling program. — D. B. V.

- 185-191. Braekken, H. Deep ore exploration by electrical methods. Some experiments and developments (with discussion): *Geophys. Prosp.*, v. 9, no. 1, p. 144-162, 1961.

Under favorable conditions, such as exist in parts of Norway, electrical and electromagnetic surveys may penetrate to great depths. An ore body extending downward from 700 m, separated from but representing the continuation of a body that ended at 500 m, was located by surface measurements using a frequency of 500 cycles per second and was traced over a considerable distance by further electromagnetic measurements at the surface in which the energizing current was fed directly to the ore in drill holes. Possibilities, problems, and further improvements in deep electromagnetic techniques and interpretation are discussed. The electromagnetic results were confirmed by d-c equipotential mapping at the surface, with the current fed directly to the ore. Problems and developments in such deep charged potential prospecting techniques and interpretations are also discussed. — D. B. V.

- 185-192. Sarma, V. V. Jagannadha. Electrical resistivity investigations along Jaggannapeta-Bodasakurru Road—East Godavary Dt: *India Natl. Inst. Sci. Proc.*, v. 26, pt. A, no. 6, p. 587-591, 1960.

A geological cross section along the Jaggannapeta-Bodasakurru road based on results of an electrical resistivity survey of the area is presented. The cross section confirms the observation that the course of the Godavary River at Bodasakurru has shifted from a previous course near Nagaram. The electrical resistivity results also indicate the presence of a layer highly saturated with saline water. — V. S. N.

Central Water and Power Research Station Poona. Geophysical investigations at Mohana dam site. See *Geophys. Abs.* 185-559.

- 185-193. Akimov, A. T. Rezul'taty merzlotno-geofizicheskikh issledovaniy v vostochnoy chasti Bol'shezemel'skoy tundry [Results of permafrost-geophysical investigations in the eastern part of the Bol'shaya Zemlya tundra]: Akad. Nauk SSSR, Inst. Merzlotovedeniya Trudy, v. 15, p. 5-46, 1959.

Electrical and geochemical studies made both in the laboratory and in the field in the vicinity of Vorkuta in the northwestern Siberian tundra are reported. The permafrost ranges from 0 to 200 m in thickness, and the temperature is not below  $-2^{\circ}\text{C}$ ; thawed areas are dispersed among the frozen areas. Isore-sistivity maps are presented. — A. J. S.

- 185-194. Dostovalov, B. N. Merzlotnaya s'emka metodom soprotivleniy v usloviyakh Severo-Zapadnoy Sibiri [Cryological survey by the resistivity method under the conditions of northwestern Siberia]: Akad. Nauk SSSR, Inst. Merzlotovedeniya Trudy, v. 15, p. 47-80, 1959.

An electrical survey was made of the permafrost in the Poluy River region of Siberia in 1948. The geology and physical geography are discussed on the basis of the results of this survey. The margins of the permafrost were clearly outlined by the survey, and thickness determinations were possible in some places. — A. J. S.

- 185-195. Dostovalov, B. N. Issledovaniye merzlykh porod metodom soprotivleniy v nizov'yakh r. Indigirki [Permafrost investigation by the resistivity method in the lower reaches of the Indigirka River]: Akad. Nauk SSSR, Inst. Merzlotovedeniya Trudy, v. 15, p. 81-112, 1959.

Resistivity investigations of the permafrost in the region of the lower reaches of the Indigirka River are reported; the procedures are described in detail. A geocryological analysis of the region is also given. — A. J. S.

- 185-196. Yakupov, V. S. Opredeleniye moshchnosti sovremennykh rykhlykh otlozheniy metodom vertikal'nogo elektricheskogo zondirovaniya v rayonakh s nizkoy temperaturoy mnogoletnemerzlykh porod [Determination of thickness of contemporary friable deposits by the method of vertical electric sounding in regions of low temperature permafrost]: Akad. Nauk SSSR, Inst. Merzlotovedeniya Trudy, v. 15, p. 144-183, 1959.

Geologic profiles were constructed for permafrost, taking advantage of the fact that frozen friable material has a much higher electrical resistivity than does an underlying sandstone or shale. A method is developed for determining thickness of permafrost in regions of minus  $2^{\circ}\text{C}$ - $3^{\circ}\text{C}$ . — A. J. S.

- 185-197. Polishchuk, N. K., Filosofov, G. N., and Balobayev, V. T. Usloviya zaleganiya merzlykh porod v Chul'manskom rayone po dannym elektrometricheskikh izmereniy [Deposition conditions of frozen rocks in the Chul'man region according to electrometric measurements]: Akad. Nauk SSSR, Inst. Merzlotovedeniye Trudy, v. 15, p. 184-193, 1959.

The outline of the permafrost area in the Chul'man coal district of the Aldan mining region was determined by vertical electrical sounding. Thickness determinations were not possible due to unknown variations in the water content of the rocks. — A. J. S.



- 185-198. Gaskell, T[homas] F., and Threadgold, P. Borehole surveying, in *Methods and techniques in geophysics*, v. 1: New York, Interscience Publishers, Inc., p. 62-103, 1960.

An historical summary of electrical well logging is given, and a discussion of the rock formation characteristics—electrical resistivity, natural and induced radioactivity, and acoustic wave velocity—and of the effects of the presence of the borehole is presented as an introduction to the principles and applications of various logging devices. The microlog, microlaterolog, neutron-gamma log, focused-current devices, and radioactive measurements are described, and their use in estimating porosity and relative fluid contents of the reservoir rocks as well as in assessing the flow characteristics of the reservoir rocks is discussed. Additional borehole measurements at present not used directly in hydrocarbon estimation—continuous velocity logging, measurement of strata dip, temperature logs, and pressure measurements—are described briefly. In conclusion a discussion of possible future developments is presented. Technical problems of drilling to the M-discontinuity are considered in a brief appendix. — V. S. N.

- 185-199. Threadgold, P. Advances in well logging: *Inst. Petroleum Rev.*, v. 14, no. 168, p. 389-391, 1960.

Well logging, although introduced in the 1920's, was not accepted as a routine field tool until Archie (1942) worked out the basic equations relating resistivity of porous strata to relative fluid saturations of the strata. The next fundamental development was that of Doll and Wyllie (1943) on the elucidation of the spontaneous potential curve. Since that time numerous advances in instrumental techniques have been made, but none represents a fundamentally new development. The various logging methods are reviewed, and possibilities for future developments are discussed. It is suggested that computer techniques will be applied to well logging and make it possible to replace the log with direct interpretations from computers at the wellhead. — V. S. N.

- 185-200. Duersterhoeft, W. C., Jr. Propagation effects in induction logging: *Geophysics*, v. 26, no. 2, p. 192-204, 1961.

Induction logging utilizes the component of induced receiver coil voltage that is in phase with transmitter coil current as a measure of the conductivity of material surrounding the coils. This paper considers the problem of the field of a vertical magnetic dipole in a horizontally stratified, isotropic conductive formation and shows the receiver coil voltage can be considered as composed of responses due to electromagnetic waves in the formation. These waves which experience attenuation and phase shift as they propagate in the formation are reflected at each interface encountered, and a component of receiver coil voltage is induced for each passage of a wave. The relation of the receiver coil voltage components to the geometric factor of previous analysis is discussed. Universal curves that are useful in determining the response due to unreflected primary and reflected secondary waves are presented. Example induction log system responses based on the analysis of the present paper are presented. — Author's abstract

- 185-201. Henkel, J[ohn] H., and Collins, T. C. Induced polarization in electrolyte saturated earth plugs: *Geophysics*, v. 26, no. 2, p. 205-210, 1961.

This paper describes the results of some studies of the dependence of induced polarization and of the formation resistivity factor upon solution concentration in saturated porous plugs. Two theories based upon two different

simple models are developed. The first treats induced polarization as an electric dipole polarization occurring at the surface of clay particles. It is a relaxation theory that does not lead to results agreeable with experiments. The second theory treats induced polarization as a concentration polarization which is induced at solution-clay surfaces when current flows across the surfaces. The second theory is more successful than the first in two ways: (1) it leads to a time dependence more consistent with the experimental decays; (2) it leads to equations involving the resistivity of the saturating solution  $\rho_s$  which are also more consistent with experiments. — Authors' abstract

- 185-202. Lishman, J. R. Salt bed identification from unfocused resistivity logs: *Geophysics*, v. 26, no. 3, p. 320-341, 1961.

Salt beds have almost infinite electrical resistivity. They differ from other infinitely resistive beds in that they are usually soluble in drilling fluids, and give rise to enlarged boreholes. An infinitely resistive bed lying between shales may be recognized from the characteristic shape of the electric log resistivity curves and ratios of their readings. Any one of the curves may then be used to compute the borehole diameter, and hence decide whether the bed is salt. Where a washed out salt bed is adjacent to another infinitely resistive bed in which the borehole is to gauge, the configuration of the curves is very characteristic. Apparent resistivity ratios again help to identify the salt. — Author's abstract

- 185-203. Walker, Terry. Simplified log interpretation: *Petroleum Engineer*, v. 32, no. 5, p. B90-95, B99-100 (pt. 1); *ibid.*, no. 6, p. B66, B69, B75, B78, B82, B88 (pt. 2); *ibid.*, no. 9, p. B70, B74, B78-79 (pt. 3), 1960.

Saturation determinations require two primary measurements from logs—true resistivity and porosity. The simplified logging technique presented in this series of papers is based upon the focused devices, and each measurement comes from just one curve with little or no correction required and permits interpretation without laborious calculations from equations.

In parts 1 and 2, the means of simplifying the proper choice of logging tools and the interpretation of the induction or guard tools used in conjunction with the FoRxo tool are discussed. The characteristics of the guard and induction tools and the area of application of each are treated in detail. Simplified saturation charts to be used for calculation of induction and guard logs are presented in part 2, and field examples of induction- and guard-FoRxo combination logs discussed.

In part 3 the applications of a radioactive logging device in radiation-induction logging are discussed. Radiation-induction and radiation-guard saturation charts are presented for use in obtaining quick readings in deep investigations. — V. S. N.

- 185-204. Burjakowskij [Buryakovskiy], L. A. Permeabilitätsbestimmung mit Hilfe der Widerstandskarottage [Permeability determination by means of resistivity logging]: *Zeitschr. Angew. Geologie*, v. 6, no. 3, p. 112-114, 1960.

This is a German version of a paper published in *Geologiya Nefti i Gaza*, no. 1, p. 47-51, 1959 (see *Geophys. Abs.* 184-299). — D. B. V.

- 185-205. Lehnert, Klaus. Einige Besonderheiten konventioneller elektrischer Bohrlochmesskurven in "hartem" Gebirge [Some features of conventional electric logs in "hard" rock (with English and Russian summaries)]: Zeitschr. Angew. Geologie, v. 6, no. 5, p. 207-210, 1960.

Quantitative interpretation of conventional resistivity logs obtained with normal and lateral devices is impossible in "hard" rocks (defined as those in which the resistivity is several times higher than in normal sandy-clayey sediment), and adequate qualitative results are possible only in some cases. Nevertheless, certain information concerning porous and permeable zones may be deduced from these logs, in addition to their use for correlation purposes, if the characteristic shape and major kicks of the curve are known. In many cases information can no longer be obtained by modern logging methods because the holes have been cased or flooded since the conventional logs were run. Examples from Thuringia are given in illustration. — D. B. V.

- 185-206. Fujiwara, Chuichi. Studies on electrical well log analysis (pt. 3): Tohoku Kozan, v. 7, no. 2, p. 49-53, 1960.

This is a continuation of studies on fundamental problems in electrical well-log analysis (see Geophys. Abs. 183-263). In this part the experimental relation between resistivity and SP is discussed. — V. S. N.

- 185-207. Holz, Peter. New electronic instrument to survey boreholes: Canadian Mining Jour., v. 82, no. 1, p. 45-46, 1961.

A new transistorized electronic instrument for surveying deep boreholes, designed and built in South Africa, is described. The instrument provides all required information instantly, any number of readings may be taken at varying depths, and changes of angle and direction are calculated rapidly. Basically the instrument consists of a stable radio frequency oscillator and an amplifier connected by cable to a console at the surface of the ground. Other components are a carriage, pendulum, compass needle with a shortened "south pole," light source, tuning condenser, and photo-transistor. Movements of the pendulum alter the setting of the tuning condenser attached to it, and the signal transmitting to the surface changes in frequency. — V. S. N.

- 185-208. Rollo, J. R. Ground water in Louisiana: Louisiana Dept. Conservation, Geol. Survey and Dept. Public Works Water Resources Bull., no. 1, 84 p., 1960.

The general availability of ground water throughout Louisiana is discussed for the use of those responsible for the development of ground-water resources. The use of electric logs in ground-water and geologic investigations especially as a basis for distinguishing between fresh and salt water is summarized, the subsurface geology is reviewed, and the occurrence of fresh ground water is discussed and illustrated. Data used are primarily from electrical logs, chemical analyses, records of wells, and geologic and ground-water reports. — V. S. N.

- 185-209. McCrossan, R. G. Resistivity mapping and petrophysical study of Upper Devonian inter-reef calcareous shales of central Alberta, Canada: Am. Assoc. Petroleum Geologists Bull., v. 45, no. 4, p. 441-470, 1961.

A resistivity map of the inter-reef deposits in the Woodbend group in Alberta shows haloes of high resistivity around the reefs which seem to be related to an increased calcareous content in the dominantly argillaceous section. In order to evaluate this map, the carbonate content and porosity of numerous core samples were determined and compared with resistivity logs. The rocks were also examined petrographically.

A linear relation was found between carbonate content and porosity, suggesting that reduction of porosity is directly proportional to the volume of carbonate grains present. Porosity varies inversely and resistivity directly with depth and carbonate content. Rocks high in organic matter are less porous and more resistant than nonorganic rocks, for the same carbonate content and depth.

Although not linear, the relation between carbonate content and resistivity is very useful. Subsurface mapping from resistivity logs should prove to be a valuable exploration tool for following the distribution of bulky mineral grains in shale. (See also *Geophys. Abs.* 180-143.)—D. B. V.

- 185-210. Gallup, W. B. Current exploratory techniques in the Athabasca bituminous sands area: *Canadian Mining Metall. Bull.*, v. 53, no. 576, p. 245-249, 1960; *Canadian Inst. Mining Metallurgy Trans.*, v. 63, p. 157-161, 1960.

The Athabasca bituminous sands, which occur along the Athabasca River in the vicinity of Fort McMurray and Fort MacKay, have been subject to sporadic investigations since the beginning of the century. Current exploratory techniques involve a moderate amount of drilling and coring followed by electric and radioactivity logging of most holes. Cores are analyzed for bitumen by weight and percentage of connate water; this analysis is used for calibration of the logs which are then interpreted to give a qualitative analysis more accurate than that from the cores. Bitumen saturation is deduced from the resistivity as shown by the laterologs. A saturation in excess of 10 percent bitumen by weight is set arbitrarily as being of economic interest. Radioactivity logs are used to eliminate shaly and tight sand sections. —V. S. N.

- 195-211. Rodiger, Kurt. Analyse der Salzstock-Hebungen mit Hilfe elektrischer Bohrlochmessungen, dargestellt an den Salzstocken Bramstedt und Etzel [Analysis of salt dome uplifts with the aid of electric logging, as shown at the Bramstedt and Etzel salt domes]: *Erdöl u. Kohle*, v. 13, no. 3, p. 149-153, 1960.

In order to determine whether salt domes are formed all at once during an orogenic phase or by continuous movement linked to the physical properties of salt (halokinesis), it is necessary to analyze the salt dome formation process quantitatively. An attempt is made in this direction, using electric logging measurements to analyze the movements that have taken place in the vicinity of two salt domes in north Germany, the Bramstedt oilfield in the southern part of the east flank of the Bramstedt-Neumünster salt dome and the Etzel oilfield in the northwest part of the Etzel salt dome.

As the drill holes are distributed over an area, the resistivity and SP logs can be used to give curves representing the thickness of each stratigraphic unit. Movements are reconstructed from the percentage and direction of decrease in thickness of each group.

In both oilfields, salt dome uplift is shown to have been continuous throughout Cretaceous and Tertiary time, although intensified during the four orogenic phases that are reflected in the sedimentary record (Late Cimmerian, Subhercynian, Laramide, and Pyrenean). The halokinesis theory is thus corroborated. —D. B. V.

- 185-212. Oilweek. Geophysicists ponder crisis in exploration activity: Oilweek, v. 12, no. 3, p. 41, 44-46, 48-50, 52-53, 1961.

Abstracts are given for papers presented by M. B. Dobrin, D. M. E. McLarty, J. P. Woods, T. A. Link, W. T. Born, P. L. Lyons, C. M. Moore, D. C. Jones, F. A. Van Melle, L. R. Newfarmer, Colin Campbell, J. C. Hollister, and N. R. Paterson at a one-day symposium, "Exploration geophysics—today and tomorrow," at Calgary, Alberta. Geophysical activity in North America has declined 50 percent in the past eight years. Seismograph crews operating in the United States declined from 655 in 1952 to 425 in 1959; gravity crews declined from 160 to 45. In Canada, seismic crews dropped from 153 in 1952 to 67 in 1959. Nearly all experts at the symposium agreed that exploration activity will increase in view of large additional reserves needed to meet the steadily growing world demand. All warned that to increase or even maintain exploration efforts in North America, new reserves must be found at costs that are competitive with alternate sources of oil, such as secondary recovery, tar and shales, and from increased foreign imports. — V. S. N.

- 185-213. World Oil. How closely is U. S. wildcat drilling controlled by seismograph?: World Oil, v. 152, no. 5, p. 72, 1961.

The number of wildcat wells drilled in any year is greatly influenced by the amount of seismic work done four years previously. Exploration drilling appears to be destined for a decline over the next four years provided that new methods of direct explorations do not change the current trend. — J. W. C.

- 185-214. Oil in Canada. Geophysical work up 43.5 percent in month: Oil in Canada, v. 13, no. 12, p. 18, 1961.

Geophysical activity in western Canada at mid-January showed an increase of 43.5 percent over December but was down 9.2 percent from last January. A total of 85 seismograph crews and 4 gravimeter crews were active—30 in British Columbia, 49 in Alberta, 1 in Saskatchewan, and 9 in the Northwest Territories. — V. S. N.

- 185-215. Finsterwalder, Richard. Polarforschung und Internationale Glaziologische Grönland-Expedition 1957/60 [Polar research and International Glaciological Greenland Expedition of 1957-60]: Bayerische Akad. Wiss. Sitzungsber. Math.-Naturw. Kl., v. 1958, p. 37-50, 1958.

The objectives of the Greenland expedition of 1957-60 are outlined. The main task was the construction of a geodetic-geophysical transverse profile across the center of Greenland from Disko Bay to Cecilia Nunatak, supplemented by a north-south profile on the west flank of the ice cap about 50 km from the coast. Geophysical projects include seismic and gravimetric determinations of ice thickness and bedrock topography, and temperature measurements in the ice (see also Geophys. Abs. 185-299). — D. B. V.

- 185-216. Facsinay, László, and Mészáros, Mihály. A perkupai gipsz-anhidrit terület geofizikai újraértékelése [Geophysical reevaluation of the Perkupa gypsum-anhydrite area (with English and Russian summaries)]: Geofiz. Közlemények, v. 8, no. 4, p. 151-176, 1960.

Geophysical investigations in the Perkupa area of Hungary since 1920 are reviewed and the results compared with the geologic evidence. Recommendations are made for additional magnetic and gravity measurements and electrical test measurements. — D. B. V.

- 185-217. Lányi, János. A Magyar Kisalföld mélyszerkezete a geofizikai mérések alapján [The deep structure of the Little Hungarian Plain on the basis of geophysical measurements (with German summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 219-240, 1960.

The Little Hungarian Plain has been investigated geophysically since 1893 by means of the pendulum, torsion balance, and gravimeter; also by magnetic measurements and, more recently, reflection, refraction, and telluric surveys. The results show two major fracture lines, trending northeast-southwest, that divide the area into three parts. In the western part the basement consists of crystalline schists and diabase, in the central part of crystalline and Mesozoic rocks, and in the eastern part of Mesozoic rocks entirely. The cover formations are Miocene and younger in the west and Eocene and younger in the east. — D. B. V.

- 185-218. Skorupa, Jan. Metody badań geofizycznych zakrytych obszarów na przykładzie północno-wschodniej Polski [Methods of geophysical investigations of covered regions in the example of northeastern Poland (with English summary)]: *Przegląd Geol.*, v. 9, no. 4, p. 206-209, 1961.

The geophysical methods used to distinguish the main structural elements of northeast Poland are described; gravity and magnetic surveys were used first and then seismic surveys. Depth to basement was determined at many points by magnetic surveying supplemented by gravity data. These values were not entirely satisfactory, however, and were checked by refraction surveys. A map is presented of the basement surface that is based on seismic and magnetic data. — J. W. C.

- 185-219. Gafarov, R. A. Stroyeniye dokembriyskogo fundamenta severa Russkoy platformy [Structure of the Precambrian basement of the north of the Russian platform]: *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 1, p. 59-71, 1961.

The structure of the Precambrian basement in the area comprising the east flank of the Baltic shield, the Moscow syncline, the northern part of the Volga-Ural antecline, and the Timan and Pechora synclines and their environs is elucidated on the basis of data from geophysical investigations and deep drilling. Karelian, Baikalian, and Hercynian folded systems are present. Results are compiled in maps showing the constitution and relief of the basement. — D. B. V.

- 185-220. Volodarskiy, R. F. Regional'nyye gravimetricheskiye issledovaniya vostochnykh rayonov Russkoy platformy [Regional gravimetric investigations of the eastern regions of the Russian platform]: *Moskov. Univ. Vestnik*, ser. 4, *Geol.* no. 6, p. 59-63, 1960.

The geology of western Bashkir A.S.S.R. and eastern Tatar A.S.S.R. is reinterpreted on the basis of new geophysical data and information from drill holes. In the area of the eastern gravity minimum (Cis-Ural downwarp) the crystalline basement lies at great depth and is not in a position to produce large anomalies in the vertical component of the magnetic field. In the western

platform areas the basement stands much higher and is lithologically inhomogeneous. Where gentle structures accompanied by gravity and magnetic anomalies occur in Paleozoic sediments of the platform, uplifts of the crystalline basement are probably present. — J. W. C.

- 185-221. Subbotin, S. I. Glubinnaya struktura territorii Ukrainskoy SSR po dannym geofizicheskikh issledovaniy [Deep structure of the territory of the Ukrainian SSR according to data of geophysical investigations (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 58-66, 1960.

On the basis of geophysical data (gravity, magnetic, and seismic) the Ukrainian S. S. R. is divided into tectonic units based on the deep structure, and the structural features of some of these units and the transition zones between them are deduced. Vertical movements of blocks have resulted from phase transformations of subcrustal material (expansion under the Ukrainian Shield; compression under the Dnieper-Donets, Pri-Black Sea, Indolo-Kuban, Pri-Carpathian, Transcarpathian, and Black Sea depressions; and complex differential expansion and compression under the Donets, Carpathian, and Crimean folded structures). The deep structures, particularly deep fractures, govern the disposition of mineral deposits and thus serve as prospecting guides. — D. B. V.

- 185-222. Sollogub, V. B. Glubinnoye stroyeniye peredovykh progibov Al'piyskoy geosynklinal'noy zony yugo-zapada SSSR po dannym geofizicheskikh issledovaniy [Deep structure of the foredeeps of the Alpine geosynclinal zone of southwestern USSR according to data of geophysical investigations (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 67-81, 1960.

The geologic structure of the Precambrian, Pri-Dobruja, North Crimean, and Azov-Kuban foredeeps of the Alpine geosyncline in the European part of the U. S. S. R. has been interpreted from geophysical surveys. The margins of the Russian platform and adjoining foredeeps have a block structure; the main joints and fractures strike northeast. The foredeeps range in age from Neogene to Jurassic and differ structurally. The Precambrian and Azov-Kuban foredeeps are of dual nature; an outer zone is characterized by platform-type folding and an inner zone by geosynclinal folding. — D. B. V.

- 185-223. Zhuravlev, V. S. Osnovnyye cherty glubinnoy tektoniki prikaspiyskoy sineklizy [Main features of the deep tectonics of the Pri-Caspian syncline]: Akad. Nauk SSSR, Geol. Inst., Trudy, no. 42, 270 p., 1960.

The third chapter of this work is devoted to the results of geophysical investigations of the Pri-Caspian syncline. Several profiles based on seismic and drilling data are presented for the Cis-Ural downwarp in the vicinity of Aktyubinsk. Extensive gravity, seismic, and magnetic surveys have been made of the Khobda, Aralsor, and South Emba gravity maximums; these results are given on maps and profiles and are discussed in detail. — J. W. C.

- 185-224. Shibato, Kihei, and Odani, Yoshitaka. Geophysical prospecting surveys for the uranium resources at Matsuiwa mine, Miyagi Prefecture [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 11, no. 6, p. 357-368, 1960.

The results of electric, magnetic, and radioactive surveys carried out at the Matsuiwa mine, Miyagi Prefecture, Japan, in August 1958 are reported. The spontaneous polarization and magnetic methods were found to be effective in outlining these hydrothermal sulfide deposits, which occur along a fault in eruptive rocks. The magnetic survey located one anomalous zone other than that produced by the known deposit. — V. S. N.

- 185-225. Thiel, Edward, and Ostenso, Ned A. The contact of the Ross Ice Shelf with the continental ice sheet, Antarctica: *Jour. Glaciology*, v. 3, no. 29, p. 823-832, 1961.

A profile of ice thickness along the 647 mile trail from Little America V to Byrd Station has been obtained from altimetric, seismic, and gravity measurements, and detailed studies made at the junction of the Ross Ice Shelf and the Marie Byrd Land plateau. The surface elevation profile clearly shows the depression characteristic of this contact. The thickness of the floating ice shelf has been determined from the elevations assuming hydrostatic equilibrium; for this purpose the accurately known density-depth relationship obtained from a deep borehole at Little America V was employed. The buried rock topography at the contact has been deduced from a seismic sounding and variations in the gravity anomaly. Movement studies over a 22 month period are presented, and the crevasse pattern of the contact is analyzed in terms of ice movement. Suggestions are given for traversing the region by vehicle. — Authors' abstract

- 185-226. Bentley, Charles R., and Ostenso, Ned A. Glacial and subglacial topography of West Antarctica: *Jour. Glaciology*, v. 3, no. 29, p. 882-911, 1961.

A summary of the techniques used and results obtained from three over-snow traverses in Marie Byrd Land and the Ellsworth Highland between January 1956 and January 1959 is presented. Seismic reflection shooting at 30 nautical mile (55.5 km) intervals was combined with gravity, magnetic, and altimetric measurements to determine the glacial and subglacial topography. It was found that a vast portion of West Antarctica has an ice-rock interface well below sea level. A major connecting channel with a maximum depth of more than 2,500 m below sea level exists between the Ross and Bellingshausen-Amundsen Seas, whereas there is no major topographic connection between the Ross and Weddell Seas. This channel divides West Antarctica into two provinces with granite and rocks of sedimentary origin to the east and south, and a volcanic region to the northwest. Present ice flow is outward from two high areas, centered over mountainous regions on either side of the channel. It is concluded that the present ice sheet has grown from the convergence of the two smaller ice sheets which formed in the mountainous areas and joined across intervening open water. (See also *Geophys. Abs.* 185-565). — Authors' abstract

#### GENERAL

- 185-227. Roy A[malendu], and Jain, S[udhir]. A simple integral transform and its application to some problems in geophysical interpretation: *Geophysics*, v. 26, no. 2, p. 229-241, 1961.

A simple integral transform, defined by

$$f(x) = \int_{-\infty}^{+\infty} F(x, y) dy,$$



where  $F(x, y)$  represents the measured geophysical field and  $x$  and  $y$  are suitably chosen directions, has been used for formulating convenient interpretation techniques to some geophysical problems that are normally not amenable to easy quantitative interpretation. Some synthetic numerical examples are given. — Authors' abstract

- 185-228. Bullard, E. C. The automatic reduction of geophysical data: Royal Astron. Soc. Geophys. Jour., v. 3, no. 2, p. 237-243, 1960.

The automatic recording and reduction of geophysical data is discussed, the results obtained with a proton magnetometer towed behind a ship being used as an example. Data are recorded on punched tape, the sequence of punching being controlled by a uniselector. Each number on the tape is preceded by a symbol that indicates the nature of the quantity recorded; this facilitates the elimination of punching errors and allows quantities to be punched in arbitrary sequence. The computer programme uses first and second differences to eliminate grossly erroneous readings. — Author's summary

- 185-229. Baranov, V[ladimir]. El papel de las matemáticas en el arte de la interpretación [The role of mathematics in the art of interpretation]: Rev. Geofísica, v. 19, no. 75, p. 323-330, 1960.

This is a Spanish translation of the paper published originally in French in Geophys. Prosp., v. 8, no. 2, p. 141-147, 1960 (see Geophys. Abs. 183-293). — D. B. V.

- 185-230. Heathcote, Niels H. de V., and Armitage, Angus. The First International Polar Year (1882-1883): Internat. Geophys. Year Annals, v. 1, p. 6-99, French version, p. 105-203, 1959.

This is a review of the organization, equipment, and objectives of the various countries' expeditions during the First International Polar Year: the Austrian, to Jan Mayen Land; the British-Canadian, to Great Slave Lake, Canada; the Danish, to the west coast of Greenland; the Dutch, to the mouth of the Yenisei; the Finnish, to northern Finland; the French, to Cape Horn; the German, to Baffin Land and South Georgia Island; the Norwegian, to the north coast of Norway; the Russian, to the mouth of the Lena to Novaya Zemlya; the Swedish, to Spitsbergen; and the American, to Grinnell Land and the north coast of Alaska. — D. B. V.

- 185-231. Bartels, J[ulius], and others. The Second International Polar Year: Internat. Geophys. Year Annals, v. 1, p. 205-381, 1959.

After an introduction by Bartels, the results obtained in different fields during the Second International Polar Year (1932-33) are summarized by different authors. Each part is given in both English and French. V. Laursen discusses the organization of the undertaking as a whole; C. E. P. Brooks summarizes the meteorological results, V. Laursen the geomagnetic results, J. Paton the aurora studies, W. J. G. Beynon the ionospheric observations, and E. H. Vestine and T. Nagata the ionospheric electric current systems. — D. B. V.

- 185-232. Spencer Jones, Harold. The inception and development of the International Geophysical Year: Internat. Geophys. Year Annals, v. 1, p. 383-413, French version, p. 415-446, 1959.

The development of the International Geophysical Year program is traced from the time of its informal proposal in 1950 to its ultimate organization. — D. B. V.

- 185-233. Nicolet, M[arcel] and Baker, F. W. G., eds. The Fifth meeting and the termination of the CSAGI: *Internat. Geophys. Year Annals*, v. 10, 288p., 1960.

This terminates the publications undertaken by the Comité Spécial de l'Année Géophysique Internationale at the inception of the International Geophysical Year. It includes the general reports on all the CSAGI disciplines (world days, meteorology, geomagnetism, aurora and airglow, ionosphere, solar activity, cosmic rays, latitudes and longitudes, glaciology, oceanography, rockets and satellites, seismology, gravimetry, and nuclear radiation), a list of resolutions, and the report of the termination of the CSAGI and formation of the Special Committee for Inter-Union Cooperation in Geophysics (SCG). — D. B. V.

- 185-234. Baile, Richard A. Current and future parameters in geophysics: *Geophysics*, v. 26, no. 3, p. 355-358, 1961.

The cause of the present decline in use of geophysical effort is economic; the return on investment in exploring for oil in the United States is poor. The solution lies in maintaining petroleum competitive with other sources of energy and keeping the United States competitive with other producing areas. Exploration is the key to meeting this challenge. Planning, personnel, research, and stability in exploration are discussed. — D. B. V.

- 185-235. Romberg, Frederick E. Exploration geophysics: a review: *Geol. Soc. America Bull.*, v. 72, no. 6, p. 883-932, 1961.

The art of exploration geophysics is reviewed with reference to classical and current literature. Its main features are described, the state of instrumentation and theory are discussed, and the problems it has yet to solve are examined. A 10-page bibliography is given. — D. B. V.

- 185-236. Bruckshaw, J. McG. Geophysics today: *Inst. Petroleum Rev.*, v. 14, no. 167, p. 353-355, 1960.

The capabilities of the three main geophysical methods currently in use for oil exploration—the gravitational, magnetic, and seismic—are reviewed. It is concluded that the magnetic and gravitational methods have reached the peak of their development but that there is much to be attained in the seismic method. — V. S. N.

- 185-237. Hall, T[homas] O. Is there a future need for geophysics?: *Geophysics*, v. 26, no. 2, p. 133-137, 1961.

There is a future for exploration geophysics if the industry stays modern, efficient, and competitive. Operating costs must be reduced, new tools and techniques must be developed continuously, and interpretative methods must be radically improved. Much has been accomplished in the first two of these objectives. For the third, a top-flight geophysical interpreter must be well qualified in all phases of geophysics; he must also be a competent geologist and a man with drive and imagination. A fourth objective, which vitally affects the other three, is basic research. — D. B. V.

- 185-238. Smellie, D. W. Mining exploration: *Canadian Mining Jour.*, v. 82, no. 2, p. 154-157, 1961.

The more important methods and techniques of application of geophysics, geochemistry, and geology to mining exploration during 1960 are reviewed briefly. Significant instrumental developments are also discussed. A list of 36 references is included. — V. S. N.

- 185-239. Aleksin, A. G. O printsipial'noy skheme metodiki poiskov i razvedki skopleniy nefiti i gaza [Outline in principle of the method of exploration for oil and gas deposits]: *Geologiya Nefiti i Gaza*, no. 4, p. 24-31, 1959.

The program of oil and gas exploration in new regions is divided into four stages. The first stage is designed to reveal the main geologic features of a region; airborne magnetic and radioactivity surveys and ground gravity surveys are combined with geomorphological studies in this phase. During the second stage the main structural elements are investigated. Gravity surveys are combined with slim-hole drilling for structural studies. The third stage provides for study of local structures for possible new oil and gas fields using structural and geophysical surveys at a scale of 1:10,000 to 1:50,000. The fourth stage consists of preparing structures for exploration drilling. Detailed seismic surveying dominates among the geophysical methods. Gravity and electrical surveys are used where the section contains rocks that are amenable to such methods. — J. W. C.

- 185-240. Mitura, Feliks. Ein Grundschema für die Methodik der Erdölprospektion [A basic scheme for methods of petroleum prospecting (with English and Russian summaries)]: *Zeitschr. Angew. Geologie*, v. 6, no. 6, p. 255-259, 1960.

A basic scheme for systematic petroleum prospecting is presented. Increasingly detailed results are obtained in four steps. A table gives the objective, methods, and main results of operations involved in each step. The first step uses gravimetric, magnetic, and geomorphic regional surveys, basic drilling, and sampling of potentially oil-bearing rocks. The second step has two stages: first, structural geologic surveys, special gravimetric and magnetic surveys, regional radioactivity and surface geochemical surveys, drilling to define structures, and sampling; and second, regional seismic investigations, special surface geochemical surveys, and precise radioactivity and resistivity surveys.

The third step also has two stages: first, special seismic investigations and precise structural geologic surveys, exploratory drilling of structures, subsurface geochemical surveys, and sampling of horizons that have oil and gas indications; and second, further drilling and sampling of oil and gas horizons, and well logging. The fourth step comprises still more drilling to delineate oil and gas horizons exactly, well logging, sampling, and test production. — D. B. V.

- 185-241. Filippov, Yu. V., Kel'ner, Y. G., and Byushgens, L. M. Karty prirody v zarubezhnykh kompleksnykh spravochnykh atlasakh (gosudarstv i rayonov) [Maps of nature in foreign complex information atlases (countries and regions)]: *Trudy Tsentral'nogo Nauchno-Issledovatel'skogo Instituta Geodezii, Aerofotografii i Kartografii* [Proceeding of the Central Scientific Research Institute of Geodesy, Airborne Survey, and Cartography], no. 125, Moscow, 147 p., 1958.

A review of 25 non-Russian atlases is presented which encompasses maps of gravity, seismicity, magnetism, volcanism, tectonics, stratigraphy, relief, oceanography, and climate. — A. J. S.

- 185-242. Hales, A. L. Research at the Bernard Price Institute of Geophysical Research, University of the Witwatersrand, Johannesburg: Royal Soc. [London] Proc., v. 258, no. 1292, p. 1-26, 1960.

Geophysical research by the Bernard Price Institute in South Africa is reviewed. Seismological work has included studies of crustal structure, microseisms, and development of the continuous ground excitation method of prospecting. Gravity work has included pendulum and regional gravimeter surveys, and analysis of the isostatic anomalies of South Africa. Geochronological measurements have been made by the rubidium-strontium method. Paleomagnetic measurements have been made on the Pilansberg dike system, Stormberg lavas, Karroo dolerites, parts of the Bushveld Complex, and the Table Mountain series. A list of the works in which details of these studies can be found is given by subject. — D. B. V.

- 185-243. Petroleum Times. European Association of Exploration Geophysicists: Petroleum Times, v. 65, no. 1656, p. 99-101, 1961.

The proceedings of the 19th meeting of the European Association of Exploration Geophysicists in Paris, France, on December 7-9, 1960 are reviewed. Informative abstracts are given for a large number of the papers presented. — J. W. C.

- 185-244. Jaeger, J. C., and Thyer, R. F. Geophysics in Australia: Royal Astron. Soc. Geophys. Jour., v. 3, no. 4, p. 450-461, 1960.

This is a review of recent research in geophysics of the solid earth in Australia and associated regions. More than 10,000 new gravity stations were occupied during the past year, about 70 percent by private companies; their data have been made available for use in preparation of a Bouguer anomaly map of Australia, the preliminary version of which has been compiled.

The Watheroo Magnetic Observatory's equipment and personnel were transferred in 1959 to Mundaring, about 100 miles further south. Magnetic observatories are also operated at Toolangi, Victoria; Port Moresby, Papua; Gnanagara (near Perth), Western Australia; and also at Macquarie Island, Mawson and Wilkes stations, Antarctica. More than 700 field magnetic stations have been occupied in Australia and New Guinea since 1910; about 20 of these are reoccupied every 5 years to determine secular variation. Isogonic maps are issued every 5 years, and isomagnetic maps of all elements for the epoch 1957.5 are in press. Large areas of Australia have been surveyed by airborne magnetometer.

Two earthquakes in the Adelaide region have been studied in detail, and several seismic observatories are studying small local tremors and their geologic interpretation. A few seismic measurements of crustal thickness have been made. Work on theoretical seismology has been carried on at the University of Sydney under the direction of K. E. Bullen.

Several universities are actively studying rock magnetism in the field and in the laboratory. Heat flow measurements have been made in Tasmania, in the Snowy Mountains, and in mines and drill holes throughout the country; heat conductivity of rocks has been studied in the laboratory and the possibility of its measurement in place in water-filled boreholes has been investigated. Isotope studies and absolute age determinations by different methods have been carried on at two universities. Research is in progress at Canberra on deformation and phase transitions at high temperatures and pressures. — D. B. V.

- 185-245. Hughes, D[arrell] S. Properties of rocks under high pressure and temperature, in Methods and techniques in geophysics, v. 1: New York, Interscience Publishers, Inc., p. 308-324, 1960.

The properties of rocks under pressure that are being actively investigated at the present time—elastic constants and velocities, plastic deformation and polymorphism—are discussed in some detail. The important but somewhat neglected properties of thermal conductivity, thermal capacity, electrical conductivity, and magnetic parameters as functions of pressure and temperature are mentioned briefly; they would be of great assistance in formulating and testing hypotheses concerning the structure of the earth. A reference list of 66 items is included. — V. S. N.

GEODESY

- 185-246. Hirvonen, R. A. The reformation of geodesy: Jour. Geophys. Research, v. 66, no. 5, p. 1471-1478, 1961.

Three unrelated and paradoxical new ideas express a common trend toward radical reformation of geodesy. In gravimetric geodesy, where determination of the geoid has been the principal problem, the geoid is now considered to be quite unnecessary and its determination an unsolvable problem. In geometric geodesy modern computation techniques permit the use of a three-dimensional system of coordinates, thus by-passing the need for geodetic lines on the surface of a reference ellipsoid. The theory of adjustments should be based on mathematical statistics, not on the vague concept of errors that has often been considered to be a special domain of geodesy. These three ideas are discussed briefly. — D. B. V.

- 185-247. O'Keefe, John A. Discussion of paper by W. A. Heiskanen, "The latest achievements of physical geodesy": Jour. Geophys. Research, v. 66, no. 6, p. 1992-1993, 1961.  
Heiskanen, W. A. Answer to the discussion of Dr. O'Keefe on my earlier article, "The latest achievements of physical geodesy": *ibid.*, p. 1993, 1961.

In view of objections raised by Heiskanen (see Geophys. Abs. 183-310) to criticism by O'Keefe (see Geophys. Abs. 180-183), the reasoning leading to the adoption of the value  $1/299.8$  for the flattening of the reference ellipsoid is stated more completely. The considerations discussed take into account fully the fact that hydrostatic equilibrium is not complete. The new numerical data mean that in estimating the contribution of the unexplored portions of the earth's gravitational field, one should assume nonhydrostatic contributions in accordance with those found from satellites, which are approximately 10 times those assumed by Heiskanen and Vening Meinesz (see Geophys. Abs. 175-191).

Heiskanen replies that he is convinced that after two years, when the gaps in the gravity anomaly field are filled and the results of satellite geodesy are on a firmer basis, the existing differences in opinion will disappear and the methods of physical geodesy and satellite geodesy will complete, not compete with, one another. — D. B. V.

- 185-248. Kaula, W[illiam] M. A geoid and world geodetic system based on a combination of gravimetric, astrogeodetic, and satellite data: Jour. Geophys. Research, v. 66, no. 6, p. 1799-1811, 1961.

A worldwide estimate of the gravity field, based on all available gravimetry and extended by using correlation with elevation in a Markov analysis, was combined with an estimate of the geoid based on astrogeodetic data covering 19 percent of the earth and with variation in satellite orbits (1957 $\beta$  and 1958 $\beta$ ) in least squares adjustments to give the following geoid: equatorial radius—6,378,163 $\pm$ 21 m; flattening— $1/298.24\pm 0.01$ ; and equatorial gravity—978,043.6 $\pm$ 1.2 mgal (Potsdam system). Datum shifts for the Americas system are ( $\pm$ 35 m), for the Europe-Africa-Siberia-India system ( $\pm$ 38 m), and for the Japan-Korea-Manchuria system ( $\pm$ 68 m). The methods used could be improved in several respects, but it is felt that the standard deviations given for the results ( $\pm$ 10 to  $\pm$ 20 m for worldwide geoid heights) are more reliable than those given in most past studies. — D. B. V.

- 185-249. Arnold, Kurt. Beiträge zur gravimetrischen Geodäsie [Contributions to gravimetric geodesy]: Potsdam Geod. Inst. Veröffentl., no. 11, 30 p., 1956.

An expansion series is presented for determination of geoid undulations according to the Stokes formula that can also be used for gravimetric determination of the curvature of the plumbline of the geoid. A similar power series development given earlier by other authors is shown to be inadequate.

The gravimetric correction of astronomic leveling is treated. Defects of the so-called "circular arc condition theory" are eliminated. In determination of relative geoid undulations by the astronomic leveling method no question arises concerning the magnitude of any higher powers of an expansion series. The effect of curvature of the plumbline on astronomic-geodetic leveling can be determined separately; it is not treated here, however.

The problem of the most hypothesis-free determination of curvature of the plumbline is discussed, starting from differential quotients rather than from difference quotients. — D. B. V.

- 185-250. Arnold, Kurt. Numerische Beispiele zur strengen Theorie der Figur der Erde [Numerical examples of the rigorous theory of the figure of the earth]: Potsdam Geod. Inst. Veröffentl., no. 16, 66 p., 1960.

This paper is in 6 parts: (1) The formulas derived earlier for deflections of the vertical (see Geophys. Abs. 182-288) are applied to a model terrain; (2) the rigorous theory is applied to the north-south component of deflection at the Brocken massif in the Harz Mountains of Germany; (3) the corrections for deflection of the vertical for points in the vicinity of Cyprus, where gravity anomalies are intense are given; (4) the rigorous formulas for geoid undulations (see Geophys. Abs. 182-251) are applied to a model terrain; (5) the theory is applied to Mount Blanc; and (6) a general discussion is given of the foregoing results. — D. B. V.

- 185-251. Boaga, Giovanni. Sul calcolo delle quote ortometriche normali e convenzionali [On the calculation of normal and conventional orthometric heights]: Accad. Naz. Lincei Atti, Cl. Sci. Fis. Mat. e Nat. Rend., v. 26, no. 1, p. 9-13, 1959.

The use of observed gravity values alone (measured at the principal points along a precise leveling line) in determining orthometric heights gives results that are closer to reality than those obtained by using normal gravity values alone or observed gravity combined with theoretical gravity corrected for altitude. (See also Geophys. Abs. 185-256.) — D. B. V.

- 185-252. Ledersteger, K[arl]. Die heterogenen sphäroidischen Gleichgewichtsfiguren und das Normalsphäroid der Erde [Heterogeneous spheroidal equilibrium figures and the normal spheroid of the earth (with English summary)]: *Geofisica Pura e Appl.*, v. 44, p. 1-19, 1959.

Equilibrium figures can be characterized independently of interior density because of the condition that the absolute value of the shape parameter must be a minimum. This gives an equation between flattening and the Stokes constants  $\epsilon$  and  $\delta$  by which the  $\omega^3$  equilibrium figures can be selected from the  $\omega^4$  solutions of Helmert's equations for a given mass. Any inhomogeneous spheroidal equilibrium figure is determined unequivocally by the mass and shape of its free surface, or by the mass and three physical parameters; its density law is strictly individual. Out of the infinite number of equilibrium figures, linear series can be singled out either by fixing two physical parameters or by computing the figures which have a common outer level surface or the series of figures which can be formed from all the external level surfaces of a given equilibrium figure.

Although moment of inertia ( $C$ ) is not a Stokes constant, the normal spheroid of the earth defined by  $\omega$ ,  $W_0$ , and  $C$  can be determined without hypotheses because the moments of inertia and dynamic flattening are constant in the series ( $\omega$ ,  $K$ ); the empirically determined dynamic flattening can be substituted for the static flattening by going back to the homogeneous initial figure of the series ( $\omega$ ,  $K$ ). The derivation of the normal spheroid must be based on the value of gravity at the equator and the equatorial axis instead of on the unknown values of the earth's mass and geoid potential.

The three linear series ( $\omega$ ,  $W_0$ ;  $\omega$ ,  $K$ ; and  $W_0$ ,  $K$ ), which must intersect the normal spheroid, and the boundary surface of the equilibrium figures in Cartesian coordinates are also discussed. — D. B. V.

- 185-253. de Graaff-Hunter, J[ames]. The shape of the earth's surface expressed in terms of gravity at ground level: *Bull. Géod.*, no. 56, p. 191-200, 1960.

In the model earth with smoothed topography (see *Geophys. Abs.* 178-202), slopes hardly exceed 0.01. The data of gravity and potential at the surface of the actual earth can easily be related to the corresponding data for the model earth; if the problem of the shape of the model earth is then solved, the shape of the actual earth follows without difficulty. A solution based on Green's theorem is given.

This method involves assumptions of crustal density in a layer between the actual earth and model earth of thickness  $h$ - $H$ ; in isostatic methods the assumptions concern thickness  $h$ . — D. B. V.

- 185-254. Schmidt-Falkenberg, Heinz. Die geodätischen Grundlagen unserer Kartenwerke von der Erde [The geodetic bases of our mapping of the earth]: *Forschungen u. Fortschritte*, v. 34, no. 1, p. 10-13, 1960.

This review of the geodetic basis of cartography discusses such questions as reference surfaces, the mean earth ellipsoid, the different altitude systems and their mutual relations, working heights, and the German main altitude network. — D. B. V.

- 185-255. Fischer, Irene. A map of geoidal contours in North America: Bull. Géod., no. 57, p. 321-324, 1960.

A map of geoidal contours of North America, constructed by Hayford's method, is presented. Comparison with Hayford's map of 50 years ago shows not only that large blank areas have been filled in, but also that there are pronounced differences in elevation in the Western United States, where Hayford's values averaged 30 m higher and were never negative. A comparison with the 1951 Canadian map shows agreement in general features, with some discrepancies of smaller degree.

A noteworthy feature of the map is a geoidal depression north of the Great Lakes, with an apparent center in the southwestern part of Hudson Bay. This may be related to the last glaciation (see Geophys. Abs. 176-161); if so, the amount of expected postglacial uplift may be in some proportion to this depression. — D. B. V.

- 185-256. Boaga, Giovanni. Sulle livellazioni dinamiche [On dynamic leveling]: Accad. Naz. Lincei Atti, Cl. Sci. Fis. Mat. e Nat. Rend., v. 25, no. 6, p. 395-400, 1958.

Comparison of results obtained using observed and normal gravity values shows that in determining dynamic heights along lines of precise leveling, particularly in zones of large gravity anomalies, it is not sufficient to use normal gravity values. Measurements must be made along the altimetric route at all principal points using the formula for dynamic height given in an earlier paper (see Geophys. Abs. 178-210). — D. B. V.

- 185-257. Ramsayer, K[arl]. Report about gravity reduction of the levelling network in Baden-Württemberg (summary): Bull. Géod., no. 52, p. 76-79, 1959.

In order to compare the different altitude systems in a large leveling network, the following heights were calculated for the junction points of the Baden-Württemberg network in Germany: geopotential numbers, dynamic heights, Helmert heights, heights with minimum gravity reduction, and heights without gravity reduction. The smallest corrections were obtained by using measured heights without any gravity reduction and adjusting them; this method is therefore suitable for ordinary use, but as it does not take closure error into account, it cannot be used for highly precise work.

A worldwide system of heights suitable for both scientific and practical purposes is obtained by using Helmert heights as follows: the leveling network is adjusted with the Helmert reduction without further gravity reductions; the lines of equal differences between Helmert heights and leveling heights are plotted on a map; if later a line of second or lower order is measured, the difference at the beginning and end of the line is read from the map to give an approximate value of the Helmert reduction of the line.

In order to determine whether normal gravity could be used instead of true gravity, normal dynamic and normal orthometric heights were also calculated. Use of normal gravity reduction reduces the mean square error from 0.99 mm per  $\sqrt{\text{km}}$  to 0.74 mm per  $\sqrt{\text{km}}$ ; use of true gravity reduces it still further to 0.64 mm per  $\sqrt{\text{km}}$ . — D. B. V.

- 185-258. Baeschlin, C. F. Rapport spécial sur le nivellement et la pesantueur [Special report on leveling and gravity]: Bull. Géod., no. 57, p. 247-298, 1960.



According to a decision made at the International Association of Geodesy at its 1954 meeting in Rome, all international comparisons and adjustments of geodetic networks should be made only by the differences in geopotential numbers. The gravimetric aspects of precise leveling are discussed in the light of this resolution. The eleven sections of the report are devoted to geopotential heights, orthometric altitudes, transformation of raw leveling altitudes into geopotential heights, orthometric correction of raw leveling altitudes, formation of geopotential heights, theory of errors in gravity reduction of levelings, layout of gravimetric stations, application of the theory of errors to some examples, methods of calculating orthometric altitudes, ordinary altitudes, and the use of spheroidal altitudes and isoanomaly maps. — D. B. V.

- 185-259. Kääriäinen, Erkki. Adjustment of the Northern Bloc in U. E. L. N. and accuracy of the geopotential differences in it: *Bull. Géod.*, no. 57, p. 299-310, 1960.

The results are reported of computation of the mean errors for existing geopotential differences for the Northern Bloc (Norway, Sweden, and Finland) of the United European Leveling Networks (U. E. L. N.), made in connection with the resolution to use only geopotential numbers in international comparisons and adjustments (see *Geophys. Abs.* 185-258). — D. B. V.

## GEOTECTONICS

- 185-260. Ringwood, A. E. Changes in solar luminosity and some possible terrestrial consequences: *Geochim. et Cosmochim. Acta*, v. 21, no. 3/4, p. 295-296, 1961.

The geologic consequences of an increase of the sun's luminosity by a factor of 1.6 during the past 5 billion years, as calculated recently by astronomers, are pointed out. Other factors being equal, the average surface temperature of the earth must have increased 30°C-40°C over that period. This implies that from the time of the earth's formation some 4.5 billion years ago until about 3 billion years ago most of the water on the earth was frozen. During such an intense ice age normal surface geological processes would not be operative, and crustal dynamics would be radically different. The formation of sediment-filled geosynclines would be prevented, and thus the processes of metamorphism, granitization, and the formation of silicic magmas associated with geosynclinal folding would not occur.

Most ancient dated rocks are of granitic origin; if the formation of such rocks was prevented, a possible explanation for the marked hiatus in age determinations between 3 and 4.5 billion years is apparent. In that period the continents may have consisted largely of mafic and intermediate volcanics formed by fractional melting of the upper mantle. The Conrad discontinuity may represent the original surface of the earth about 3 billion years ago, before the normal geologic cycle began to operate. — D. B. V.

- 185-261. Eardley, Armand J. The cause of mountain building—an enigma, in *Science in progress* 11th ser.: New Haven, Yale University Press, p. 1-37, 1960.

The foundations of the earth's crust are discussed and illustrated by a general survey of the problems of the Rocky Mountains and Appalachian Mountains, the constitution of the North American continent, the nature of the ocean basins as deduced from modern exploratory methods, and finally by a comparison of ocean basins and continents. Hypotheses to explain the mechanisms of mountain building are classified, and the concepts of the principal

categories presented briefly. The following hypotheses are included: older contraction; Wegener's continental drift; radioactivity and melting of the sub-crust including Joly's global subcrustal melting, Vening Meinesz' tectogene, and Rich's blister hypotheses; Hess and Benioff's mantle fault; Bucher's gravity sliding; Wilson's (detailed by Eardley) asymmetric convection; Hess' serpentinization; and Ewing and others' tension hypothesis. — V. S. N.

- 185-262. Beck, A[lan] E. Energy requirements of an expanding earth: *Jour. Geophys. Research*, v. 66, no. 5, p. 1485-1490, 1961.

To estimate the energy required for, and hence the physical possibility of, an expanding earth, the gravitational potential energy of the present earth and of various primitive earth models are compared. If the primitive density distribution is given by  $\rho r = \rho_0(1 - kr^n)$ , then with plausible values of  $\rho_0$ ,  $k$ , and  $n$  expansions of the radius of about 100 km, with a net loss of gravitational potential energy, cannot be ruled out. Earth models with moments of inertia higher or lower than that of the present earth can be selected from the range of plausible smaller primitive models available for each value of  $n$ . Expansions of the radius of about 1,000 km can be entertained only if highly improbable density distributions are assumed. The conclusions are not substantially altered even when additional sources of energy are taken into account. [See also *Geophys. Abs.* 181-239.] — Author's abstract

- 185-263. Reitan, Paul H. The earth's volume change and its significance for orogenesis: *Jour. Geology*, v. 68, no. 6, p. 678-680, 1960.

Recent studies on the thermal history of the earth (Jacobs, 1956; MacDonald, 1959) [see *Geophys. Abs.* 173-218, 179-236] allow the net volume change of the earth due to temperature changes during the last  $10^9$  yr to be calculated. The circumference changes for four models vary from -13 km (contraction) to approximately +31 km (expansion). From this it appears that orogeny cannot be explained as the result of contraction due to heat loss. — Author's abstract

Cox, Allan [V.], and Doell, Richard R. Paleomagnetic evidence relevant to a change in the earth's radius. See *Geophys. Abs.* 185-449.

- 185-264. Aslanyan, A. T. Dinamicheskaya problema geotektoniki [The dynamic problem of geotectonics (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov*, Problema 18, p. 5-16, 1960.

If the contraction hypothesis is liberated from five false assumptions, it appears to be the only justifiable theory of crustal evolution from the point of view of energetics. The questionable assumptions concern the adoption of the relaxation principle; crustal stability and its limits; the elastic limit; the interpretation of negative gravity anomalies over folded ranges; and the spasmodic nature of folding, orogenic phases, and contraction. The assumptions are examined mathematically and the true picture elucidated. — D. B. V.

- 185-265. Haites, T. Binnert. Perspectives in the solar system: *Alberta Soc. Petroleum Geologists Jour.*, v. 8, no. 12, p. 345-362, 1960.

The stations of the planets on a radius of the solar system appear to be respectively related to the absolute dates of terrestrial diastrophisms and probably also to the spacing of the discontinuities in the earth's interior and atmosphere. This points to cosmic forces as the cause of terrestrial orogenies

and discontinuities; it also follows that the planets were born in the order of their increasing distances from the sun and are much younger than is generally accepted. Mass redistributions accompanying their births disturbed the existing gravity regime of the solar system and caused diastrophisms and development of discontinuities on the pre-existing planets. This hypothesis accounts for six orogenic sequences on earth. Given the stations of the planets and the absolute dates of three major orogenic events, other diastrophisms can be found by interpolation and extrapolation; similarly, depths of three first-order discontinuities would determine the spacing of other transition zones. — V. S. N.

- 185-266. Harrison, E. R. Origin of the Pacific Basin: a meteorite impact hypothesis: *Nature*, v. 188, no. 4756, p. 1064-1067, 1960.

To explain the major surface characteristics of the Pacific Basin, which is surrounded by a variety of features parallel to its coastlines, it is proposed that the basin was the seat of an immense explosion in the primitive earth and that this explosion might have been due to collision with a planetesimal or satellite about 100 km in radius. A large crater several hundred kilometers in radius and some hundreds of kilometers deep was excavated. The great masses of material that were swept back and dropped at the crater rim formed the discontinuities of crustal structure and composition that survive to the present day and are responsible for the peripheral features of the basin. Following the recovery of hydrostatic equilibrium, there remained a shallow permanent depression (because of the absence of surface layers) which is the present Pacific Basin. — D. B. V.

- 185-267. Subbotin, S. I. O prichinakh i mekhanizme obrazovaniya platformnykh i geosinklinal'nykh progibov zemnoy kory [On the causes and mechanism of formation of platform and geosynclinal depressions of the earth's crust (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov, Problema 18*, p. 39-49, 1960.

The formation of geotectonic units and structures that determine the distribution of mineral deposits is related to polymorphic changes at depth accompanied by volume changes. Crustal depressions are caused by decreases in volume in the asthenosphere at depths up to 300 km. Areas of compression and expansion are determined on the basis of regional gravity anomalies, seismological data, and other geophysical and geological data. The phase transformations result from changes in geodynamic stresses in the mantle. These polymorphic changes occur in a horizontal layer and are accompanied by absorption or release of energy; the energy transfer brings thermodynamic conditions in the underlying and overlying layers to a critical level so that polymorphic conversion takes place in a sort of chain reaction successively involving new layers.

The dynamics of formation of platform depressions and geosynclines are described in some detail. — D. B. V.

- 185-268. Fedynskiy, V. V. Geofizicheskiye dannyye o nekotorykh chertakh stroeniya i razvitiya zemnoy kory [Geophysical data on certain features of the structure and development of the earth's crust (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov, Problema 2*, sec. 2, p. 5-13, 1960.

Present knowledge of the thickness, nature, and development of the earth's crust as revealed by geophysical investigations is summarized. The weight of evidence favors the hypothesis that the principal cause of oscillatory movements, and probably also of horizontal movements, is phase transitions in the subcrustal material. The structure and the geologic history of large crustal blocks are determined mainly by endogenous forces. — D. B. V.

- 185-269. McBirney, A[lexander] R., and Best, Myron G. Experimental deformation of viscous layers in oblique stress fields: *Geol. Soc. America Bull.*, v. 72, no. 3, p. 495-498, 1961.

Alternating layers of soft viscous wax and asphalt were squeezed in various orientations within a constant-strain squeeze box. Compression produced folds and small wrinkles whose axial orientation is determined solely by the intersection of the plane normal to the direction of maximum shortening with the layer surface. Formation of folds in viscous materials appears to be a function of the strain rate. — Authors' abstract

- 185-270. Belousov, V. V. Experimental geology: *Sci. American*, v. 204, no. 2, p. 96-104, 1961.

An account is given of laboratory work in the U. S. S. R. on the use of scale models to visualize tectonic processes. Most of the material discussed in this paper is included in the more technical version by Belousov published in *Geol. Soc. America Bull.*, v. 71, no. 8, p. 1255-1270, 1960 (see *Geophys. Abs.* 183-346). — V. S. N.

- 185-271. Ma, Ting Ying H. Continental drift and polar wandering: Research on past climate and continental drift, v. 15, 24 p., 1960.

This is a further development of Ma's thesis that continental drift and polar wandering have been caused by the repeated sudden total displacement of the solid earth shell. This displacement may be traced from coral reef data and has resulted in producing the major tectogenic structures and sedimentary anomalies of the ocean floor. (See also *Geophys. Abs.* 174-170, -171.) — V. S. N.

- 185-272. Ma, Ting Ying [H.]. My genetic view of major structures on the ocean floor: *Oceanographia Sinica*, v. 6, no. 1, 18 p., 1960.

The major tectogenic structures and their patterns in the ocean basins as well as the sedimentary anomalies on the ocean floor came from the repeated sudden total displacement of the solid earth shell over the liquid core and the accompanying drift of continental crustal masses. Studies of tectogenic structures and alteration of sedimentary facies on the ocean bottom make it possible to determine the course of displacements of the earth shell and of drift of the continents during the Cenozoic. — V. S. N.

- 185-273. Raven, Theodore. Alpine folding as related to continental drift: *Eclogae Geol. Helvetiae*, v. 53, no. 1, p. 161-168, 1960.

Modern ideas of Alpine paleogeography are reconciled with the hypothesis of continental drift. The fact that the main orogenesis was not contemporaneous with or immediately subsequent to the collision at the end of the Jurassic of northeastward-drifting Africa and eastward-drifting Eurasia is explained if the acme of compression occurred when the convection currents had optimal speed and power but the acme of drift was when the slowly accelerating cur-

rents were not yet bothered by sial in their descending branches (before the Tethys was bridged by sial in its floor). In Early Cretaceous the mechanism changed from the type conceived by Holmes to that of Vening Meinesz—the convection system disengaged from the continental crust when sial entering into the root acted as a brake.

Holmes' idea of a wide Tethys separating Gondwanaland from Laurasia is accepted; the paleogeographic evidence allows this essential departure from Wegener's concept of Pangaea. With this arrangement the Carboniferous coal fields of the northern hemisphere fall in the tropical belt, and the Permocar-boniferous glacial deposits that are too extensive to have been due to mountain glaciers are conveniently grouped around the South Pole. Two land bridges permitted land plants and animals to cross the Tethys, the eastern one represented by the continuous sialic swell still connecting southeast Asia to Australia, and the western one comprising the sialic crust under Italy and part of the ocean floor between the Azores and Portugal and Morocco. — D. B. V.

- 185-274. Evison, F. F. On the growth of continents by plastic flow under gravity: Royal Astron. Soc. Geophys. Jour., v. 3, no. 2, p. 155-190, 1960.

A coherent explanation of many major geologic phenomena follows from the hypothesis that the strength of basement rocks at shallow levels is very small for long-continued stresses, and that gradual plastic flow occurs widely in a superficial layer of the crust. A likely mechanism of flow in a layer 2-3 km thick is that of solution and recrystallization. It is shown that the continental masses are approximately in equilibrium for a yield point of the order of  $10^6$  dper  $\text{cm}^2$ ; and increase in their average height by volcanic or orogenic activity causes the continents to grow in area and thus to encroach on neighboring oceans. The growth pattern is generally asymmetrical and changes with time; recent rates of radial expansion have ranged up to the order of 0.1 cm per yr.

The configuration of the slip-line field in a plastic sheet suggests a mechanism of geologic faulting by shear fracture induced by plastic flow. Rift valleys and tilted blocks are thus seen as essentially shallow phenomena. Thrust sheets and insular aprons are attributed to extrusion at the base of plastically subsiding mountains and seamounts. The fundamental postulate of stress tectonics, that the crust is acted upon by horizontal forces originating in the mantle, becomes largely redundant. Disturbances projected into the substratum as a result of superficial flow are linked with orogenic, volcanic, and seismic activity in a complex of cause and effect. It is suggested that mid-oceanic elevations develop by deformation of the substratum due to progressive loading at the adjacent margins as the continents expand. — D. B. V.

- 185-275. Bondarchuk, V. H. Proheolohichni rukhy i yikh pokhodzhennya [On geologic movements and their origin (with Russian summary)]: Akad. Nauk Ukrain. RSR Heol. Zhur., v. 20, no. 1, p. 3-16, 1960.

Geologic movements are geocosmic (simple mechanical displacements), tectonic (more complex mechanical and physical movements with related sub-tectonic plastic movements), gravitational (complicated mechanical displacements and physicochemical processes), and geochemical (very complex movements of matter affecting the entire thickness of the outer shell of the earth). Their character and direction vary with the composition and physical state of the mineral mass. The outer mobile part of the earth, or tectonosphere, consists of the bathytectonic (deep), hypotectonics (intermediate, and epitectonic (shallow) zones. In the bathytectonic zone polar flattening and equatorial expansion occur as a result of the earth's rotation; these are related to deep migration

and differentiation of matter. In the crust, or hypotectonic zone, the chief motions are subsidence or uplift; magma generation is one of the forms of tectonic movement connected with geosynclinal subsidence. The epitectonic region is the scene of gravitational movements which bring about a complete qualitative reorganization of the material of weathering, erosion, and sedimentation. — D. B. V.

- 185-276. Peyve, A. V. Tektonika i magmatizm [Tectonics and magmatism]: Akad. Nauk SSSR Izv. Ser. Geol., no. 3, p. 36-54, 1961.

Recognition of the block structure of the earth's crust and of the importance of horizontal movements is fundamental in modern tectonic concepts. The problem of crustal structure and movements and their relation to magmatism is examined in this review, written to honor the memory of F. Yu. Levinson-Lessing. — D. B. V.

- 185-277. Charlesworth, H. A. K. Some observations on the origin of the earth's crust: Edmonton Geol. Soc. Quart., v. 4, no. 11, p. 1-7, 1960.

The oceanic crust or sima should be considered as an extension of the upper mantle since it is chemically indistinguishable from it; its thickness is controlled by the depth at which the basalt-eclogite transition occurs, and this depends on the temperature variation within the upper mantle. As basalt is added to the sima by extrusion on the ocean floor, isostatic depression occurs, leading to a temporary lowering of the M-discontinuity; as basalt changes to eclogite and equilibrium is restored, the thickness of the sima is kept approximately constant. Epeirogenic movements of both oceanic and continental crustal areas may be caused by temperature changes in the neighborhood of the M-discontinuity (possibly associated with convection currents in the mantle).

Recent studies by Officer et al (see Geophys. Abs. 180-243) suggest that continents are made up of segments that are the end-product of periods of sedimentation and volcanic and orogenic activity. The raw material that contributes to continental growth is andesite produced by differentiation or some similar process within the crystalline mantle. The cycle of activity in continental accretion is discussed and illustrated. Eventually continental sial will probably cover the entire earth's surface, continental drift will no longer be possible, and the present type of mountain building will come to an end. — V. S. N.

- 185-278. Sheynmann, Yu. M. Velikiye obnovleniya v tektonicheskoy istorii Zemli [Major rejuvenations in the tectonic history of the earth (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 104-113, 1960.

Stille's distinction of three major periods of structural development separated by epochs of rejuvenation is examined in the light of recent Precambrian age determinations. Present knowledge confirms the fact of structural rejuvenation. This regeneration is regional and does not involve the whole earth during a given period. The process is not a simple rejuvenation of existing structures, but involves the formation of new patterns. In the destruction of preexisting platforms and their marginal belts, some parts develop into new geosynclinal systems and others form the cratons of the next epoch; the concept of an old nucleus gradually expanding by addition of younger structures is incorrect.

Two or three periods of regeneration can be distinguished in the basements of Africa and India and probably also of the Canadian and Russian platforms. The oldest periods of regeneration evidently were not contemporaneous. The process of destruction and regeneration began at least 3,000 million years ago, when platforms and geosynclines were created. — D. B. V.

- 185-279. Lindström, Maurits. Methods of differentiating tectonic regimes: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 347-352, 1960.

Large amounts of data are required to distinguish chance deformation of the crust from regularly occurring trends of tectonic regimes. Furthermore, to differentiate tectonic regimes one must be able to distinguish unimodal from polymodal or discontinuous variation in the deformation features. This cannot be done solely from maps, but requires synoptic diagrams that disregard the local context of data. The significance of small-scale data which can be collected in vast amounts (such as lineations, interrelations of small folds, or  $\beta$ -intersections of cleavage planes) is discussed in the light of experience in the northern Caledonides of Sweden. — D. B. V.

- 185-280. Wilson, J. Tuzo. Geophysics and continental growth, in Science in progress, 11th ser.: New Haven, Yale University Press, p. 61-91, 1960.

This is virtually the same as the paper published in Am. Scientist, v. 47, no. 1, p. 1-24, 1959 (see Geophys. Abs. 176-162). — V. S. N.

- 185-281. Pushcharovskiy, Yu. M. Osobennosti tektonicheskogo stroyeniya i razvitiy krayevykh progibov [Features of the tectonic structure and development of foredeeps (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 73-79, 1960.

The term longitudinal foredeep, or simply foredeep, should be applied only to deep linear synclines located at the junction of platform and folded areas, which originate and develop during the period of completion and uplift of geosynclines. There are essential differences between foredeeps bordering old (Precambrian) and young platforms. Those of the former group consist of an outer zone in which dislocations are of platform type and an inner zone of folding, whereas those of the latter group, which are exceptionally disproportional, have no such division. The simpler structural features of the second group are explained by the comparative mobility of young platforms; as they are more yielding, conditions are favorable for the smoother discharge of tectonic strains. — D. B. V.

- 185-282. Stovas, M. V. Deyaki zakonornosti v hoehrafichnomy rozpodili platform i skladchastosti [Some regularities of the geographic distribution of platforms and folding]: Akad. Nauk Ukrainy. RSR Heol. Zhur., v. 20, no. 4, p. 54-61, 1960.

The distribution of platform and geosynclinal areas is explained in terms of deforming forces called into play by variations in the earth's rotational velocity (see Geophys. Abs. 178-52, -206, -207; 179-192; 180-52). — D. B. V.

- 185-283. Glangeaud, Louis, Caire, André, and Grandjacquet, Claude. L'orogénèse ponto-plio-quaternaire de l'arc calabrosicilien et ses caractères géodynamiques [The Ponto-Plio-Quaternary orogenesis of the Calabro-Sicilian arc and its geodynamic features]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 1, p. 145-147, 1961.

Data from gravimetric and seismologic investigations are used in conjunction with structural and geomorphic evidence to explain the formation of the Calabro-Sicilian arc. Two phases of folding are recognized, one earlier and the other later than deposition of the Miocene polychrome series. — D. B. V.

- 185-284. Sugimura, Arata. Zonal arrangement of some geophysical and petrological features in Japan and its environs: Tokyo Univ. Fac. Sci. Jour., sec. 2, v. 12, pt. 2, p. 133-153, 1960.

The topography, gravity, earthquake seismology, and volcanic petrology of Japan and its environs exhibit a regular zonal arrangement along two island arcs—one from Kamchatka through the Kuriles, northeast Japan, and the Si-tito (Shichito) to the Mariana Islands; the other from Kyushu through the Ryukyu Islands to Taiwan. Each zone is characterized by a foredeep; a characteristic distribution of gravity anomalies, seismic velocities, younger volcanoes and hot springs; and a seismic plane which slopes toward the continent. The chemical compositions of the basaltic rocks of the Japanese volcanoes show a near constant value for each volcano as well as a geographic distribution of the values that seems to be related to the above zones and particularly to the depths of earthquake focuses. The deeper the earthquake focus, the more alkalic are the rocks erupted above it; the shallower, the more silicic. A grouping of volcanoes of Japan into two volcanic belts based on zonal relationships is proposed to replace the currently used volcanic zones. — V. S. N.

- 185-285. Azhgirey, G. D. Geologicheskkiye usloviya formirovaniya, kinematika i dinamika obrazovaniya skladok geosinklinal'nogo tipa [Geologic conditions of forming, kinematics, and dynamics of evolution of folds of geosynclinal type (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 59-64, 1960.

In geosynclines folding is due mainly to upward plastic flow of material under tangential compression. Study of flow cleavage provides the most valuable data on the kinematic conditions of deformation. The festoon, arcuate plan characteristic of almost all folded belts can be explained only by tangential deforming forces oriented transversely with respect to the trend of the linear folds. Horizontal shifting along the strike, also caused ultimately by tangential forces, sets folded complexes en echelon with respect to the strike of the fold belt as a whole.

The main systems of anticlines of geosynclinal type are formed above older deep faults; this position is determined by an increase in heat flow along these faults at times of more intense orogeny. The concept that the main stages of folding and orogenic uplift are not contemporaneous is contradictory to the established kinematic conditions of folding. — D. B. V.

- 185-286. Azhgirey, G. D. Dva geneticheskikh tipa geosinklinal'noy skladchatosti [Two genetic types of geosynclinal folding]: Moskov. Univ. Vestnik, Ser. 4, Geol. no. 6, p. 13-26, 1960.

Folding in the central tectonic zones of geosynclines during the early stages of the tectono-magmatic cycle is greatly different from that during the late stages. The early folding is synsedimentary and develops under conditions of general subsidence of the crust. The late folding is orogenic and is expressed by a general uplift of the crust in the mobile belts. Examples of these two types of folding in the Greater Caucasus are discussed. — J. W. C.



- 185-287. Scheidegger, A[drian] E[ugen]. Faults and earthquakes: Canadian Oil and Gas Industries, v. 14, no. 4, p. 33-42, 1961.

An evaluation of the stresses within the earth and the effect of these stresses on deformation of the material composing the earth should make it possible ultimately to tell what kind of structures will be found in various places near the surface. Such information would be of great importance in oil exploration. Several theories—contraction, polar wandering, convection, and continental drift—for the physical processes or orogenies that may have caused the deformations of the earth's crust are reviewed briefly. Most of the theories lead to a very uniform stress state in the crust, and this stress state should be responsible for all of the deformations. The effects of the stresses may be studied by geological field work; study of well fracturing data and seismic observations are means of determining the actual stresses. Fault plane solutions are discussed in some detail as a key to the large-scale tectonic picture of an area. Examples are cited from the Caucasus and eastern Asia. — V. S. N.

- 185-288. Oulianoff, N[icolas]. Cassures, eau et déplacements des masses rocheuses par les efforts tectoniques [Fractures, water, and displacements of rock masses by tectonic forces]: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 277-279, 1960.

Folds are actually the sum total of innumerable very small fractures. Fossil waters set in motion by tectonic forces lubricate fractures of all dimensions and facilitate the deformation of rock masses by those forces. — D. B. V.

- 185-289. Peyve, A. V. Razlomyy i ikh rol' v stroyenii i razvitiy zemnoy kory [Fractures and their role in the structure and development of the earth's crust (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 65-72, 1960.

The English version of this paper has been published in the Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 280-286, 1960 (see Geophys. Abs. 184-352). — D. B. V.

Tazieff, Haroun. Concerning the tectonic significance of large landslips provoked by the great Chilean earthquake of May 1960. See Geophys. Abs. 185-131.

- 185-290. Ehara, Shingo. The Kaikoura diastrophism and the Fossa Magna disturbance: Jour. Geography [Tokyo], v. 69, no. 5, p. 200-208, 1960.

The middle Tertiary orogenic movements in New Zealand (Kaikoura diastrophism) and in Japan (Fossa Magna disturbance) are believed to have produced the deep earthquake zones that are associated with the westward dipping fault zones intersecting the Tonga-Kermadec Trench off New Zealand and the Shichito Trench off Japan. These fault planes are believed to represent the boundary between the underthrusting forces of the Pacific basin and the overthrusting forces of the Asiatic continent. — V. S. N.

- 185-291. Khain, V. Ye. Osnovnyye tipy tektonicheskikh struktur, osobennosti i prichiny ikh razvitiya [Main types of tectonic structures, their features and causes of development (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 89-103, 1960.

This is the Russian version of a paper published in English in *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 18, p. 215-226, 1960 (see *Geophys. Abs.* 183-319). — D. B. V.

Rodiger, Kurt. Analysis of salt dome uplifts with the aid of electric logging, as shown at the Bramstedt and Etzel salt domes. See *Geophys. Abs.* 185-211.

185-292. Sim, Victor W. Maximum post-glacial marine submergence in northern Melville Peninsula: *Arctic*, v. 13, no. 3, p. 178-193, 1960.

The crustal depression produced by the weight of the ice sheet over the Melville Peninsula on the east coast of the Northwest Territories, Canada, is estimated to have been at least 1,100 feet. The amount of uplift in the peninsula to date has been approximately 450 feet and, assuming that the process of depression is completely reversible, the crust should rise another 650 feet before equilibrium will have been reestablished. At present there is no method of measuring the amount of early recovery that took place as the ice started to melt and before the margin retreated sufficiently to allow the sea to inundate the land to form strandlines. Four criteria for determining the post-glacial marine submergence in this area are discussed in detail: (1) the highest altitude at which marine shells occur; (2) the highest altitude at which strandlines are preserved; (3) the lowest altitude at which undisturbed ground moraines can be recognized; and (4) the lowest altitude at which perched boulders are found. — V. S. N.

185-293. Kropotkin, P. N. *Neotektonika i geofizicheskiye dannyye o tolshchine i deformatsiyakh zemnoy kory* [Neotectonics and geophysical data on the thickness and deformations of the earth's crust (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov*, Problema 18, p. 80-88, 1960.

Neotectonic maps showing total vertical displacements during Neogene and Quaternary time have been compiled for the U.S.S.R. as a whole, for the world, for individual continents, and for certain areas within the U.S.S.R. These have been compared with the gravimetric maps (Bouguer) compiled by Kropotkin and Lyustik (1956-58) which also give seismic data on crustal thickness.

Horizontal movements of individual crustal blocks evidently play a predominant role in recent deformation. Tension results in the formation of large troughs, the expansion of ocean basins, and thinning of the crust; compression results in thickening of the crust and formation of folds and overthrusts. The most recent major structural units of the crust are oceanic platforms, geosynclines, and continental platforms. Within the latter, stable and mobile areas may be distinguished according to the degree of recent deformation. — D. B. V.

Shepard, Francis P. Rise of sea level along northwest Gulf of Mexico. See *Geophys. Abs.* 185-35.

Koldewijn, B. W. Sediments of the Paria-Trinidad shelf. See *Geophys. Abs.* 185-37.

185-294. Popov, V. V., and Chernyavkina, M. K. *Nekotoryye rezultaty nablyudeniy nad deformatsiyami zemnoy poverkhnosti na geofizicheskoy stantsii "Yalta."* [Some results of observations of deformations of the earth's surface at the geophysical station "Yalta"]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 7, p. 1005-1012, 1960.

An attempt to develop and employ an efficient method for interpreting and evaluating the observation data on tilting and slow deformation of the crust at the geophysical station "Yalta" is reported. Diurnal periodic displacements having harmonics of the first and second orders are definitely established. The amplitude maximums of both harmonics occur during summer months, having maximum values of  $10^{-7}$  and  $2 \times 10^{-8}$ , respectively. The forms of vector diagrams of variations in diurnal deformations are similar, but their amplitudes and the directions of their major axes change from month to month turning from NW to SE in winter and in the opposite direction during the summer. An annual periodicity in amplitude and direction of tilt and displacement is qualitatively established, and approximate amplitudes of the components are given. — A. J. S.

- 185-295. Sakaguchi, Yutaka. The crustal movement of Hokkaido in the latest geologic age [in Japanese with English abstract]: *Geog. Rev. Japan*, v. 32, no. 8, p. 401-431, 1959.

Recent crustal movements in Hokkaido as illustrated by two marine terraces in the Haboro district in northwestern Hokkaido are described. The relation of the terrace altitudes to tectonic movements in Hokkaido and the chronology of the terrace-surface-forming periods are discussed. It is shown that the coast lines with large vertical displacements of former shore lines are parallel to a series of major structural lines and to the Ezo Arc; this indicates that the activity of the Kuril Arc has continued during the latest geologic time. — V. S. N.

## GLACIERS

- 185-296. Allen, C[larence] R., Kamb, W. B[arclay], Meier, M[ark] F., and Sharp, R[obert] P. Structure of the lower Blue Glacier, Washington: *Jour. Geology*, v. 68, no. 6, p. 601-625, 1960.

The physical behavior of glacier ice is of particular interest as an indication of how other rocks may react under conditions of higher temperature, confining pressure, and stress. In this paper results are discussed of a study of some structures in the Blue Glacier—the foliation pattern, an unusual longitudinal septum, ogives, crevasses, and related ice fabric. A 300-m icefall separating the major accumulation basins from the ice tongue plays a dominant role in the formation of the principal foliated structures. Three types of ice are involved, coarse-bubbly ice, coarse-clear ice, and fine ice. Most or all of the latter represents partly recrystallized insets or infolds of firn. — V. S. N.

- 185-297. Sharp, Robert P., Epstein, Samuel, and Vidziunas, Irene. Oxygen-isotope ratios in the Blue Glacier, Olympic Mountains, Washington, U. S. A.: *Jour. Geophys. Research*, v. 65, no. 12, p. 4043-4059, 1960.

The mean permil deviation from a standard (average ocean water) in the  $O^{18}/O^{16}$  ratio of 291 specimens of ice, firn, snow, and rain from the Blue Glacier is -12.4; extremes are -8.6 and -19.2. This is consistent with the moist temperate climatological environment. The  $O^{18}/O^{16}$  ratio of snow decreases with declining temperature of precipitation, and it also decreases with increasing altitude at a rate of 0.5 per 100 m. The ratios for coarse-clear ice are generally lower and for fine ice generally higher than for coarse-bubbly ice. This indicates that the fine ice represents masses of firn and snow recently incorporated into the glacier by filling of crevasses or by infolding in areas of severe deformation. Coarse-clear ice masses may re-

present fragments of coarse-bubbly ice within a breccia formed in the icefall; because of unfavorable orientation, these fragments could have undergone exceptional recrystallization with reduction in air bubbles and, possibly, a relative decrease in  $O^{18}$ .

A longitudinal septum in the lower Blue Glacier is characterized by higher than normal ratios, consistent with an origin involving incorporation of much surficial snow and firn near the base of the icefall. Samples from longitudinal profiles on the ice tongue suggest that ice close to the snout comes from high parts of the accumulation area. Analyses from the light and dark bands of o-gives are compatible with the concept that the dark bands represent greatly modified insets of firn-ice breccia filling icefall crevasses.

The range in ratios is much greater in the accumulation area than in the ice tongue; this is attributed to homogenization, mostly during the conversion of glacier ice. This concept is supported by comparative analyses of snow when new and months later after alteration. Refreezing of rain and meltwater percolating into underlying cold snow is an important mechanism, as shown by analyses of ice layers and lenses in the firn formed in this manner. — D. B. V.

- 185-298. Paterson, W. S. B. Movement of the Sefstrøms Gletscher, north-east Greenland: *Jour. Glaciology*, v. 3, no. 29, p. 845-849, 1961.

In the summer of 1958 weekly observations were made of the horizontal and vertical components of surface movement of the Sefstrøms Gletscher, north-east Greenland. The glacier is of the subpolar type in Ahlmann's classification. Results of measurements on 18 markers are given in tables. The most conspicuous features of the transverse profile are the very rapid increase in velocity across the marginal zones and the presence of a central zone, 400 m wide, in which the velocity is approximately constant. Along the longitudinal profile the glacier is in a state of extending flow, which is consistent with Nye's concept. Vertical movement measurements show that the direction of ice flow is upward relative to the surface although the surface component decreases with distance down the glacier. Melting observations were also made, and an estimate of ice thickness was derived from measurements of surface slope. — V. S. N.

- 185-299. Brockamp, Bernhard. Erweiterter Nachtrag zu den wissenschaftlichen Ergebnissen der Deutschen Grönland-Expedition Alfred Wegener [Expanded supplement to the scientific results of the Alfred Wegener German Greenland expedition]: *Deutsch. Geod. Komm. Veröffentl.*, ser. B, no. 48, 76 p., 1959.

The first part of this paper reports results of measurements of altitude and temperature made during several traverses from the coast to the "Eismitte" station in the center of the Greenland Ice Cap. Two profiles are reproduced, West Station-Eismitte and north route.

The second part reports results of measurements of ice thickness and temperature. The ice thickness calculated from Bouguer gravity anomalies is 1,510, 1,820, and 2,815 m for points 82, 120, and 300 km inland, respectively. Seismic refraction and reflection surveys showed that the thickness of the firn (firn depth = depth where ice density reaches 0.91) is 40-50 m at 42 km inland, 100 m at 62 km, 140-150 m at 120 km, and, by extrapolation, about 350 m at the center of the icecap. Elastic wave velocities in the ice show a temperature effect: At 0°C, longitudinal wave velocity is 3.60 km/s and transverse wave velocity is 1.68 km/s; at -6.5°C, corresponding velocities are 3.72 and 1.75 km/s; at -10°C, 3.80 and 1.8 km/s; and at -18°C (150 m deep), 4.0 and 1.85 km/s. A pressure effect surely must also exist, but could not be ascertained from the seismic measurements.

Plasticity also is affected by temperature. The viscosity coefficient  $\eta$  is  $1 \times 10^{-14} \text{ g cm}^{-1} \text{ sec}^{-1}$  for glacier ice at melting temperature, and  $1 \times 10^{-15} \text{ g cm}^{-1} \text{ sec}^{-1}$  at 24 m depth, where the temperature is  $-14^\circ\text{C}$ . The ice surface closely reflects bedrock topography nevertheless. Near the coast where the ice is quite plastic throughout and under high lateral pressure, no long or large spaces can exist; they are constantly filled in and corresponding valleys appear at the ice surface. — D. B. V.

185-300. British Glaciological Society. Field work: Ice, British Glaciological Soc. News Bull., no. 7, 16 p., 1961.

Reports on some of the projects carried out by the Subcommittee on Glaciology of the Associate Committee on Geodesy and Geophysics, National Research Council of Canada, in the summer of 1960 are summarized briefly. Areas in Canada, Alaska, the Arctic, Norway, Switzerland, and the Antarctic are included. The work on inventory of Canadian glaciers, and photogrammetric and laboratory studies are summarized also. Full reports will be published in the Canadian Geophysical Bulletin for 1960. — V. S. N.

Vallon, Michel. Thickness of the Tacul glacier (Mont Blanc massif). See Geophys. Abs. 185-548.

#### GRAVITY

185-301. Goguel, Jean. Calcul de l'attraction d'un polygone horizontal de densité uniforme [Calculation of the attraction of a horizontal polygon of uniform density (with English abstract)]: Geophys. Prosp., v. 9, no. 1, p. 116-127, 1961.

The vertical component of the gravitational attraction exerted by a horizontal homogeneous polygon is obtained as the sum of terms proportional to the difference, for each of the vertices, between the external angle and its spherical perspective. A set of 5 computation charts is presented, each for a fixed value of the angle of the polygon, that give the difference between the external angle and its spherical perspective as a function of the quotient of the distance from the sides to the vertical through the station over the depth. The chart for the right angle is an alinement chart, permitting a rather accurate reading; the others are graphs in rectangular coordinates.

For a distant station the result would be obtained as a small difference between relatively large quantities, and hence would not be very precise; for such stations it is preferable to assume that the entire mass is concentrated at the center of gravity. — D. B. V.

185-302. Lambert, Walter D. Note on the paper of A. H. Cook, "The external gravity field of a rotating spheroid to the order of  $e^3$ ": Royal Astron. Soc. Geophys. Jour., v. 3, no. 3, p. 360-366, 1960.

In the paper in question (see Geophys. Abs. 180-179), Cook's formulas for the potential of a rotating spheroid stop with the term in  $P_6(\sin \phi)$ , which is given to an accuracy of  $e^3$ . This note states, without proof, formulas for the coefficients of  $P_{2n}(\sin \phi)$  with no limit on  $n$  and no limit to the formal numerical accuracy of such coefficients. It is also suggested that some of Cook's other formulas may be simplified by a slight change in notation. — D. B. V.

- 185-303. Boaga, Giovanni. Sulla determinazione della densità media del Geoid per mezzo di gravità osservate a latitudini diverse [On the determination of the mean density of the geoid by means of gravity observed at different latitudes]: *Accad. Naz. Lincei Atti Cl. Sci. Fis., Mat. e Nat. Rend.*, v. 26, no. 3, p. 316-320, 1959.

Using Somigliana's formula for the gravity field of an ellipsoid of rotation and gravity values observed at 20 places covering a wide range of latitudes and longitudes, the mean value of the density of the geoid is calculated to be  $5.5174 \pm 0.0002$ . This agrees well with the value of 5.52 obtained experimentally and accepted by the International Union of Geodesy and Geophysics, and with the value of  $5.516 \pm 0.005$  given in the "Handbuch der Geophysik," which is an average of 7 values. This demonstrates from another point of view the great practical importance of Somigliana's formula. — D. B. V.

- 185-304. Coloma Pérez, Antonio. Sobre las estructuras corticales plano-paralelas [On plane-parallel crustal structures]: *Rev. Geofísica*, v. 19, no. 73, p. 1-12, 1960.

The relationships found by Lozano Calvo are generalized for use in the case of horizontal crustal layering. A formula is given for density of the upper medium, bounded by the surface of the earth, which is shown to be independent of the other mediums so far as the formula is concerned. Formulas are also given for the thickness of the second layer and for the depth to the first discontinuity. Difficulties encountered in applying these formulas in the Segovia region of Spain and steps taken to overcome these difficulties are described. — D. B. V.

- 185-305. Misra, Markandeya. Some axially symmetric empty gravitational fields: *India Natl. Inst. Sci. Proc.*, v. 26, pt. A, no. 6, p. 673-680, 1960.

An axially symmetric gravitational field has been considered in oblate spheroidal coordinates. It is well known that one of the field equations for an empty space-time in case of axially symmetric gravitational fields is the Laplace equation. Three special solutions of the field equations  $T^{\alpha}_{\beta} = 0$  have been obtained. Considering the motion of test particles two of the solutions are identifiable as the relativistic analogues of the Newtonian field due to an oblate spheroidal homoeoid and the field due to a homogeneous oblate spheroid respectively. The equations of motion to the first order of approximation reduce to the well-known Newtonian form. — Author's abstract

Arnold, Kurt. Contributions to gravimetric geodesy. See *Geophys. Abs.* 185-249.

de Graaff-Hunter, J[ames]. The shape of the earth's surface expressed in terms of gravity at ground level. See *Geophys. Abs.* 185-253.

Beck, A[lan] E. Energy requirements of an expanding earth. See *Geophys. Abs.* 185-262.

Coloma Pérez, Antonio. On the potential of attraction of a nonhomogeneous sphere. See *Geophys. Abs.* 185-345.

- 185-306. Danes, Z. Frankenberger. On a successive approximation method for interpreting gravity anomalies: *Geophysics*, v. 25, no. 6, p. 1215-1228, 1960.

A new method of quantitative interpretation of gravity anomalies is presented. The disturbing body is represented by a finite number of vertical prisms arranged on a predetermined, regular grid. The horizontal dimensions of individual prisms are small enough that they can be approximated by vertical-line mass elements at the axis of the prisms. Formulas for gravity due to one prism are derived and, for the case of Gulf Coast salt densities, plotted on a graph. Gravity due to the whole body is an algebraic sum of the contributions of all prisms at the appropriate depths and distances. Direct interpretation is possible by successive approximations, introducing proper geologic limitations. The method is particularly suitable for features with a predominantly vertical dimension such as salt domes and igneous plugs. Accuracy is as good or better than that of graphical dot chart methods, and with a digital computer (on which all the numerical work can be done conveniently) should be about a thousand times faster. — D. B. V.

- 185-307. Pham-Van-Ngoc. Prospection gravimétrique par mesure directe des dérivées secondes verticales de l'intensité de la pesanteur [Gravimetric prospecting by direct measurement of the vertical second derivatives of the intensity of gravity]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 18, p. 1889-1891, 1960.

Vertical second derivatives of gravity can be measured in the field by a new technique proposed by Cagniard which gives the "pseudoderivatives" more precisely than current methods of calculation. If  $M_1, M_2, \dots, M_n$  are the points of a regular polygon with  $n$  sides inscribed in a circle of radius  $r$ , the pseudoderivative ( $C$ ) of gravity ( $g$ ) at the center ( $0$ ) of the polygon for horizontal ground would be  $C = 4/nr^2 [ng(0) - g(M_1) - g(M_2) - \dots - g(M_n)]$ . The grouping and spacing of stations is chosen to suit the terrain and object of exploration; for instance, in petroleum prospecting an equilateral triangle and  $r = 500$  m could be used, and in mineral prospecting a square and  $r = 50$  m or less. The gravimeter is carried from the center to the points to measure the raw differences in  $g$  between the  $n+1$  stations of the group, and  $C$  is calculated from the formula.

The topographic and gravity measurements can be made with maximum precision. Because the measurements of  $g$  are "reduced" to an independent local level, the center of the polygon, the Bouguer and free-air corrections (which may be seriously affected by errors in altitude and uncertainties concerning density) are dispensed with entirely. The topographic corrections, generally very small, can be calculated totally to combine simplicity, rapidity, and precision. A chart is given for the topographic corrections for the case of an equilateral triangle grouping. — D. B. V.

- 185-308. Halushko [Galushko], P. Ya. Analiz zalezhnosti izostatichnykh anomalii vïd budovy zemnoyi kory v oblasti okeanichnykh prostoriv [Analysis of the dependence of isostatic anomalies on crustal structure in regions of oceanic expanses (with Russian summary)]: Akad. Nauk Ukrain. RSR Heol. Zhur., v. 20, no. 5, p. 18-29, 1960.

Isostatic anomalies over oceans do not truly reflect the quantitative distribution of mass in the crust. Isostatic reductions should be replaced by the method of structural compensation described in this paper. Calculations show that in the reduction of gravity observations at sea the density of the compensating mass should be  $0.4 \text{ g per cm}^3$ , which is the difference between the density ( $3.2 \text{ g per cm}^3$ ) of the part of the subcrustal layer lying above the depth of compensation and that of the crustal mass ( $2.8 \text{ g per cm}^3$ ) above it. A structural reduction is illustrated for Vening Meinesz' profile no. 16 across the

Indonesian Archipelago. In this reduction broad fields of positive anomalies are absent, but the belts of negative anomalies include the deep sea trenches. Structural anomalies are easily interpreted by introducing suitable changes in the structurally compensated model to bring the disturbed field to uniformity. — D. B. V.

- 185-309. Kazinskiy, V. A. Interpretatsiya gravitatsionnykh poley, porozhdayemykh krutopadayushchimi geologicheskimi telami [Interpretation of gravity fields produced by steeply dipping geologic bodies]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 595-601, 1961.

The approximation theory of geophysical anomalies and reductions based on an oblique coordinate system is analysed mathematically and discussed. The anomalies and reductions for steeply dipping geologic bodies of arbitrary form are considered, and a mathematical technique is developed that saves substantial time and labor in evaluation and interpretation of anomalies. — A. J. S.

- 185-310. Graf, Anton, and Schulze, Reinhard. Improvements on the sea gravimeter Gss2: Jour. Geophys. Research, v. 66, no. 6, p. 1813-1821, 1961.

Improvements on the Askania "Sea Gravimeter Gss2 after Graf" that have considerably widened the scope of application of the instrument are described, particularly the results of the heavier damping used. Accelerations of up to  $\pm 100,000$  mgal produced in the laboratory caused discrepancies of only about 2 mgal between the static and mean dynamic values. Completely irregular accelerations with peaks up to 200,000 mgal yielded dynamic mean values that did not deviate appreciably from the static value. With the new gyro-stabilized platform it is possible to obtain accurate results even in rather rough seas. All the disturbing effects predicted by theory can now be either eliminated by suitable measurement procedure or else accounted for. — D. B. V.

- 185-311. Harrison, J[ohn] C. The measurement of gravity at sea, in Methods and techniques in geophysics, v. 1: New York, Interscience Publishers, Inc., p. 211-229, 1960.

The instrumental difficulties in the measurement of gravity at sea and the history of sea-going gravimeters are discussed briefly. The Vening Meinesz pendulum apparatus has proved to be very reliable when used on submarines. For various operational reasons and because of the lengthy computations needed, the pendulum apparatus is being replaced rapidly by gravimeters for measurements at sea. Theoretical considerations of gravimeters to be used at sea are discussed, and it is concluded that such a gravimeter may be stabilized along the true vertical or be allowed to swing in a gimbal suspension; corrections to be made in each case are summarized. Brief descriptions of the Graf, LaCoste, and vibrating-string gravimeters are given. — V. S. N.

- 185-312. Sazhina, N. B. Ob oshibkakh morskoi gravimetricheskikh opredeleniy na nadvodnykh sudakh [Errors in gravimetric determinations at sea on ships]: Razvedochnaya i Promyslovaya Geofizika, no. 23, p. 70-73, 1958.

Pendulum surveys were made in the Caspian Sea during 1935-36 and 1949-51. The coastal regions of the Azerbaijan S.S.R. have subsequently been surveyed more accurately with bottom gravimeters. The results of the two methods are compared. The errors in the pendulum determinations are attributed to roll of the ship and miscalculation of geographic position. — J. W. C.



- 185-313. Damrel, J. B. The effect of temperature and time on the scale factor of the Worden Gravity Meter: *Boll. Geofisica Teor. ed Appl.*, v. 2, no. 8, p. 567-573, 1960.

For the purpose of checking the scale factors of the Worden Gravimeter at various temperatures, tests were made on several instruments. All calibration tests were made on a test calibrator at element temperatures ranging from 40°C to 50°C. The results indicate an increase in scale factor with increase in element temperature of approximately 0.13 percent per °C. Tests to determine the effect of time on the scale factor indicate that there is no change in scale factor with time as such. There is a decrease in scale factor, however, with a change in the pressure inside the element container assembly. This change in pressure is a function of time, but will vary widely from instrument to instrument depending upon the degree of vacuum integrity of the evacuated system. Also, the gradual change in pressure inside the evacuated container has direct influence upon the thermal drift characteristics. Some obvious precautions are proposed to aid in obtaining higher quality gravity data. — V. S. N.

- 185-314. Tulin, V. A. Термостат с непрерывным регулированием [Thermostat with continuous control]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 10, p. 1499-1503, 1960.

A thermostat for continuous control of temperature of the element assembly of gravimeters was constructed and tested. The theory of the instrument is discussed and practical suggestions given for its adjustment. With a change of 32°C in the ambient temperature, a control coefficient of the order of 500 was attained when the amplification coefficient of the amplifier was about 1,000 and no compensation introduced. — A. J. S.

Bulakh, Ye. G. Application of electric calculating machines for interpretation of magnetic and gravity anomalies. See *Geophys. Abs.* 185-477.

- 185-315. Grossmann, Walter. Bestimmung der Schwereunterschiede Zwischen europäischen Flughäfen mit einem Askania-Gravimeter GS 12 [Determination of the gravity differences between European airports with an Askania GS-12 gravimeter]: *Deutsch. Geod. Komm. Veröffentl.*, ser. B, no. 66, 36 p., 1960.

Gravity measurements were made during 1958-60 at various airports in western Europe in order to connect first order stations of the European network. Observers carrying an Askania GS-12 gravimeter made numerous trips by commercial airlines and took their measurements during scheduled stops. The good internal agreement of the results indicates that this instrument is well suited to large scale measurements with transport by air between stations. — D. B. V.

- 185-316. Robertson, H. W., and Garrick, R. A. Gravity measurements in New Zealand with the Cambridge pendulum apparatus: *New Zealand Jour. Geology and Geophysics*, v. 3, no. 4, p. 626-642, 1960.

A framework of 19 gravity reference stations was established in New Zealand during 1947 and 1948 using the Cambridge pendulum apparatus. The gravity values, referred to the Cambridge (England) value of 981,250.0 mgal, were obtained by swinging the 6 pendulums at Cambridge before and after the New Zealand observations were made. Full details of the results and station locations are given. — D. B. V.

- 185-317. Algermissen, S. T. Underground and surface gravity survey, Leadwood, Missouri: Geophysics, v. 26, no. 2, p. 158-168, 1961.

A surface gravity survey consisting of 214 stations covering approximately 4 sq mi was conducted over and adjacent to the North Leadwood Mines at Leadwood, Mo. A corresponding survey of 278 stations was carried out in the mine workings. A method of reducing underground gravity observations is outlined. The principal factors limiting the accuracy of the underground observations are given. Methods for determining rock densities are described. A comparison of the surface and underground gravity maps shows that major Precambrian knobs were revealed by both surveys. Smaller structures not shown on the surface map were revealed by the underground survey. Anomalous density areas between the level of the two surveys were easily located. — Author's abstract

- 185-318. Ghigone, João Ítalo. Reconhecimento gravimagnético na Bacia de Pelotas [Gravity and magnetic reconnaissance in the Pelotas Basin]: Bol. Tecn. Petrobrás, v. 3, no. 2, p. 73-78, 1960.

The first geophysical work in the Pelotas sedimentary basin in Rio Grande do Sul, Brazil, was carried on in 1959. Gravity and magnetic measurements were made along 5 profiles from the crystalline shield to the ocean; 953 stations were occupied. A Worden gravimeter and two Schmidt vertical magnetometers were used. The results are presented in the form of 5 gravity profiles with corresponding interpretation of basement relief, a figure showing more detailed magnetic and gravity anomalies along a portion of the Jaguarão profile, and a map of Bouguer anomalies. The maximum thickness of the sediments is about 1,400 m. — D. B. V.

- 185-319. Hales, A. L., and Gough, D. I. Isostatic anomalies and crustal structure in the Southern Cape: Royal Astron. Soc. Geophys. Jour., v. 3, no. 2, p. 225-236, 1960.

In a previous paper it was suggested that the tendency of the isostatic anomalies to be systematically negative on the seaward side of the great escarpment which lies about 200 km from the eastern and southern coasts of South Africa could be explained in terms of compensation of topography removed by erosion (see Geophys. Abs. 180-227, 182-352). In this paper one of the negative anomaly zones in the Southern Cape is examined in detail, and it is found that at least 1.4 km of material has been removed over a strip 80 km wide. The resulting stress differences are of the order of  $2.3 \times 10^8$  d per  $\text{cm}^2$  if the load is being carried by both crust and mantle. If the crust is floating on the mantle, the stresses in the crust are of the order of  $120 \times 10^8$  d per  $\text{cm}^2$  in the center of the strip.

One of the noteworthy features of the gravity map of South Africa is a number of positive anomalies associated with the Bushveld complex. The gravity picture supports Cousins' view that the mafic rock of the complex do not form part of a lopolith but lie in two deep troughs. Assuming that the extra load due to the mafic rocks is uncompensated, their minimum thickness is estimated to be of the order of 7 km (for a density difference of 0.3 g per  $\text{cm}^3$ ). — D. B. V.

- 185-320. Jones, L., Mathieu, P. L., and Strenger, H. Gravimétrie [Gravimetry]: Mus. Royal Congo Belge Annales Ser. 8, Sci. Geol., v. 36, 46 p., 1960.

A gravimetric survey of the Congo Basin made between 1952 and 1955 is reported. The equipment, procedures, and methods of calculation are described. Results are presented in a Bouguer anomaly map. — D. B. V.

- 185-321. Gerke, Karl, and Watermann, Heinz. Übersichtskarten der Schwere und der mittleren Höhen von Westdeutschland 1:4,000,000 [Generalized maps of gravity and mean altitudes of West Germany, 1:4,000,000-scale (with English and French summaries)]: Deutsch. Geod. Komm. Veröffentl., ser. B, no. 46, pt. 3, 19 p., 1960.

The series of general gravity maps of West Germany is concluded with four 1:4,000,000-scale maps, printed in 3 colors, that show Bouguer (2 maps), free air, and isostatic (Airy,  $T=30$  km) anomalies. One Bouguer map was generalized from the 1:1,000,000 scale map and the other, practically identical, was obtained by interpolating isoanomalies using the representative values of  $6' \times 10'$  grid squares. The free-air anomaly map was similarly obtained by interpolation, whereas the isostatic anomalies were partly obtained by interpolation, partly calculated from Bouguer anomalies, and partly taken from existing maps. A fifth map shows mean altitudes for  $12' \times 20'$  grid squares for West Germany and surrounding regions. — D. B. V.

- Ramsayer, K[arl]. Report about gravity reduction of the leveling network in Baden-Württemberg. See Geophys. Abs. 185-257.

- 185-322. Oelsner, Christian. Schweremessungen unter Tage [Gravity measurements underground (with English and Russian summaries)]: Zeitschr. Angew. Geologie, v. 6, no. 4, p. 172-177, 1960.

After a review of the literature concerning gravity investigations in mines, a study designed to limit the possibilities of interpretation in a given case is described. The survey in question was made in the Otto Brosowski mine in the Mansfeld basin of East Germany in an attempt to locate thin salt bodies. The results are presented in the form of maps of Bouguer anomalies on level 7 and at the surface, a gravity profile along level 7,  $U_{zzz}$  maps at the surface and a block density map for the depth interval between the surface and level 7. Any distinct mass deficit thus revealed probably represents a salt intercalation. — D. B. V.

- 185-323. Scheffer, V[iktor]. Some contributions to the geophysical knowledge of the Carpathian basins [with French, German, and Russian summaries]: Acad. Sci. Hungaricae Acta Tech., v. 30, no. 3-4, p. 423-461, 1961.

The structure of the northeastern Carpathians and their outer foreland is interpreted with the help of gravity and magnetic data. Ten maps (including Bouguer anomalies of central Europe, vertical magnetic anomalies in the Great Hungarian Plain, gravity anomalies and main tectonic lines in East Slovakia, geotectonic elements of the northern part of the Great Hungarian Plain, and several maps of structural and drainage elements), three block diagrams, and a gravity profile across the northwestern Carpathians are given. — D. B. V.

- 185-324. Balavadze, B. K., and Tvaltvadze, G[uri] K. Stroyeniye zemnoy kory Zakavkasko-Kaspiyskoy vpadiny po geofizicheskim dannym [Crustal structure of the Transcaucasian-Caspian depression according to geophysical data (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 82-90, 1960.

Crustal structure in the Transcaucasus depression and Caspian Sea basin has been interpreted from gravity and seismic data. Differences in apparent velocities in different directions from epicenters of local earthquakes are attributed to variations in depth of crustal discontinuities. Layer thicknesses and velocities and gravity anomalies along a profile from Anaklia on the Black Sea to Karshi on the east shore of the Caspian Sea are shown in a diagram. — D. B. V.

- 185-325. Garetskiy, R. G., and Shraybman, V. I. Glubina zaleganiya i stro-yeniye skladchatogo fundamenta severnoy chasti Turanskoy plita (Zapadnyy Kazakhstan) [Depth of occurrence and structure of the folded basement of the northpart of the Turan plate (west Kazakh-stan): Akad. Nauk SSSR Geol. Inst. Trudy, no. 44, 90 p., 1960.

The fourth chapter of this work is devoted to the results of geophysical investigations of west Kazakh S. S. R. in the area centered around the Aral Sea. The depth to basement is calculated on the basis of magnetic, gravity, and electrical data. There is in general a direct relationship between gravity maximums and uplifts of the surface of the basement; minimums correspond to downwarps. Where a gravity maximum does not correspond to an uplift on the basement, it is accompanied as a rule by intensive magnetic anomalies, which indicate the presence of dense, magnetic rocks. Several maps and profiles are presented. — J. W. C.

Kharechko, G. E. On the problem of the structure of the Russian platform in the area of the cities Berdyansk and Nogaysk (according to the data of geophysical investigations). See Geophys. Abs. 185-555.

- 185-326. Marussi, A[ntonio]. Les resultats des recherches géophysiques de l'expédition italienne au Karakorum, 1954-1955 [The results of the geophysical investigations of the Italian expedition to the Karakorum, 1954-1955]: Ciel et Terre, v. 75, no. 7/8, p. 237-245, 1959.

The thickness of the Baltoro glacier in the Karakorum range was measured in two ways by the Italian expedition of 1954-55: by Somigliana's method, based on photogrammetric measurements of the rate of ice movement along transverse sections, with the assumption that the bottom is semielliptical in shape; and by calculation from gravity anomalies measured along transverse profiles. The gravimetric results are shown in graphs.

A detailed gravimetric survey was made of the area traversed by the expedition, using Worden gravimeters; 300 stations were occupied covering all the western Karakorum, the Dardisan, the Swat, and the Hindu Kush south of the Pamir. This survey fills a gap in the regional gravity map of central Asia. A sketch map of isostatic anomalies for central Asia (Airy,  $T=30$  km) shows that the Fergana, Tadzhik, Kucha, Yarkand, and Indo-Gangetic depressions are related to marked negative anomalies as expected; however, these anomalies are too large to be explained solely by the lower density of the sedimentary fill and therefore suggest deeper structural anomalies.

Strong negative anomalies along the axis of the Karakorum, bordered on both sides by positive anomalies, suggest the presence of a core of granitic material that is compact but of density lower than that of the sediments. This view is supported by Russian seismic measurement in the Pamir, which show a thickening of the granite layer (more than 30 km) coinciding with strong negative anomalies. Granitic intrusions of this type not only might explain the vertical isostatic uplift of the Karakorum but also the horizontal movements of folding and overthrusting in the outer part of the range. — D. B. V.

- 185-327. Hofman, B. J. Gravimetric base points in the Digoel area, Netherlands New Guinea: *Nova Guinea*, n. s., v. 10, pt. 1, p. 149-158, 1959.

Between May 1956 and June 1957 a widespread network of gravimeter stations was established over an area of 100,000 sq km in the Digoel area, Netherlands New Guinea, from the Bloemen River in the west to the Merauke River on the Dutch-Australian border. The network was established for determining the regional geologic structure. Results are given in tables and on an isostatic anomaly map. — V. S. N.

McMutrie, I. H., and Moorcroft, E. Gravity and magnetic traverses over aeromagnetic anomaly—hundred of Carina. See *Geophys. Abs.* 185-483.

Talwani, Manik, Worzel, J. Lamar, and Ewing, Maurice. Gravity anomalies and crustal section across the Tonga Trench. See *Geophys. Abs.* 185-363.

- 185-328. Bull, C. Gravity observations in the Wright Valley area, Victoria Land, Antarctica: *New Zealand Jour. Geology and Geophysics*, v. 3, no. 4, p. 543-552, 1960.

Gravity measurements were made during an east-west traverse from the coast of McMurdo Sound near Marble Point, across the Wilson Piedmont glacier and the Lower Wright glacier toward the head of Wright Valley. The Bouguer anomaly along this line ranges from -10 mgal at the coast to -80 mgal at the western edge of the Lower Wright glacier and -110 mgal at the head of the valley. The gravity gradient is 5 mgal per km near the coast and 1 mgal per km along the valley. — D. B. V.

## HEAT AND HEAT FLOW

- 185-329. Clark, Sydney P., Jr. Heat flow from a differentiated earth: *Jour. Geophys. Research*, v. 66, no. 4, p. 1231-1234, 1961.

Calculations are made of the heat flow from an initially cold earth with radioactivity distributed uniformly through a surface shell, with account taken of radioactive decay. It is found that the heat flow exceeds the heat produced by about 10 percent if the abundances of radioactive elements are the same as in chondrites and the radioactive shell is less than about 300 km thick. The heat flow calculated in this way exceeds the observed value, but neither figure is considered known accurately enough to warrant rejection of the chondrite model of the earth. — Author's abstract

- 185-330. Clark, [Sydney] P., Jr. Geothermal calculations: *Carnegie Inst. Washington Year Book* 59, p. 144-147, 1960; reprinted in *Carnegie Inst. Washington Geophys. Lab. Ann. Rept. of Director for 1959-1960*, 1960.

The problem of the cooling of a radioactive sphere can be broken down by the principle of superposition into two simpler problems: (1) Temperatures are calculated for a sphere at some low, uniform temperature with heat produced by radioactive decay; and (2) temperature is taken to be some function of radius initially, and it is assumed that there is no heat production. In both, the surface of the sphere is assumed to be maintained at zero for all time and the temperature is assumed to depend on radius only. The sum of the temperatures calculated is then the temperature in a sphere with heat production and with a nonzero initial temperature.

Some limits can be set to the effects of radiative transfer and other processes that lead to high thermal conductivity at high temperatures from earth models with nonuniform thermal conductivity. Definite information about temperatures at shallow depths is derived from a model sphere composed of an outer shell with a finite conductivity surrounding the core (not the seismically determined core) in which thermal conductivity is infinite, and from contrasting it with a more conventional model in which conductivity is assumed to be uniform. With uniform conductivity there is no thermal gradient at great depth if heat production is uniform, and cooling can be achieved only by changing the model. A thermal gradient can be set up by supposing that partial fusion and resulting mass transfer took place, and then cooling at all depths becomes possible. It appears, however, that the cooling of the deep interior always must be slight.

Earth models are commonly based on the assumption that initial temperatures were the temperatures of solidification, at least throughout the mantle. The discussion presented here suggests that the temperatures at present are within a few hundred degrees of such initial temperatures, and, thus, the problem of calculating temperatures at great depth becomes the problem of estimating the initial temperatures. — V. S. N.

- 185-331. Ringwood, A. E. Some aspects of the thermal evolution of the earth: *Geochim. et Cosmochim. Acta*, v. 20, no. 3/4, p. 241-259, 1960.

Empirical data relating to the thermal history of the earth are examined. Recent astronomic and geochemical evidence strongly suggests that the earth formed by accretion from an initially low-temperature gas-dust cloud of solar composition. The distribution of U, Pb, Th, and K within the earth implies that it passed through a melting or partial melting process about  $4.5 \times 10^9$  yr ago. This conclusion is confirmed if the core is assumed to consist dominantly of iron-nickel. Formation of the core, which likewise occurred about  $4.5 \times 10^9$  yr ago, would liberate sufficient gravitational energy to cause melting. Evidence in favor of melting is also provided by analogy with meteorites.

Of the possible causes of this early melting, gravitational energy is considered to be chiefly responsible. Radioactive heating does not appear to be important. A metallic phase is produced by reduction due to interaction of accreting dust falling with high velocity into the primitive reducing atmosphere surrounding the earth.

The distribution of temperature within the earth  $4.5 \times 10^9$  yr ago will be given by the melting-point gradient. Recent data on the electrical conductivity of the mantle and the melting point of materials under high pressures suggest that the present temperature distribution is much less than the melting point gradient. This implies that the earth has cooled considerably. The inferred cooling is consistent with present data on the abundance of radioactive elements in meteorites and in the earth, and also with possible modes of internal heat transfer, particularly convection and radiation. — D. B. V.

- 185-332. Lyubimova, Ye. A. K voprosu o razogrevanii Zemli [On the problem of the heating of the earth (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov*, Problema 2, sec. 2, p. 14-19, 1960.

Calculations show that it is unlikely that heat loss due to convection currents can result in cooling of the earth, otherwise observed heat flow would be greater than it is. The presence of a thermal conductivity minimum at about 50 km depth prevents intensive heat loss from the interior, allowing gradual accumulation of heat from radioactive sources. The earth should be expanding slightly at a rate of about 1 cm of radius per thousand years; in the

past the rate of expansion might have been greater (5-10 m per thousand years). Expansion should eventually cease. The amount of expansion is inadequate to explain continental drift, but it might account for the formation of deep fractures along which magma can ascend. — D. B. V.

Rikitake, Tsuneji. Thermo-magneto-hydrodynamic oscillations in the earth's core. See *Geophys. Abs.* 185-376.

185-333. Bullard, E. C. Measurement of temperature gradient in the earth, in *Methods and techniques in geophysics*, v. 1: New York, Interscience Publishers, Inc., p. 1-9, 1960.

The techniques and instruments employed in measurements of the temperature gradient of the earth in boreholes, in mines and tunnels, and in sediments beneath the ocean floor are discussed. Factors that produce variations in the temperature gradient are mentioned, and it is noted that no useful purpose is served by attempting to make very accurate measurements of the gradient; the elimination of gross systematic errors is much more important. — V.S.N.

185-334. Misener, A. D., and Beck, A[lan] E. The measurement of heat flow over land, in *Methods and techniques in geophysics*, v. 1: New York, Interscience Publishers, Inc., p. 10-61, 1960.

Some of the more important methods of determining the pattern of terrestrial heat flow are described in detail, and the physical limitations of the methods are discussed. To find the flux occurring locally, the temperature gradient and the thermal conductivity of the rocks in the area are determined; if the dimensions of the area are small in comparison to the dimensions of the earth and if there is no horizontal variation of constituents, the flow of heat may be considered linear and the flux is the product of the temperature gradient and the thermal conductivity. A correction is applied to allow for effects of the geological history and thus to arrive at a value for the equilibrium heat flux.

The types of thermometers used in the measurement of temperature gradients are described and the field use for each type of equipment discussed. Laboratory and field methods of measurement of thermal conductivity are presented in detail, and, lastly, the methods of combining gradient and conductivity to calculate heat flux are discussed. The effects of ice ages, uplift and erosion, topography, and local sources of heating on the equilibrium heat flow are also treated. — V. S. N.

185-335. Moses, P. L. Geothermal gradients now known in greater detail: *World Oil*, v. 152, no. 6, p. 79-82, 1961.

Temperature-depth relationships are presented for many active oil-producing areas of the United States and Canada. Where sufficient data are available, the information is presented on a map showing isothermal gradient lines. Data on other areas are listed in a table. This compilation is an updating of the earlier work by Nichols (see *Geophys. Abs.* 127-8890). Temperatures were obtained from glass maximum recording thermometers, and the measurements were made in conjunction with bottom-hole pressure surveys and subsurface sampling. The readings were made in wells that had been completed for periods of several days to several years. Temperature increase with depth is approximately linear in most places. — J. W. C.

185-336. Cheremenskiy, G. A. Geotermicheskiye issledovaniya v Sibiri [*Geothermal investigations in Siberia*]: Akad. Nauk SSSR, Inst. Merzlotovedeniya Trudy, v. 15, p. 132-143, 1959.

Geothermal investigations made in boreholes in Siberia from 1939 to 1954 are reported. Isothermal profiles are presented, and isothermal maps show the temperature gradient to depths of 500 and 1,500 m. The geothermal step ranges from 13.4 to 34.6 m per °C in the various regions of Siberia in the interval between 100 and 1,000 m. The configuration of the geothermal surfaces corresponds in general to that for the surface of the basement. — A. J. S.

- 185-337. Dean, Christopher. Using nuclear resonance to sense temperature: Electronics, v. 33, no. 28, p. 52-54, 1960.

A temperature-sensing system is described that has constant calibration as long as the associated electronics operate. The spectra used are nuclear quadrupole resonance (NQR) r-f absorption lines whose frequencies decrease smoothly with temperatures. This relation is essentially fixed for all samples of the selected material indefinitely. An electronic spectrometer is used to locate the NQR frequency and then transmit it. The monitoring station measures the frequency and makes the conversion to temperature, thus assuring reliability. Precision with the circuitry described is a few tenths of a degree. More elaborate equipment for laboratory measurements can attain a precision of a few thousandths of a degree.

The unique properties of the NQR temperature-measuring technique, even with its drawbacks, makes it invaluable for such uses as a permanent unmanned weather station, long-range space exploration, and continuous measurements on the ocean floor or in a drill hole. The probe would deliver well-calibrated telemetered data for such applications for long periods of time, the length depending on the life of the electronic components and power supply.

An excellent probe material is  $\text{KClO}_3$ . It is stable and has a singlet spectrum (relatively narrow line-width compared to the rate of change of NQR frequency with temperature). Resonance frequency = 28.2134 Mc, line width = 500 cycles per second, and rate of change = -4.8 kc per °C at 0°C.

The NQR instrument described is a self-quenched super-regenerative r-f spectrometer. Other spectrometers have been used for NQR that are basically similar to grid-dip meters.

References to related theory and other equipment are given. — H. C. S.

- 185-338. Lewis, Donald R., Whitaker, Thomas N., and Chapman, Carl W. Thermoluminescence of rocks and minerals. Pt. 1. An apparatus for quantitative measurement: Am. Mineralogist, v. 44, no. 11-12, p. 1121-1140, 1959.

Equipment which permits quantitative recording of the thermoluminescence emitted by samples with a high degree of reproducibility and sensitivity has been developed. The equipment operates over the temperature range from 25°C to 600°C at rates from 10°C per min to 100°C per min. The apparatus has high light-detection sensitivity and broad spectral response. The construction combines reliability and flexibility with simplicity of operation. Not more than 50 mg of sample is ordinarily required.

An analysis of the instrumental and physical factors which determine the precision of making glow curves is made to evaluate the requirements for each section of the apparatus. — Authors' abstract

- 185-339. Thompson, G. K. Shallow temperature surveying in the Wairakei-Taupo area: New Zealand Jour. Geology and Geophysics, v. 3, no. 4, p. 553-562, 1960.

The 1-m temperature probe has proved of value in indicating the boundaries of subsurface heat storage in the Wairakei geothermal power area in New



Zealand. It provides a method of rapid reconnaissance, indicating areas worthy of further investigation by drilling. In general the 1-m temperature contours correlate well with isotherms obtained from borehole temperature measurements. — D. B. V.

- 185-340. Bell, J. D., Crooks, R. C., Holser, W. T., Sachsels, G. F., Williams, J. R., Rilbert, R. B., Jr., and Stone, J. J., Jr. Availability of geothermal energy for the demineralization of saline water: U.S. Dept. Interior Research and Devel. Prog. Rept., no. 27, 56 p., 1959.

The availability of geothermal energy is surveyed, and its potential use in the demineralization of saline water is evaluated. The investigation covers a summary of available geothermal data, a mathematical analysis of the potential availability of geothermal energy, and an analysis of some engineering mechanisms of importance in the utilization of geothermal energy. — V. S. N.

- 185-341. MacDonald, J. R., Stensaas, E. R., and Stafford, P. M. Investigation of the availability of geothermal energy for the demineralization of saline water in the Black Hills Region, in Investigation of the availability of geothermal energy for the demineralization of saline water: U.S. Dept. Interior Research and Devel. Prog. Rept., no. 28, pt. 1, p. 1-24, 1959.

Data from wells in the Black Hills indicate that thermal gradients are not appreciably higher than the average for the earth's crust except in a few local areas with 2 or 3 times the magnitude; the highest well temperature measured was 168° at a depth of 6,250 feet. This temperature level is low for practical purposes; therefore, the Black Hills region does not offer any unique advantages for extraction of geothermal energy. — V. S. N.

- 185-342. Cope, Joseph H. Investigation of the availability of geothermal energy for the demineralization of saline water in California, in Investigation of the availability of geothermal energy for the demineralization of saline water: U.S. Dept. Interior Research and Devel. Prog. Rept., no. 28, pt. 2, p. 25-43, 1959.

The availability of thermal energy in California is investigated from two aspects: (1) thermal wells, and (2) hydrothermal sources such as hot springs, geysers, and steam wells. The available geothermal data do not show that California has unusually high temperature gradients; the largest value is at Huntington Beach, 49.3°C per km, which is only about twice the mean value of the earth's gradient. Thus, thermal wells are not economically practical sources of thermal energy in California. Of the many hydrothermal sources in California, steam wells offer the nearest approach to a geothermal energy source for demineralization of saline water. (See also Geophys. Abs. 185-341.) — V. S. N.

#### INTERNAL CONSTITUTION OF THE EARTH

- 185-343. MacDonald, Gordon J. F., and Ness, Norman F. A study of the free oscillations of the earth: Jour. Geophys. Research, v. 66, no. 6, p. 1865-1911, 1961.

Published observations on the toroidal oscillations of the earth are reviewed critically. A supplementary analysis of the record obtained by the Lamont strain seismometer is presented. Eleven toroidal modes are identified, and

it is concluded that the periods are known to within 1 percent. A perturbation scheme involving the ratio of the angular velocity of the earth to the resonant frequency is used in calculating the effect of rotation on resonant frequency. The perturbations of the toroidal oscillations due to core-mantle interaction are treated in detail.

A calculation of elastic energy in the low-order oscillations suggests a value of  $10^{18}$  ergs per cph for the energy density at low frequencies in the Chilean earthquake. Each mode of oscillation has a characteristic radial distribution of elastic energy associated with it; this distribution determines which parts of the earth contribute most heavily in determining a particular resonant frequency. The distribution of energy for the lower 17 modes and the resonant frequencies are calculated for different earth models. The Gutenberg model fits the observations most closely and a slight alteration (lowering the shear-wave velocity in the lower mantle) gives a substantially better fit.

The physical conditions required for the formation of a low-velocity layer are examined in detail. The results confirm Birch's statement (see *Geophys. Abs.* 151-14075) that a temperature gradient in excess of  $6^{\circ}$ - $7^{\circ}$  per km is needed to produce a decrease in velocity. The temperature need not approach or exceed the melting temperature. If the upper mantle is homogeneous, the low velocity zone should extend from the base of the crust to 150 km under the oceans and 100 km under continental regions. The distribution of thermal conductivity and radioactivity consistent with the low-velocity layer is also considered. — D. B. V.

- 185-344. Boaga, Giovanni. Su talune questioni relative alla funzione di Roche sulla distribuzione della densità nello interno delle Terra [On some questions relative to Roche's function on the density distribution in the interior of the earth]: *Accad. Naz. Lincei Atti, Cl. Sci. Fis., Mat. e Nat. Rend.*, v. 26, no. 2, p. 123-129, 1959.

Calculations show that Roche's hypothesis, based on Clairaut's equation concerning the equilibrium of a rotating fluid mass, does not reproduce all at one time the values actually observed for the different geometric and geophysical parameters of the earth. This should be borne in mind when Roche's hypothesis is applied in geophysical investigations. — D. B. V.

- 185-345. Coloma Pérez, Antonio. Sobre el potencial de atracción de una esfera no homogénea [On the potential of attraction of a nonhomogeneous sphere (With English summary)]: *Rev. Geofísica*, v. 18, no. 70, p. 119-141, 1959.

The laws of density distribution for the earth's mantle and core are analyzed, and approximations are derived for each. Using these approximations and assuming a constant density for the crust, formulas are derived for the potential of attraction of points outside, on the crust, in the mantle, and in the core of a spherical earth. Poisson's equations and the mean density of the core and of the mantle are worked out, and mean density of both core and mantle together is also given. Finally, the moments of inertia in the core and in the mantle with respect to the axis of rotation are calculated. — D. B. V.

- 185-346. Afanas'yev, G. D. Stroyeniye zemnoy kory i nekotoryye problemy petrografii [Structure of the earth's crust and some problems in petrography]: *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 3, p. 22-35, 1961.

This is a review of geophysical information concerning the nature of the crust and mantle, particularly in the vicinity of the M-discontinuity. The ex-

act petrographic nature of the rocks is still impossible to determine. The contributions of Levinson-Lessing in this field are stressed, and possible lines of future investigation are discussed. — D. B. V.

- 185-347. Shimazu, Yasuo. A note on genesis and upward transfer of parental magma of igneous rocks. A thermodynamical aspect of the earth's interior, Pt. 3: Nagoya Univ. Jour. Earth Sci., v. 7, no. 2, p. 91-97, 1959.

In the genesis and upward transfer of parental magmas, discussed from a thermodynamic view point, heat concentration is more effective in melting rocks than is stress release. Two possible mechanisms of transfer of the magmas are suggested: (1) Hydrodynamic transfer through fissures is effective in orogenic or volcanic processes. The minimum rate of transfer is 30 g per  $\text{cm}^2$  per yr. (2) Zone melting transfer was effective on a global scale during the high temperature period of  $0.5-1 \times 10^9$  yr after the birth of the earth. Orogenic processes were not necessarily an accompaniment. About  $10^6$  yr are necessary for the magma to float up 100 km, and a concentration of low melting components during the transfer is an important feature. — V. S. N.

- 185-348. Shimazu, Yasuo. A role of water in metamorphism as illustrated by some reactions in the system  $\text{MgO-SiO}_2\text{-H}_2\text{O}$ . A thermodynamical aspect of the earth's interior, Pt. 4: Nagoya Univ. Jour. Earth Sci., v. 8, no. 1, p. 86-92, 1960.

The mineral reactions in the  $\text{MgO-SiO}_2\text{-H}_2\text{O}$  system are a key to dehydration processes within the primeval earth, and, consequently, discussion of hydration-dehydration reactions in the system is useful for study of global physico-chemical processes which took place during terrestrial evolution as well as for preliminary study of regional metamorphism.

The effects of migration of water vapor upon the thermodynamic state of the  $\text{MgO-SiO}_2\text{-H}_2\text{O}$  system is studied, assuming a hydrodynamic flow of vapor and applying the thermodynamics of a steady state. Univariant curves (paragenesis of three minerals) and divariant regions (paragenesis of two minerals) correspond to hypothetical petrograds and metamorphic facies, respectively. Variations in association of metamorphic facies are obtained for various constrained conditions of the following variables: pressure, temperature, and chemical potential of the vapor. — V. S. N.

- 185-349. Shimazu, Yasuo. Physical conditions of contamination and fractionation of basaltic parental magmas: Nagoya Univ. Jour. Earth Sci., v. 8, no. 1, p. 72-85, 1960.

Basaltic parental magmas form within the mantle and move toward the surface; in the process of movement interaction takes place between the cooling magmas and the surrounding solid rocks. The amount of contamination and fractionation that takes place in the magma depends upon the speed of movement and the rate of cooling of the magma. If movement is too slow, magmas will solidify in place without appreciable contamination; if it is too fast, fractionation will not occur. It is calculated that the optimum speed of movement to produce an anorthite-albite binary magma is 1-10 cm per yr. The physical conditions necessary to obtain the optimum speed of movement are also studied, and it is concluded that a floating-up of magmas by zone melting is a possible mechanism. A 6 to 1 ratio of horizontal extent to thickness is the optimum shape of a magma sheet. — V. S. N.

- 185-350. Aldrich, L. T[homas], Asada, T., Bass, M[anuel] N., Hales, A. L., Tuve, M[erle] A., and Wetherill, G[eorge] W. The earth's crust: Carnegie Inst. Washington Year Book 59, p. 202-208, 1960; reprinted in Carnegie Inst. Washington Dept. Terrestrial Magnetism Ann. Rept. of Director for 1959-1960, 1960.

The seismic studies carried out in 1959-60 as a part of the larger study of Precambrian geologic and tectonic history are reviewed. During the year a network was established which consists of 6 seismic stations in southern Peru, 3 in Bolivia, and 4 in northern Chile with equipment specialized for recording local earthquakes in order to analyze the great attenuation of waves observed across the Andes ranges and the Altiplano.

Preliminary experiments were carried out to determine whether difficulties encountered in using near-vertical reflections for the study of crustal structure could be overcome. This was a continuation of work started in 1958-59 (see Geophys. Abs. 184-427). Reconnaissance seismic studies of earth structures were resumed also in 1959 with observations along azimuths due east from three shot points in Montana and northeast Wyoming. The data observed are presented in three traveltime curves and in a table. — V. S. N.

Shor, George G., [Jr.], and Fisher, Robert L. Middle America Trench: Seismic-refraction studies. See Geophys. Abs. 185-543.

Shurbet, D. H. Determination of sedimentary thickness in the Mexican geosyncline by Rayleigh wave dispersion. See Geophys. Abs. 185-142.

Matthews, D. H. Lavaš from an abyssal hill on the floor of the North Atlantic Ocean. See Geophys. Abs. 185-587.

- 185-351. Tryggvason, Eysteinn, and Báth, Markus. Upper crustal structure of Iceland: Jour. Geophys. Research, v. 66, no. 6, p. 1913-1925, 1961.

Results are presented of seismic measurements made in 1960 of the thickness and structure of the lava layer that covers all of Iceland. Eight refraction profiles ranging from 20 to 41 km long were made in a line crossing central Iceland from southwest to northeast. The lava layer consists of three sections with longitudinal velocities of  $3.7 \pm 0.3$ ,  $4.95 \pm 0.2$ , and  $5.55 \pm 0.05$  km/s. The 3.7 km/s layer is found mainly in the southwest, where the other two are absent. In north Iceland the 4.95-km/s layer is near the surface and the 5.55-km/s layer at a depth of about 2 km. Total lava thickness ranges from 1.73 km in the southwest to 4.81 km in the north. Below the lava the longitudinal velocity is about 6.2 km/s, increasing to 6.7 km/s at a depth of about 5 km. Shear waves were clearly recorded on 3 profiles in north Iceland but were recorded not at all or only faintly elsewhere. — D. B. V.

- 185-352. Choudhury, Mansur Ahmed. Sur la structure générale de la croûte terrestre en Europe occidentale [On the general structure of the earth's crust in western Europe]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 9, p. 1362-1364, 1961.

Crustal structure in western Europe has been studied, using Pn-, Pc-, and Sc-wave data from 28 near earthquakes or explosions. The numerical values of the function  $F$  in the equation  $Pc-Pn=F\{H, h, (Sc-Pc)\}$  (where  $H$ =total thickness of crust,  $h$ =focal depth) were calculated for three crustal models: model

A, with constant velocity ( $V_p=6.0$  km/s) down to the M-discontinuity; model B, with  $V_p=6.0$  km/s to 20 km and 6.5 km/s below that; and model C, with  $V_p=6.0$  km/s to the base of the sediments and 6.2 km/s below that. In all cases a value of  $V_p/V_s=1.743$ , as ascertained from explosion data, was used. Model A best fits the observed data. — D. B. V.

Bisztricsány, Ede, and Kiss, Zoltán. Computation of the mean crustal thickness on a Eurasian path based on Love wave dispersion curves. See *Geophys. Abs.* 185-143.

185-353. Gal'fi, Ya. [Gálfi, János], and Shtegena, L. [Stegena, Lajos]. Budova zemnoy kory v Ugorshchyni [Structure of the earth's crust in Hungary]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 20, no. 3, p. 42-46, 1960.

The results of crustal structure investigations in Hungary, mainly by seismic depth sounding, are summarized (see *Geophys. Abs.* 168-195, 171-212, -213, 173-248). — D. B. V.

Gálfi, János, and Stegena, Lajos. Deep reflections and crustal structure in the Hungarian Basin. See *Geophys. Abs.* 185-553.

Gálfi, János, and Pálosk, Miklós. Crustal-study refraction profile in the Hungarian Basin. See *Geophys. Abs.* 185-552.

185-354. Grachev, Yu. N., Dekhnich, M. Ya., Litvinenko, I. V., Nekrasova, K. A., and Sosnovskaya, A. V. Glubinnyye geofizicheskiye issledovaniya na territorii Baltyskogo shchita [Deep geophysical investigations in the territory of the Baltic shield (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 43-50, 1960.

Combined geophysical methods (including seismic techniques) were used in investigations of the deep structure of the Baltic shield, where the granite layer is well exposed, for the purpose of assessing the possibilities of such an approach in regions where the granite is hidden. Conditions in northern Karelia were found to be favorable for deep seismic sounding. With low-frequency apparatus, deep waves could be recorded several tens of kilometers from the shot point with charges of 20-40 kg detonated in shallow water bodies; for distances greater than 200 km, 400-500 kg charges were needed.

Many longitudinal, transverse, converted, and surface waves were recorded. For many wave groups observations were complete enough to permit the plotting of continuous correlated intersecting traveltime curves and to determine the dynamic characteristics of elastic waves. Discontinuities were clearly recognizable at 10-12 km and 30-40 km. A relationship is apparent between deep-seated and surface structures. The study of the upper 10-12 km of the Precambrian (of interest for the solution of practical problems) by seismic prospecting methods appears to be feasible. — D. B. V.

185-355. Panasenkov, G. D. Struktura zemnoy kory Kol'skogo poluostrova po seismicheskim dannym [Crustal structure of the Kola Peninsula according to seismic data (with English summary)]: Internat. Geol. Cong. 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 51-55, 1960.

The existence of three active fracture zones in the Kola Peninsula and northern Karelia, recognized earlier on the basis of geologic, geomorphic, and

earthquake data, is confirmed by the records of weak local earthquakes at the Apatity seismic station. Records from industrial explosions show a transverse wave phase that is interpreted as a reflection from a flat-lying horizon.

Analysis of records of distant earthquakes indicates a three-layered crust. The average crustal thickness is about 51 km, which is considerably more than the average for central Europe (27 km). The average thickness of the granite layer is 20 km. The M-discontinuity dips southward. — D. B. V.

- 185-356. Yevseyev, S. V. Zemletrus 20 lyutoho 1951 r. ta budova zemnoy kory v rayonī Zakarpattya [The earthquake of February 20, 1951 and the structure of the earth's crust in the Transcarpathian region]: Akad. Nauk Ukrayin, RSR Heol. Zhur., v. 18, no. 4, p. 112-116, 1958.

Crustal structure in the Transcarpathian region is deduced from arrivals at 21 European seismic stations of P- and S-waves from the Nograd (Hungary) earthquake of February 20, 1951. Yevseyev locates the epicenter at  $\phi=47^{\circ}57.4'N.$ ,  $\lambda=19^{\circ}12.9'E.$ ; Karník (1953) located it at  $\phi=47^{\circ}58.9'N.$ ,  $\lambda=19^{\circ}16.1'E.$  The granitic and the basaltic layers are calculated to be 15 and 29 km thick, respectively, as compared to Karník's corresponding values of 9 and 26 km. — D. B. V.

- 185-357. Neprochnov, Yu. N., Goncharov, V. P., and Neprochnova, A. F. Seysmicheskiye dannyye o stroeniye zemnoy kory v tsentral'noy chasti Chernogo Morya [Seismic data on crustal structure in the central part of the Black Sea]: Akad. Nauk SSSR Doklady, v. 129, no. 2, p. 408-411, 1959.

Seismic depth sounding and echo-sounding surveys were carried out concurrently in the summer of 1958 in the Black Sea south and southeast of the Crimean Peninsula. Three crustal profiles were established, two across the continental slope into the deep sea and one along the central part of the deep sea basin connecting the southern ends of the first two. The results show that there is a granitic layer 4-6 km thick under the continental shelf; it pinches out southward. Under the deep sea basin the crust is two-layered and about 28-30 km thick including the water layer. In one of the profiles across the continental slope, both the top of the basaltic layer and the M-discontinuity dip northward under the granitic layer, the basalt surface sloping from a depth of 12-13 km to a depth of 20 km and the base of the crust from 30-32 km to more than 36 km. In the other profile the basalt surface rises northward to a depth of 10 km not far from the coast off Yalta. In general the crust under the central Black Sea is thicker but otherwise analogous to that southwest of the Crimea outside the continental slope; the difference lies mainly in the thickness of the basaltic layer.

The seismic data help to explain the gravity field of the region; for example, the predominance of positive Bouguer anomalies over the mountains of Crimea (in contrast to other areas of uplifted Alpine geosynclines) can be attributed to the shallowness of the basaltic layer. — D. B. V.

- 185-358. Tvaltvadze, G[uri] K. Stroyeniye zemnoi kory v Gruzii po seysmicheskim dannym i postroyeniye sistem teoreticheskikh godografov [Crustal structure in Georgia according to seismic data and construction of a system of theoretical traveltime curves]: Tbilisi, Akad. Nauk Gruzin. SSR, 144 p., 1960.

The crust in the Georgian S.S.R. has been studied using earthquake and explosion seismology data. In the Borzhomi valley the first layer (sediments)

is 3.5-4.0 km thick, and the P- and S-wave velocities are 4.4 km/s and 2.6 km/s, respectively. The second layer (granitic) is 20 km thick, and the P- and S-wave velocities are 5.6 km/s and 3.2 km/s, respectively. The third layer (basalt) is 24 km thick, and the P- and S-wave velocities are 6.7 km/s and 4.0 km/s, respectively.

In the Tkibuli region the sediments are 7 km thick, and the P- and S-wave velocities are 4.3 km/s and 2.6 km/s, respectively. The granitic layer is about 17 km thick, and the P- and S-wave velocities are 5.6 km/s and 3.4 km/s, respectively. The thickness of the basaltic layer could not be determined, but the P- and S-wave velocities are 6.5 km/s and 3.9 km/s, respectively.

In the Caucasus the sedimentary layer is 10 km thick, and the P- and S-wave velocities are 4.5 km/s and 2.6 km/s, respectively. The average thickness of the granitic layer is 15 km, and the P- and S-wave velocities are 6.0 km/s and 3.4 km/s, respectively. The average thickness of the basaltic layer is 25 km, and the P- and S-wave velocities are 7.0 and 4.0 km/s, respectively. P- and S-wave velocities are 8.0 km/s and 4.7 km/s, respectively, for the surface of the mantle. — J. W. C.

- 185-359. Pronin, A. A. O glubinnoy tektonike i obrazovanii granitov Urala [On the deep structure and formation of the granites of the Urals (with English summary)]: Internat. Geol. Cong. 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 217-223, 1960.

Throughout its whole geologic history the folded belt of the Urals has been a mobile crustal zone. The sial underlying the Urals is heterogeneous in structure. In zones of Paleozoic subsidence it consists of a lower basaltic layer and an upper sedimentary layer, the latter including igneous intrusions and extrusions. In zones of uplift it consists of three layers: basaltic, granitic, and sedimentary. The Ural granites are of metasomatic origin, formed by granitization of ancient paragneisses and other metamorphic and sedimentary rocks. — D. B. V.

- 185-360. Shikhalibeyli, E. Sh. K voprosu o glubinnom stroyeniye vpadiny Yuzhnogo Kaspiya i okruzhayushchikh oblastey [On the problem of the deep structure of the South Caspian depression and neighboring regions (with English summary)]: Internat. Geol. Cong., 21st Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 171-178, 1960.

The deep structure of the South Caspian depression and its environs is outlined on the basis of data from recent geophysical (particularly gravimetric) investigations. This depression is the eastward continuation of the Lower Kura basin. The basement structure, masked by Cenozoic deposits, is heterochronous and varies from place to place in a complicated way. The granitic layer pinches out toward the axial part of the South Caspian depression and is lacking under the Lower Kura basin; the crust there is oceanic in character, analogous to parts of the Mediterranean area, including the Black Sea. — D. B. V.

- 185-361. Veytsman, P. S., Gal'perin, Ye. I., Zverev, S. M., Kosminskaya, I. P., and Krakshina, R. M. Nekotoryye dannyye o stroyenii zemnoy kory v perekhodnoy zone ot Aziatskogo kontinentak Tikhomy okeanu [Some data on crustal structure in the transitional zone from the Asiatic continent to the Pacific Ocean (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 37-42, 1960.

This is a short version of the paper published in *Freiberger Forschungshefte C 81 Geophysik*, p. 150-159, 1960 (see *Geophys. Abs.* 184-431). — D.B.V.

- 185-362. Maeda, Y. Crustal structure in and near Shikoku district as deduced from forerunner analysis [in Japanese with English abstract]: *Quart. Jour. Seismology* [Tokyo], v. 25, no. 2, p. 35-44, 1960.

A study of waves of different periods and amplitudes in the forerunner group of earthquake waves is an effective means of determining crustal structures. The crustal structure in and near the Shikoku district was studied using Takagi's method and Matuzawa's standard crustal structure of two layers above the M-discontinuity with thickness and P-wave velocity of 20 km at 5.0 km/s and 30 km at 6.3 km/s and with a P-wave velocity below the M-discontinuity of 7.5 km/s. The thickness of Matuzawa's first layer and the depth of the M-discontinuity in the Shikoku district as deduced from the study are shown in figures. — V. S. N.

- 185-363. Talwani, Manik, Worzel, J. Lamar, and Ewing, Maurice. Gravity anomalies and crustal section across the Tonga Trench: *Jour. Geophys. Research*, v. 66, no. 4, p. 1265-1278, 1961.

The seismic structure determined by Raitt and others (see *Geophys. Abs.* 163-256) for the Tonga Trench was projected to one of the gravity profiles obtained in 1956 with the Vening Meinesz pendulum apparatus. The gravity anomaly profile computed on the basis of the seismic structure is in fair agreement with the observed profile, but the two profiles differ by about 100 mgal in the vicinity of the trench. Interposing a seismically "masked" layer under the trench and increasing the crustal thickness there to 23 km improves the fit.

A crustal thickness of 36 km is derived from gravity and seismic data for the Tonga-Kermadec Ridge. The disagreement between this value and one obtained by Officer (see *Geophys. Abs.* 162-232) from surface wave dispersion data might be explained by an abnormally low shear velocity in the crust underlying the ridge. — D. B. V.

- 185-364. Evison, F. F., Ingham, C. E., Orr, R. H., and LeFort, J. H. Thickness of the earth's crust in Antarctica and the surrounding oceans: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 3, p. 289-306, 1960.

Love and Rayleigh waves from eight earthquakes recorded at Hallet Station, Scott Base, and Mirny have been analyzed, and the dispersion compared with that predicted by theory for simple crustal models. It is concluded that the crust in eastern Antarctica as a whole is continental with a thickness of about 35 km. In contrast, Marie Byrd Land has an average crustal thickness of about 25 km. The data do not extend to the rest of western Antarctica, nor has it been possible to study the important transition zone from the Ross Sea to the Weddell Sea. The average crustal thickness of 25 km in the western sector could be explained in a variety of ways. The concept of an archipelago of mountainous island chains is supported by recent seismic and gravity observations.

Love wave dispersion indicates that the thickness of the solid crust in the oceanic regions surrounding Antarctica ranges from about 5 to 10 km, the smaller values being associated with the deeper basins. It is shown that the determination of the thickness of the oceanic crust and of the unconsolidated bottom sediments from Rayleigh wave dispersion is in general subject to large uncertainties. — D. B. V.



- 185-365. Gaskell, T[homas] F. Drilling of deep bore-holes: *Adv. Sci.* v. 17, no. 70, p. 534-540, 1961.

Techniques of drilling deep boreholes are summarized briefly. The importance of selecting the technique most suitable for drilling to the M-discontinuity is emphasized because of the information to be gained from core recovery and measurement of rock properties in place by logging instruments. Such information will make it possible to determine whether the M-discontinuity is the result of a phase change caused by temperature and pressure effects or the result of a change in rock type that will be recognizable in the core. — V. S. N.

- 185-366. Wilson, Gilbert M. Project Mohole demonstrates deep water drilling techniques: *World Oil*, v. 152, no. 7, p. 84-90, 1961.

Six core holes have been drilled from the CUSS I drilling vessel in the Pacific Ocean. Five holes were in 3,140 feet of water and the deepest penetration was 1,043 feet. The sixth hole was in 11,700 feet of water; it passed through soft, gray-green clay of Miocene age, topped basalt at 560 feet, and was still in the basalt when it bottomed at 601 feet. Finding this basalt confirms earlier seismic surveys of the area. These tests demonstrate that depth of water need not be a barrier to oil exploration. — J. W. C.

- 185-367. Meinhold, Rudolf. Das "Mohole"-Projekt [The "Mohole" project]: *Zeitschr. Angew. Geologie*, v. 6, no. 4, p. 182-183, 1960.

This is a brief review of the "Mohole" project, particularly from the point of view of the drilling problems involved. — D. B. V.

- 185-368. Press, Frank. The earth's crust and upper mantle: *Science*, v. 133, no. 3463, p. 1455-1463, 1961.

The seismological and gravitational methods of exploring the outermost few hundred kilometers of the earth and the results obtained to date are described, and some unsolved problems and the methods of attacking them are discussed.

A complete physical explanation of the low-velocity layer has yet to be given. It is probably a result of temperature; rocks near their melting point can occur in this zone, which may be the source of the primary basaltic magma.

None of the measurements reported here settle the question of phase changes versus changes in composition as the reason for the Conrad and Mohorovičić discontinuities; it will probably be resolved only by drilling to the top of the mantle. — D. B. V.

- 185-369. Demenitskaya, R. M. Stroyeniye kristallicheskoy chasti obolochki Zemli po geofizicheskim dannym [Structure of the crystalline part of the earth's shell according to geophysical data (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 20-36, 1960.

Structurally the earth's crystalline shell can be regarded as a whole, the crust and the underlying "hyperbasite" of the mantle being closely interrelated. A world map of crustal thickness, constructed from seismological data, shows the main morphologic features of the surface of the hyperbasite; its maximum uplifts are mainly in the southern hemisphere and maximum depressions in the northern hemisphere, with maximum ruggedness in the equatorial region. At 10 km depth the granite layer is predominant in the north-

ern hemisphere, and the basalt-hyperbasite layer in the southern. At 50 km the shell consists mainly of hyperbasite, with two basalt belts—one trending almost north-south in the western hemisphere and one trending almost east-west in the eastern hemisphere; two smaller areas of basalt correspond to the roots of the Abyssinian plateau and of the cordillera of eastern Australia. — D. B. V.

- 185-370. Magnitskiy, V. A. O sootnoshenii zemnoy kory s veshchestvom obolochki Zemli po geofizicheskim dannym [On the relations between the earth's crust and the matter of the earth's mantle according to geophysical data (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 32-38, 1960.

As heat flow is the same on continents and oceans, it is inferred that the principal blocks of oceanic and continental crust were formed in their present positions. The crust and peridotitic secondary mantle were derived from a primordial eclogitic mantle. With decreasing pressure and increasing temperature, minerals of the eclogite rocks changed into two kinds of compounds. Those with relatively low melting point and density migrated upward to form the crust, and those with higher melting point and density formed the peridotitic secondary mantle. Under the continents this separation has been rather complete; under the oceans the mantle retains an almost primordial composition. — D. B. V.

- 185-371. Jobert, Georges. Sur la densité interne du Globe [On the internal density of the globe (with French, English, Esperanto, and Russian summaries)]: Annales de Géophysique, v. 16, no. 3, p. 422-425, 1960.

A method used by Stieltjes (1914) for calculating the limits of densities in the earth's interior has been modified by assuming a discontinuous density within the earth. The method is found to lose much of its effectiveness when density discontinuities are taken into account, but it still gives within relatively narrow limits the values of density at the center of the earth, at the surface of the core, and at the base of the mantle, as well as the density contrast at the core boundary. Results obtained for two different values of density at the top of the mantle ( $d=3.32$  and  $3.67$  g per  $\text{cm}^3$ ) are tabulated. It is remarkable that the minimum density contrast of  $4.68$  g per  $\text{cm}^3$  for  $d=3.67$  is very close to Bullard's solution I value of  $4.70$  g per  $\text{cm}^3$ . For  $d=3.32$ , the minimum density contrast at the core boundary is  $2.74$  g per  $\text{cm}^3$ . — D. B. V.

- 185-372. Rikitake, Tsuneji. Geophysical evidence of the olivine-spinel transition hypothesis in the earth's mantle: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 423-431, 1959.

The difference in free energy between the substances constituting the upper and lower mantle, estimated on the assumption that an olivine-spinel transition occurs at a depth of 400 km in the earth, is approximately the same as that deduced by Ringwood (see Geophys. Abs. 173-241) from experimental results. Consideration of the effect of this transition on the electrical conductivity shows that the sharp increase of conductivity at depth as inferred from studies of geomagnetic variations seems to be justified by the transition hypothesis. — D. B. V.

- 185-373. Zharkov, V. N. Fizika yadra Zemli. Termodinamicheskiye svoystva I [The physics of the earth's core. Thermodynamic properties. I]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1417-1425, 1960.

The theory of the thermodynamics of the earth's core is developed in a way similar to that used by Zharkov for the earth's mantle (see Geophys. Abs. 181-319). The core of the earth is assumed to be homogeneous, having a sharp velocity increase of longitudinal seismic waves in the inner core due to differences in state. When the oscillation period is of the order of seconds the outer core behaves as a fluid and the inner core as a solid. The velocities of longitudinal seismic waves are assumed to be  $v_{pe}^2 = (K/\rho)$  for the outer core and  $v_{pe}^2 = \frac{K + (4\mu/3)}{\rho}$  for the inner core,  $K$  being the volume modulus of incompressibility,  $\mu$  the shear modulus, and  $\rho$  the density. Using the Grüneisen parameter  $\gamma$  calculated from the Davydov formula (see Geophys. Abs. 169-194) and the Debye theory, and assuming the thermal pressure  $P_T$  in the Davydov' formula equal to zero, Zharkov arrives at the value of  $\phi = K/\rho = K\alpha/\rho$  in terms of Davydov's constants  $K_1$ ,  $K_2$ , and  $b$ . Having determined the shear modulus  $\mu$  for the "effectively solid core," Zharkov has calculated and presented graphically as a function of depth: the variation of  $K$ ,  $\mu$ , and  $P$  (pressure) in the core of the earth; the variation of seismic velocities  $v_p$  and  $v_s$  in the "effectively solid" core; the variation of the Debye temperature  $\theta_{Si}$  for the "silicate" model of the core and  $\theta_{Fe}$  for the "iron" model, and the Grüneisen parameter  $\gamma$ ; the variation of thermal pressure  $P_T^{Si}$  and  $P_T^{Fe}$  for the "silicate" and "iron" core models respectively; and the variation of the derivative  $(\partial p/\partial T)_{Ti}$  in the core of the earth. Formulas for the adiabatic temperatures and their gradients are obtained for the evaluation of the temperature variation in the inner core. — A. J. S.

- 185-374. Zharkov, V. N. Fizika yadra Zemli. Mekhanicheskiye svoystva i vyazkost', II. [Physics of the earth's core. Mechanical properties and viscosity, II]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1553-1562, 1960.

This is a continuation of Zharkov's previous paper on the earth's core (see Geophys. Abs. 185-373); problems related to viscosity are treated. Data on the passage of seismic waves of various periods through the earth's core are analyzed to determine whether Gutenberg's view is correct (see Geophys. Abs. 171-204, 175-53, -54) that a high gradient of viscosity in zone F causes a strong dispersion of longitudinal waves, or whether such a dispersion takes place according to Bullen's model wherein the dispersion occurs at the boundary of the solid inner core and the fluid outer core (see Geophys. Abs. 177-235). It was established by Gutenberg that the location of the seismic boundary of the inner core depends on the period (frequency) of the waves used in determination of the boundary. The observations that led to the discovery of the inner core were based mainly on waves of 1-10 second periods. Their behavior is not due to the existence of a real physical boundary but rather to the nature of the seismic wave propagation in the earth as a whole and to the properties of the seismographs. Zharkov considers that it is more plausible to assume that the dispersion of seismic waves of  $10^{-6}$  second period takes place at the real physical boundary between the outer and the inner cores; therefore, the actual boundary that separates the fluid part from the crystalline part of the core may be situated considerably closer to the earth's surface. Consequently, the boundary of the inner core determined by seismologists is but a seismic boundary of the inner core and not necessarily a physical boundary. Two models of the earth's core are discussed: (1) The inner part of the core is in a solid polycrystalline state and at the fluid phase boundary has an effective viscosity coefficient of the order of  $1 \text{ ps}$  for deformations

$\epsilon \leq 10^{-5}$ ; and (2) the entire earth's core is in an amorphous state, its viscosity coefficient  $\eta$  decreasing exponentially from the center to the periphery; its seismic boundary is located in the region where the values of the nonrelaxing shear moduli  $\mu$  and  $\eta$  are such as to satisfy the condition  $2\pi\eta/t\mu \ll 1$ ,  $t$  being the wave period. The result of this analysis indicates that the position of the seismic boundary for the higher frequencies ( $t \sim 0.5$  sec) can be evaluated from the graph of relaxation time as a function of depth given in the paper. This boundary should be about 100 km farther away from the center than that for the waves of 1 second period. It is considered that the transition from the effectively solid part of the core should be less abrupt than proposed by Gutenberg, that lower period waves should be reflected from zones farther from the center of the earth than the higher period waves, and that the absorption of seismic waves in the boundary zone should be one order higher than in other seismically homogeneous zones of the core. The theory explains the velocity plateau and decrease of longitudinal wave velocity in the inner core. — A. J. S.

- 185-375. Al'tshuler, L. V., and Kormer, S. B. Ovnutrennem stoyenii Zemli [On the internal constitution of the earth]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 33-37, 1961.

Experiments on dynamic and isoentropic compressibility of metals, olivine, and pyrite provided data for an interpretation of the constitution of the external and internal cores of the earth. It was found by shock compression of olivine that its density becomes about 4.9 g per  $\text{cm}^3$  under a pressure of 0.7 million atm, and  $6.8 \pm 0.2$  g per  $\text{cm}^3$  under 2.4 million atm, the temperature in the latter case reaching approximately 8,000°C. The correlation of pressure and density in the core of the earth with the dynamic adiabatic curves obtained in the laboratory for titanium, iron, molybdenum, and nickel shows that the density of the external core in the pressure range from 1.4 to 3.2 million atm is 1.5 g per  $\text{cm}^3$  lower than that of iron. The experimental data on the compressibility of elements indicate that the core of the earth contains a substantial quantity of lighter substances besides iron and nickel. This supports the Knopoff and MacDonald conclusion that the earth's core is not pure iron (see Geophys. Abs. 181-322), and that its mean atomic number is 23. A comparison of sound velocity in the pressure range of 1.4-3.2 million atm with  $v_p$  of seismic waves in the external core indicates that the sound velocity is 1.2 km/sec higher than  $v_p$  in iron and nickel in the external core. Iron and nickel densities under the range of pressures 1.4-3.2 million atm (external core) do not agree with the Bullen's distribution of densities and differ from the density data of Molodenskiy at the mantle-core boundary (see Geophys. Abs. 165-224). A comparison of sound and seismic velocity curves in the inner core favors chemical homogeneity and solid state. A core composed of oxides or iron sulfides with a substantial admixture of free metals is tentatively proposed. — A. J. S.

- 185-376. Rikitake, Tsuneji. Thermo-magneto-hydrodynamic oscillations in the earth's core: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 405-422, 1959.

A linearized treatment of the simultaneous equations of electromagnetism, hydrodynamics and heat transfer in a conducting fluid sphere is described. It turns out that a sort of thermo-magneto-hydrodynamic oscillation seems likely to occur through the couplings between magnetic fields, fluid motions and thermal fields. With some drastic simplifications, the eigen-period of the oscillation, which superposes on the steady state of the earth's dynamo, is estimated at 20 years. — Author's summary

- 185-377. Hahn-Weinheimer, P. Alterseinstufung von eklogitischen Gesteinen mit Hilfe des  $C^{12}/C^{13}$ -Isotopenverhältnisses von Graphit- und Karbonat-Kohlenstoff [Determination of the age relations of eclogitic rocks by means of the  $C^{12}/C^{13}$  isotope ratios of graphite- and carbonate-carbon]: *Geol. Rundschau*, v. 49, no. 1, p. 308-314, 1960.

Quantitative determinations of the stable carbon isotope ratios in graphite- and carbonate-carbon suggest that the eclogitic rocks of the Münchberger gneiss massif in Germany originally were slightly graphitic, dolomitic-marly schists, already metamorphosed in Precambrian time. Similarity of the  $C^{12}/C^{13}$  ratios in both types of carbon (more than 90.0) indicates syngenetic deposition of elementary carbon and carbonate. — D. B. V.

- 185-378. Park, R., and Dunning, H. N. Stable carbon isotope studies of crude oils and their porphyrin aggregates: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 99-105, 1961.

In order to elucidate the origin of the porphyrin aggregates in crude oils (which in turn is undoubtedly closely related to the origin of petroleum itself), the  $C^{13}/C^{12}$  ratios of petroleum and their porphyrin aggregates have been measured and compared with those of chemically similar substances of present-day organisms. The fact that the  $C^{13}/C^{12}$  ratios of all the relatively pure porphyrin aggregates are 4-5 permil greater than those in the crude oils suggests strongly that the former did not arise from the petroleum hydrocarbon by bacterial action, but must have been present during the formation and diagenesis of the oil. — D. B. V.

- 185-379. Cook, A. C. The carbon isotopic compositions of certain marine invertebrates and coals from the Australian Permian: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 289-290, 1961.

In a recent paper, Compston (see *Geophys. Abs.* 182-369) found no correlation of rank or chemical composition of coal with carbon isotopic composition. In view of the nature of the samples used, Compston's conclusions do not seem fully justified. Suggestions are made for disentangling the effects of rank and of maceral composition in order to eliminate some of the variables mentioned by Compston. — D. B. V.

- 185-380. Park, R., and Epstein, S[amuel]. Carbon isotope fractionation during photosynthesis: *Geochim. et Cosmochim. Acta*, v. 21, no. 1/2, p. 110-126, 1960.

It is desirable to understand the reasons for the isotopic fractionation in photosynthesis that favors the fixation of  $C^{12}$  into plants, because such knowledge should contribute to elucidation of the  $CO_2$  fixation process itself and at the same time provide information pertinent to the interpretation of the  $C^{13}/C^{12}$  ratios of fossil carbon deposits. This paper described a series of controlled experiments designed to throw light on the problem.

Experiments on the extraction of "dissolved  $CO_2$ " and on the enzymic fixation of carbon dioxide suggest that the major fractionation of carbon isotopes in the photosynthetic fixation of atmospheric carbon dioxide is due to two steps, the first involving preferential uptake of  $C^{12}$  from the atmosphere and the second the preferential conversion of  $C^{12}$ -rich "dissolved  $CO_2$ " to phosphoglyceric acid, the first product of photosynthesis. Subsequent metabolism of photosynthetic products is also accompanied by isotope fractionation, but these fractionations affect the isotopic composition of only a few minor constituents of the plant as a whole.

This two-step model explains the difference between the  $C^{13}/C^{12}$  ratio of atmospheric  $CO_2$  and plants; the variation of the  $C^{13}/C^{12}$  ratio in naturally-occurring plants; the nature of the variation of the  $C^{13}/C^{12}$  ratio of respired  $CO_2$ , particularly during the beginning of the dark period; the  $C^{13}/C^{12}$  ratio of  $CO_2$  extractable by acid from the plant; the  $C^{13}/C^{12}$  ratio difference between land and marine plants; the  $C^{13}/C^{12}$  ratio of the calcareous skeleton of algae; and the difference in the  $C^{13}/C^{12}$  ratio between lichens and higher plants. — D. B. V.

- 185-381. Pandow, M., MacKay, C., and Wolfgang, R. The reaction of atomic carbon with oxygen: significance for the natural radiocarbon cycle: *Jour. Inorg. Nucl. Chemistry*, v. 14, no. 3/4, p. 153-158, 1960.

The nuclear reaction responsible for production of natural radiocarbon in the upper atmosphere can be duplicated in an atomic reactor. When  $C^{14}$  atoms so produced are reacted with  $N_2-O_2$  mixtures under a variety of conditions and the results corrected for complicating radiation-induced effects, it is found that 90-100 percent of the  $C^{14}$  is in carbon monoxide. Previously it had been assumed that  $C^{14}O_2$  must be the product. As  $C^{14}$  in CO cannot be utilized in photosynthesis, possible mechanisms for converting CO into forms suitable for entrance into the biosphere are reviewed. The relatively long mean life of atmospheric CO leads to the prediction that the specific activity of natural CO may be greater than that of atmospheric  $CO_2$ , and therefore greater than that of biospheric  $CO_2$ . — D. B. V.

- 185-382. Bolin, Bert. On the exchange of carbon dioxide between the atmosphere and the sea: *Tellus*, v. 12, no. 3, p. 274-281, 1960.

The physical and chemical processes responsible for exchange of carbon dioxide between the atmosphere and the sea are analyzed. It is shown that the rate of transfer is considerably decreased due to the finite rate of hydration of  $CO_2$  in water. This is the case both for a smooth water surface where molecular diffusion plays a role in the first few hundredths of a millimeter as well as for rough sea where turbulence extends all the way to the surface. A general agreement is found between the transfer rate deduced in this way and the rate of exchange estimated on the basis of the  $C^{14}/C^{12}$  ratio in the atmosphere and the sea. — Author's abstract

- 185-383. Bien, G. S., Rakestraw, N. W., and Suess, H[ans] E. Radiocarbon content in Pacific Ocean water: *Tellus*, v. 12, no. 4, p. 436-443, 1960.

Results of  $C^{14}$  determinations on surface water from the Pacific Ocean are in agreement with those reported by Rafter and Fergusson (see *Geophys. Abs.* 171-215, 172-149). However, abnormal concentrations seem to exist locally for which no oceanographic explanation can be given. Data are still insufficient to permit conclusions concerning the effect of atomic bombs.

Samples from a constant depth of about 3,500 m show a decrease in  $C^{14}$  content from south to north; this may be attributed to radioactive decay of  $C^{14}$  during migration. From this, the northward component of the rate of water movement is calculated to be about 0.06 cm per sec.  $C^{13}$  determinations, made in order to correct the  $C^{14}$  values for fractionation effects, were remarkably consistent. — D. B. V.

- 185-384. Keeling, Charles D. The concentration and isotopic abundances of carbon dioxide in the atmosphere: *Tellus*, v. 12, no. 2, p. 200-203, 1960; abridged version in *Am. Geophys. Union Trans.*, v. 41, no. 3, p. 512-515, 1960 (*Internat. Geophys. Year Bull.* No. 38).

A systematic seasonal and latitudinal variation in the concentration and isotopic abundance of atmospheric carbon dioxide has been found in the northern hemisphere. In Antarctica there is a small but persistent increase in concentration. The activity of land plants in the northern hemisphere is suggested in explanation of the seasonal variation. The rate of increase at the South Pole is nearly that to be expected from combustion of fossil fuel if no removal from the atmosphere takes place; this suggests that the oceans have had no effect in reducing the annual increase resulting from combustion of fossil fuel. However, since the seasonal variation in the northern hemisphere is several times larger than the annual increase, it is as reasonable to suppose that a small change in the factors producing this seasonal variation may also have produced an annual change counteracting an oceanic effect. — D. B. V.

- 185-385. Schaeffer, O[liver] A., Thompson, S. O., and Lark, N. L. Chlorine-36 radioactivity in rain: *Jour. Geophys. Research*, v. 65, no. 12, p. 4013-4016, 1960.

Chlorine-36 in the atmosphere is an interesting isotope for study of geological problems as well as for understanding the hazards of nuclear fallout, as it has a relatively long half life (308,000 yr) and is very soluble in water. Relatively high levels of  $\text{Cl}^{36}$  activity have been found in rain, several orders of magnitude above the level to be expected from cosmic-ray production. It is almost surely the result of neutron irradiation of sea water by nuclear explosions.

The  $\text{Cl}^{36}$  has been added to the atmosphere in a relatively short time. If bomb testing is not resumed it will gradually leave the stratosphere and enter the ground water and finally the sea, where it will eventually be lost because of the large amount of stable chloride in the sea. It has already been detected in ground waters; by careful sampling it should be possible to study the processes involved in the storage of water underground. — D. B. V.

- Ehmann, William D., and Huizenga, John R. A search for long-lived  $\text{Ca}^{50}$  and  $\text{Cr}^{56}$ . See *Geophys. Abs.* 185-26.

- 185-386. Kokobu, Nobuhide, Mayeda, T[oshiko], and Urey, H[arold] C. Deuterium content of minerals, rocks, and liquid inclusion from rocks: *Geochim. et Cosmochim. Acta*, v. 21, no. 3/4, p. 247-256, 1961.

Samples of minerals, rocks, and liquid inclusions from rocks have been analyzed for water and deuterium content of the water. As juvenile water in samples from Hawaii and Japan contains less deuterium than the average surface water of the earth, it is concluded that juvenile water contains less deuterium than the oceans.

Possible explanations for this discrepancy are (1) protium equivalent to about 4 percent of the oceans has escaped from the earth; or (2) at the time of its formation the earth acquired surface water of high deuterium content and deeply buried water of low deuterium content. It is pointed out that certain carbonaceous chondrites contain the highest deuterium concentrations ever found in nature, whereas others of this group contain water of about average terrestrial composition. — D. B. V.

- 185-387. Friedman, Irving, Schoen, Beatrice, and Harris, Joseph. The deuterium concentration in Arctic sea ice: *Jour. Geophys. Research*, v. 66, no. 6, p. 1861-1864, 1961.

Analysis of the relation of deuterium content to depth in cores of sea ice collected near Ice Island and in Drifting Station Alpha demonstrates the existence of a relatively thin layer of deuterium-depleted water on parts of the surface of the Arctic Ocean during the summer. This layer is believed to form by the melting of snow, which is known to be highly depleted in deuterium, and the mixing of this melt water with sea water. Owing to vertical mixing this layer may blend with the deep water and will often disappear before the Arctic winter begins. However, in some cases a deuterium-depleted layer apparently persists until winter and becomes incorporated into the bottom of the ice that has persisted over the summer. — D. B. V.

- 185-388. Botter, René, Lorius, Claude, and Nief, Guy. Sur la datation des couches de névé dans l'Antarctique [On the dating of névé layers in the Antarctic]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 3, p. 437-439, 1961.

The relation established previously between deuterium content and temperature of formation of precipitations (see *Geophys. Abs.* 184-448) is used to date névé layers in the Antarctic ice cap; the hydrogen isotopic concentrations are correlated with observed seasonal changes in troposphere conditions in 1957-59. This application is somewhat limited because there is some irregularity in the meteorological phenomena; however, the results are no less valid than those based on stratigraphic profiles, and provide an indispensable complement to the latter. — D. B. V.

- 185-389. Horibe, Yoshio, and Kobayakawa, Mituko. Deuterium abundance of natural waters: *Geochim. et Cosmochim. Acta*, v. 20, no. 3/4, p. 273-283, 1960.

The deuterium abundance in natural waters from various sources has been determined by means of a deuterium mass spectrometer. The variation of deuterium contents of tap water at Tokyo and Osaka, Japan, during the last two years was within  $\pm 1$  percent, and no seasonal variation could be detected. Marine waters of the western Pacific have almost the same deuterium content as those of the Pacific Coast of the United States. Marine waters at various depths in the Antarctic Ocean show a relatively large variation of deuterium content from +0.84 to -1.16 percent of the standard mean ocean water (SMOW) scale whereas samples of the Black Current of the Pacific Ocean show little variation. It was found that the deuterium content of spring water suggests the origin of springs in some cases. Differences in the deuterium abundance in ground water in different parts of Japan suggest that the ground water is not necessarily of the same origin. — D. B. V.

- 185-390. Craig, Harmon. Isotopic variation in meteoric waters: *Science*, v. 133, no. 3465, p. 1702-1703, 1961.

The relationship between deuterium and oxygen-18 concentrations in natural meteoric waters from many parts of the world has been determined with a mass spectrometer. The isotopic enrichments, relative to sea water, display a linear correlation over the entire range for waters which have not undergone excessive evaporation. — Author's abstract



- 185-391. Brown, R. B. Hydrology of tritium in the Ottawa Valley: *Geochim. et Cosmochim. Acta*, v. 21, no. 3-4, p. 199-216, 1961.

Tritium deposition in rainwater at Ottawa, Canada, is reported for the years 1953-59. Correlation with the tritium content of drainage water in the district has allowed study of the hydrodynamics of the water system. A turnover rate constant of  $0.27 \text{ yr}^{-1}$  has been found for a storage reservoir of 2.1 m. The fraction of fresh precipitation in re-evaporated water has been estimated as  $0.55 \pm 0.1$ . A deposition rate of cosmic tritium of  $1.3 \pm 0.1$  atoms per  $\text{cm}^3$  per sec has been obtained from early data. — Author's abstract

- 185-392. Ashizawa, F. T., and Kuroda, P[aul] K. The occurrence of the short-lived iodine isotopes in natural and in depleted uranium salts: *Jour. Inorg. Nucl. Chemistry*, v. 5, no. 1, p. 12-22, 1958.

The occurrence of the short-lived iodine isotopes in nonirradiated uranium salts has been established. The equilibrium ratios of the short-lived iodine isotopes to  $\text{U}^{238}$  in depleted uranium agree within experimental error with those in natural uranium. The ratios, expressed in terms of  $10^{-4}$  disintegrations per sec per g  $\text{U}^{238}$ , are:  $\text{I}^{131}$ ,  $0.3 \pm 0.1$ ;  $\text{I}^{132}$ ,  $2.5 \pm 0.3$ ;  $\text{I}^{133}$ ,  $1.0 \pm 0.2$ ;  $\text{I}^{134}$ ,  $3.6 \pm 0.4$ ; and  $\text{I}^{135}$ ,  $3.5 \pm 0.4$ . Using Serge's value for the spontaneous fission half life of  $\text{U}^{238}$  of  $(8.04 \pm 0.3) \times 10^{15}$  yr, the corresponding yields of iodine isotopes are:  $\text{I}^{131}$ ,  $0.4 \pm 0.1$ ;  $\text{I}^{132}$ ,  $3.6 \pm 0.4$ ;  $\text{I}^{133}$ ,  $1.5 \pm 0.3$ ;  $\text{I}^{134}$ ,  $5.2 \pm 0.5$ ; and  $\text{I}^{135}$ ,  $5.1 \pm 0.5$  percent. — D. B. V.

- Goles, Gordon G., and Anders, Edward. Iodine content of meteorites and their  $\text{I}^{129}$ - $\text{Xe}^{129}$  ages. See *Geophys. Abs.* 185-95.

- 185-393. Russell, R[ichard] D., and Farquhar, R. M. Lead isotopes in geology: New York, Interscience Publishers Inc., 243 p., 1960.

The interpretation of lead isotope abundances as applied to geologic studies is discussed in eight chapters as follows: introduction, measurement of lead isotope ratios, age of the earth, dating galenas by means of their isotopic constitutions, anomalous leads, case histories, extensions of the Holmes-Houtermans model, and lead-uranium-thorium methods of age determination. Several hundred isotopic analyses of common leads are listed in appendices 1-12. Some of these have been obtained from the literature while others represent Toronto analyses, many of which are published here for the first time. A reference list contains 106 items. — V. S. N.

- 185-394. Nielsen, Heims. Zur lagerstättengenetischen Deutung der Isotopenverhältnisse am Blei und Schwefel [The metallogenetic significance of the isotope ratios in lead and sulfur]: *Geol. Rundschau*, v. 49, no. 1, p. 289-308, 1960.

The metallogenetic significance of the lead isotope ratios lies mainly in the anomalies with respect to the Holmes-Houtermans model lead; the absolute age is used only as a control or as a tie with the geologic time scale. The cause of the anomalies is discussed. In the lighter elements, including sulfur, isotope fractionation takes place in the course of geochemical processes; exogene circulation, for example, can be deduced from the isotope ratios. Most work in this connection has been done on galena sulfur. The techniques and results of investigations on some West Harz lead sulfide ores are presented. — D. B. V.

Marshall, Royal R., and Hess, David C. Lead from some stone meteorites. See Geophys. Abs. 185-86.

Hess, D[avid] C., and Marshall, R[oyal] R. The isotopic compositions and concentrations of lead in some chondritic stone meteorites. See Geophys. Abs. 185-87.

Sheline, R. K., and Hooper, J. E. Probable existence of radioactive manganese-53 in iron meteorites. See Geophys. Abs. 185-83.

Honda, M[asataka], Shedlovsky, J. P., and Arnold, J[ames] R. Radioactive species produced by cosmic rays in iron meteorites. See Geophys. Abs. 185-82.

185-395. Engel, A. E. J., Clayton, R[obert] N., and Epstein, S[amuel]. Variations in the isotopic composition of oxygen in the Leadville limestone (Mississippian) of Colorado as a guide to the location and origin of its mineral deposits: Internat. Geol. Cong. 20th, Mexico 1956, Symposium de Exploración Geoquímica, v. 1, p. 3-20, 1958.

Analyses of the oxygen isotopes  $O^{18}$  and  $O^{16}$  in unaltered and in hydrothermally altered limestone, dolomite, and quartz at Leadville, Colo., show that the highest  $\delta O^{18}/O^{16}$  values are obtained from bedded calcite, dolomite, and chert that have not been recrystallized by hydrothermal water (unaltered beds), whereas the lowest  $\delta O^{18}/O^{16}$  values, indicative of higher temperature, are from the hydrothermal calcite, dolomite, and quartz closest to ore. These variations in the oxygen isotope composition are consistent with independent geological evidence on the origin of the rock.

In the dolomite halo associated with the sulfide mineralization, variations in structure, texture, and concentration of elements and minerals are seemingly unsystematic with respect to ore; hence, the variations in oxygen isotopes may represent a useful guide to ore. — D. B. V.

185-396. Degens, Egon T. Stabile Isotope in ihren Beziehungen zur Zeit [Stable isotopes in their relations to time]: Geol. Rundschau, v. 49, no. 1, p. 277-278, 1960.

The use of the stable oxygen isotopes in determining the temperature of formation of ice caps or carbonate sediments is discussed briefly, and the significance of stable sulfur isotopes in ore genesis studies is mentioned. — D. B. V.

185-397. Emiliani, C[esare], Mayeda, T[oshiko], and Selli, R. Paleotemperature analysis of the Plio-Pleistocene section at Le Castella, Calabria, southern Italy: Geol. Soc. America Bull., v. 72, no. 5, p. 679-688, 1961.

A section 167.80 m thick, including the paleontologically defined Plio-Pleistocene boundary, was logged and sampled at close stratigraphic intervals. Oxygen isotope analyses of different species of pelagic and benthonic foraminifera and of shell fragments of benthonic mollusks have revealed numerous temperature oscillations. A major shift of temperature ranges toward lower values from late Pliocene to late Pleistocene is indicated. No major temperature change seems to have occurred across the Plio-Pleistocene boundary; an areal extension of the ice somewhat greater than at present is suggested.

Major continental glaciations may not have started until later than early Pleistocene, because none of the temperature minimums in the Le Castella section appear to have been as low as values obtained for the glacial ages in the eastern Mediterranean. — D. B. V.

- 185-398. Bowen, Robert. Paleotemperature analyses of Mesozoic Belemnoidea from Australia and New Guinea: *Geol. Soc. America Bull.*, v. 72, no. 5, p. 769-774, 1961.

Paleotemperature analyses were carried out by means of oxygen isotope measurements on more than 60 Belemnoidea obtained from Mesozoic strata in Western and South Australia and New Guinea. One set of data records mean rostral temperatures, and another derived by analyzing successive increments of powdered carbonate from the rostra shows the variations of temperature during ontogenies. The latter probably represent, and in this event would confirm, seasonal changes during the Mesozoic. The former demonstrate a cooling from the Jurassic into the Cretaceous and are consistent with the extension of the Albian and Coniacian-Santonian climatic maximums, previously demonstrated in Europe, into the Australian area. The Cretaceous readings dispose of the idea of an ice age in South Australia at that time. It appears that the Belemnoidea were eurythermal through most of their evolutionary history. The paleotemperature results are in accord with a possibly large migration of Australia during the Mesozoic. — D. B. V.

Sharp, Robert P., Epstein, Samuel, and Vidziunas, Irene. Oxygen-isotope ratios in the Blue Glacier, Olympic Mountains, Washington. See *Geophys. Abs.* 185-297.

Hess, David C., Marshall, Royal R., and Urey, Harold C. Surface ionization of silver; silver in meteorites. See *Geophys. Abs.* 185-89.

- 185-399. Nilsson, Ragnar; Olsson, Ingrid; Berggren, Adolf; and Siegbahn, Kai.  $S^{35}$  and  $Be^7$  contents in rain and snow: *Arkiv Geofysik*, v. 3, no. 2-3, p. 111-122, 1961.

The average  $S^{35}$  concentrations in some Swedish rain and snow samples were found to be 230 and 175 atoms per  $cm^3$  and the average  $Be^7$  concentrations to be 1,500 and 3,000 atoms per  $cm^3$  at Uppsala and Abisko, respectively.

Calculations of the production rate of  $Be^7$ , made for different locations where measurements of  $Be^7$  have been carried out, agree at least qualitatively with the experimental data. The deposition rate appears to be influenced by latitudinal and seasonal variations in tropopause height. — D. B. V.

Picciotto, Edgard E. Geochemistry of the radioactive elements in the ocean and chronology of the ocean sediments. See *Geophys. Abs.* 185-11.

Goles, Gordon G., and Anders, Edward. The record in the meteorites. 6. On the chronology of the early solar system. See *Geophys. Abs.* 185-91.

#### MAGNETIC FIELD OF THE EARTH

- 185-400. Chatterjee, J. S. Magnetic disturbances and the earth's magnetic field: *Jour. Geophys. Research*, v. 66, no. 5, p. 1535-1546, 1961.

An attempt is made to explain the origin of the observed magnetic field of the earth as being due to a current system circulating in the core, the current system in its turn being maintained by world-wide magnetic disturbances.

The mantle behaves as a semiconductor, and the conduction electron density is given by the Boltzmann distribution law. The conductivity changes steeply along the radial direction, and a "potential hill" is produced in the radial direction. Owing to interaction of the induced current with the steady magnetic field, a Hall potential is developed; this modifies the existing "potential hill," and hence the conductivity becomes to some extent dependent on the induced current vector. The consequent nonlinearity rectifies the induced current, and a net amount of unidirectional current aiding the existing magnetic field is left over at the end of the disturbance. This gradually penetrates down to the core and has a decay time of the order of a million years. The net unidirectional current then grows through successive disturbances. It is shown that, for reasonable values of conductivity, temperature, and electron mobility, the magnetic disturbances maintain sufficiently large current in the core so that the earth's magnetism can be explained as entirely due to the magnetic disturbances. — Author's abstract

- 185-401. Cagniard, Louis. Panorama du magnétisme terrestre [Panorama of terrestrial magnetism]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 1, p. 148-150, 1961.

The globe accumulates, in the form of more or less persistent induced currents, the vestiges of variations of its rotational velocity. Terrestrial magnetism, constantly evolving, represents essentially the sum of the more or less ancient, more or less dulled reminders that the earth has been able to preserve the past rotational variations. — Author's abstract, D. B. V.

- 185-402. Lucke, Otto. Die dynamischen Gleichungen des Plasmas in der Magnetosphäre [The dynamic equations of the plasma in the magnetosphere (with English abstract)]: Zeitschr. Geophysik, v. 26, no. 3, p. 105-137, 1960.

The assumptions necessary for describing large-scale movements of plasma of the magnetosphere by dynamic equations are given. For stationary conditions these equations lead to magnetic ring-currents which are intensified in the main phase of magnetic storms but are also present otherwise. They are most strongly developed in regions in which the impressed magnetic field is most deformed by the diamagnetism of the plasma. In these regions a maximum value is reached for the density of the electrically charged particles, whose magnetic moment, caused by transverse movement around the magnetic lines of force, can be regarded as an adiabatic invariant. The transverse kinetic energy density is then  $3/2$  of the energy density of the magnetic field. The maximum particle densities are calculated; they are in plausible agreement with the measured values. The results show that the theory of magnetic storms needs further development. — Author's German abstract, D. B. V.

- 185-403. Forbush, S. E. Theoretical and statistical geophysics: Carnegie Inst. Washington Year Book 59, p. 222-226, 1960; reprinted in Carnegie Inst. Washington Dept. Terrestrial Magnetism Ann. Rept. of Director for 1959-60, 1960.

Investigation of the equatorial electrojet was continued during the year (see Geophys. Abs. 184-465). Assuming a height of 100 km (106 km in the Pacific) for the eastward primary electrojet current near midday, the width of the primary current band is found to be about 660 km centered above the magnetic dip equator. A new technique was found for the separation of the observed field of the electrojet (near midday) into components of origin external and internal to the earth, together with separation of jet effects from normal effects.

The induced (internal) field is compatible with that from the image of the jet band current flowing westward at a depth of about 600 km; this is in accord with the concept that the earth's crust is essentially nonconducting to a depth of 250 km and perfectly conducting below that depth. No electrojet effects were found at night, and there is no evidence for electrojet effects on the storm time variation (Dst). Studies were conducted also to ascertain whether some of the observed asymmetry in the diurnal variation of the vertical field north and south from the center of the electrojet may arise from deviations from uniform subterranean conductivity. Fields were examined at five stations in the Peruvian net from a few night-time sudden commencements. An electrojet effect in the lunar variation is also indicated. Cosmic-ray investigations are reported briefly. — V. S. N.

- 185-404. Sakurai, Kunitomo. The cosmic ray equator and geomagnetism: Jour. Geomagnetism and Geoelectricity [Kyoto], v. 12, no. 1, p. 13-20, 1960.

Deviation of the cosmic ray equator from the geomagnetic dipole equator is found to be negligible, even if a magnetic cavity exists around the outer atmosphere. Taking this factor into account, the origin of the cosmic ray equator is considered. It is found to be produced by the higher harmonic components combined with the dipole component of geomagnetism; therefore, it originates in the interior of the earth. As it is impossible that local magnetic anomalies in the crust can be the cause, it is suggested that the origin lies in the eccentric dipoles in the outer part of the core that contribute to geomagnetic secular variation. — D. B. V.

- 185-405. Whitham, Kenneth. Measurement of the geomagnetic elements, in Methods and techniques in geophysics: London Interscience Publishers, Ltd., p. 104-167, 1959; reprinted in Dominion Observatory Ottawa Contr., v. 3, no. 30, 1959; also New York Interscience Publishers, Ltd., p. 104-167, 1960.

Following a brief description of the geomagnetic field and of absolute and relative magnetic measurements, magnitude of spatial and time variations, and limitations in magnetic measurements, the various methods of measurement of the geomagnetic elements are discussed in detail—torque, induction, saturable-core, Hall effect, magnetostriction, and proton-precession methods and methods using the deflection of free electrons in a magnetic field. The saturable-core and proton-precession methods are the most important developments in the last decade and have been developed rapidly and exploited fully in the study of spatial and time variations from a moving support. Although the use of electronic methods could be increased, good results with a sensitivity adequate for most purposes can be obtained using the classical methods, which make fewer demands on the technical competence of the operators and, thus, are important at small and isolated observatories. — V. S. N.

- 185-406. Whitham, Kenneth. National report for Canada—Geomagnetism: Dominion Observatory Ottawa Pubs., v. 24, no. 4, p. 87-98, 1960.

A compilation of geomagnetic activity undertaken by university departments and government institutions in Canada since 1957 is presented. The following activities are summarized briefly: geomagnetic surveys; magnetic charts and maps; magnetic observations and variation stations; developments in magnetic instruments; aeromagnetic interpretation and correlation studies; paleomagnetic and magnetic rock-property studies; magnetotelluric and telluric current

studies; research into the main geomagnetic field and its secular variation; studies of magnetic field variations; and research into the E. M. method of prospecting. A bibliography of published results and of forthcoming publications is included. — V. S. N.

- 185-407. Haáz, I[stván] B[éla] L'effet de la température dans les mesures au BMZ [The effect of temperature on BMZ measurements (with English, French, German, and Russian summaries)]: Acad. Sci. Hungaricae Acta Tech., v. 30, no. 3-4, p. 463-466, 1960.

In measurements with the BMZ magnetometer the temperature coefficient is a function of the Z-value, which is obtained only at the end of the calculation. The temperature correction may be computed by means of a coefficient belonging to the uncorrected Z-value, but the result may be corrected by a small value ( $\xi$ ). A formula is given for this correction and some values of  $\xi$  obtained with three different instruments are tabulated. (See also Geophys. Abs. 171-247.) — D. B. V.

- 185-408. Orlov, V. P. Mirovaya karta magnitnykh meridianov na epokhu 1955 g [World map of magnetic meridians in the epoch 1955]: Akad. Nauk SSSR, Izv. Ser. Geofiz., no. 1, p. 104-106, 1961.

A world map of magnetic meridians for epoch 1955 has been published. It consists of two sheets: Northern Hemisphere and Southern Hemisphere. These are reproduced here at a reduced scale. A world chart of the residual magnetic field Z is also given. — J. W. C.

- 185-409. Tarczy-Hornoch, Antal. Über die Berechnung der magnetischen Deklination für einen Ort aus der gleichzeitigen magnetischen Deklination einer Referenzstation [On the calculation of the magnetic declination for a place from the contemporaneous declination of a reference station (with English summary)]: Gerlands Beitr. Geophysik, v. 69, no. 6, p. 321-327, 1960.

For the determination of magnetic declination of a territory, best-osculating mathematical planes are calculated for different epochs. The declinations corresponding to these planes are the normal declinations, which can be computed by interpolation for moments between and outside the epochs; the deviations from them represent the so-called local disturbances at individual places. The calculation of normal declinations by extrapolation is inexact and can be performed only for a limited period. The local disturbances, which are necessary for calculation of true declination, are assumed to be constant over a long period of time.

As these local disturbances depend on the osculating planes chosen and on the number and distribution of points included in the adjustment, a point may have different local disturbances even at the same moment. At different moments, different local disturbances are usually obtained, even with similar osculating planes and with the same number and distribution of observation points. Then interpolations can be made between the local disturbances at the same place at given moments. — Author's German summary, D. B. V.

- 185-410. Gouin, P. Magnetic activity at Addis Ababa from January to June 1958: Addis Ababa Univ. Coll., Geophys. Observatory Bull., v. 1, no. 1, p. 5-43, 1959.

The establishment of a geomagnetic observatory at Addis Ababa, Ethiopia was recommended because of its position practically on the magnetic equator. Operation began in January 1958. The station and instruments are described. Daily observations were made of the effects of singularity associated with the magnetic equator. One such effect is the enhancement of the H diurnal variation at these latitudes under the influence of the electro-jet current. There is also a high amplitude in the background activity, and the lunar effect is very large. During the observation period the electro-jet shifted north-south between 90 and 30 km south of Addis Ababa. — J. W. C.

- 185-411. Láncoz, Pál. A földmágneses tér hatóras periódusú változásáról [The six-hour periodic variations of the geomagnetic field (with German summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 209-217, 1960.

The diurnal course of the geomagnetic X, Y, and Z components as recorded at the Budapest and Niemegk observatories since 1950 has been compared with theoretical curves in order to determine which components best reveal the features of the short-period variations. The amplitude of the 6-hr oscillation is greatest in the Y component. — D. B. V.

- 185-412. Fel'dshtein, Ya. I. The Dickson Island and Cape Cheliuskin Q-indices of magnetic activity: Canada Defense Research Board Directorate of Sci. Inf. Services, T 347 R, 7 p., 1961; translated from *Vozmuscheniya Elektromagnitnogo Polia Zemli*: Moscow, Akad. Nauk SSSR, 1960.

Data from magnetograms recorded at Dickson Island and Cape Chelyuskin from July 1956 to July 1957 are used in a study of the behavior of the new index of magnetic activity and for a comparison of results with those obtained with the old indexes. In deriving the Q-index, only the variations of the horizontal elements of the geomagnetic field, the declination D and the horizontal component H, are used. Results are illustrated in tables and graphs. — V.S.N.

- 185-413. Kakioka Magnetic Observatory. Report of the geomagnetic and geoelectric observations during the International Geophysical Year, 1957-58: Kakioka, Japan, Kakioka Magnetic Observatory, 487 p., 1960.

The results of observations during the International Geophysical Year of rapid variations in the geomagnetic field and earth currents and of principal geomagnetic storms as carried out by the Kakioka Magnetic Observatory and its two branch magnetic observatories at Memambetsu and Kanoya, Japan, are reported. Instruments and methods of observation are briefly discussed. Observations are given in tables, and some examples of rapid-run magnetograms, induction magnetograms, and rapid-run tellurigrams are reproduced. — V.S.N.

- 185-414. Parkinson, W. D., and Curedale, R. G. Isomagnetic maps of Australia for the epoch 1957.5. Pt. 1—Eastern Australia: Australia Bur. Mineral Resources, Geology and Geophysics Rept., no. 55, 13 p., 1960.

Isomagnetic maps of Queensland, New South Wales, Victoria, and Tasmania showing five magnetic elements reduced to epoch 1957.5 are presented. The maps are based on results of regional magnetic observations made since 1910;

much of the data have been obtained since 1952. Data from the reoccupation of stations have been used to revise the older results and to estimate the present rate of change of the magnetic field. The estimated rate of change is shown on each map. — V. S. N.

- 185-415. New Zealand Department of Science and Industrial Research. International Geophysical Year Ionospheric data, Scott Base 1957-58, Cape Hallet 1957-58: New Zealand Dept. Sci. Indus. Research (Geophys. Div.), Christchurch Geophys. Observatory, 450 p., 1960.

This volume presents ionospheric data in tables for Scott Base and Cape Hallet, Antarctica, for the International Geophysical Year period, July 1, 1957-December 31, 1958. Frequency plots for regular and special world days will be published in a separate volume. — V. S. N.

- 185-416. Pinn, J. D. Field magnetic observations in Antarctica: Australia Bur. Mineral Resources, Geology and Geophysics Rept., no. 51, 7 p., 1960.

The results of magnetic observations at field stations in the Antarctic since 1954 are presented in tables. No analysis is made of the data. Observation points, shown on a map, are along the coast of the Australian Antarctic Territory and along two traverses extending about 350 miles south of Mawson. — V. S. N.

- 185-417. Ostenso, Ned A., and Bentley, Charles R. Observed magnetic declinations in West Antarctica: Jour. Geophys. Research, v. 66, no. 4, p. 1301-1302, 1961.

Declination observations were made at intervals of about 30-36 nautical miles on 6 oversnow traverses and at each of the 7 stations occupied by an airborne traverse in West Antarctica. The locations of all the observation sites are plotted on a map, along with isogonic lines contoured from these data at 10° intervals and isogonic lines plotted on H. O. map 1706S (1960). Agreement between observed and computed declination is remarkably good. Such discrepancy as does exist may be due either to the fact that the observations were made over a period of 3 yr, during which some secular variation would occur, and (or) to the fact that magnetic susceptibility is higher than normal in the western part of West Antarctica. — D. B. V.

- 185-418. Cagniard, Louis. La variation magnétique seculaire interprétée comme un "effet Rowland," accompagné de phénomènes d'induction électromagnétique [Secular magnetic variation interpreted as a "Rowland effect" accompanied by electromagnetic induction phenomena]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 19, p. 2053-2055, 1960.

The Rowland effect has never been invoked to explain secular magnetic variation because it generates a field that is proportional to the rotational velocity, a phenomenon which does not obtain. Furthermore, if very small fluctuations in rotation can cause magnetic variations of several hundred gammas, as recently suggested (see Geophys. Abs. 184-464), it is implied that the magnetic field itself should be of the order of billions of oersteds.

The Rowland effect could operate and still be compatible with the observations if it is assumed that certain parts of the globe are highly conducting. In a regime of uniform rotation, the positive and negative charges give rise to



enormous Rowland fields, but these will almost cancel out if the charges are situated in a "double layer" at the boundary between the core and mantle. When rotation varies, this compensation ceases; and if the conductivity of the interlayer is high enough, intense induced currents will flow there. Such an electromagnetic perturbation would require several centuries to be manifested outside the double layer. Calculations show that this effect is compatible with empirical data if the conductivity of the mantle is of the order of that of the electrolytes. — D. B. V.

Rikitake, Tsuneji. Thermo-magneto-hydrodynamic oscillations in the earth's core. See *Geophys. Abs.* 185-376.

185-419. Jacobs, J. A., and Sinno, K. World-wide characteristics of geomagnetic micropulsations: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 3, p. 333-353, 1960.

Geomagnetic micropulsations recorded by rapid-run magnetographs during the International Geophysical Year at 17 widely distributed observatories are analyzed. A number of well-defined cases (14 Pt's and 3 Pc's) are investigated in detail. Diurnal and world-wide characteristics are derived, and the equivalent overhead current systems that may give rise to the micropulsations are constructed.

Pt's can be divided into two groups: Pt<sup>-</sup>, associated with a negative bay in the auroral zone, and Pt<sup>+</sup>, associated with either a positive bay or no bay in the auroral zone. Both classes have more or less coherent, synchronous wave forms over a wide area; that is, they have the same period at different stations, where they are either nearly in or out of phase. Pc's are found to consist of two different wave bands, both occurring during the daylight hours. The first band contains shorter period Pc's (15-30 sec) with maximum amplitudes of a few gammas in the polar regions; they are well synchronized around the world. Longer period continuous pulsations (LPc's) usually appear simultaneously with Pc's in polar regions.

An attempt is made to explain the characteristics of micropulsations in terms of hydromagnetic oscillations in the outer atmosphere excited by solar corpuscular streams. — D. B. V.

185-420. Law, P. F., and Fannin, B. M. Radiation from a current filament above a homogeneous earth, with application to micropulsations: *Jour. Geophys. Research*, v. 66, no. 4, p. 1049-1059, 1961.

The electric and magnetic fields in the vicinity of a plane, homogeneous earth due to a line current source above this earth model are examined in order to throw light on the origin of geomagnetic micropulsations. As the micropulsation frequencies are quite low (of the order of 1 cycle per second), the nearfield considerations become significant. The solution for this nearfield problem is presented, and the fields at the earth's surface are evaluated for a set of parameter values chosen to approximate an ionospheric source at a typical micropulsation frequency. — D. B. V.

185-421. Tepley, Lee R. Observations of hydromagnetic emissions: *Jour. Geophys. Research*, v. 66, no. 6, p. 1651-1658, 1961.

Preliminary results of a frequency-time analysis of geomagnetic micropulsations in the frequency range 0.5-5 cycles per second are presented. At times, oscillatory signals of slowly varying frequency were observed continuously for periods of several hours; signals of more rapidly varying frequency were also observed, but for shorter periods of time. The oscillations are

called hydromagnetic emissions, as they are probably generated above or high in the ionosphere and are propagated downward by hydromagnetic waves. The nature of the oscillations was undoubtedly influenced by solar-flare activity that occurred before and during the observation period. — D. B. V.

- 185-422. Terashima, Yoshinosuke. Solar modulation of primary cosmic rays: *Prog. of Theoretical Physics*, v. 23, no. 6, p. 1138-1150, 1960.

A combined model is developed to account for the modulation of cosmic rays by both disordered and ordered magnetic fields of solar origin. The diffusion region of disordered magnetic fields is assumed to extend widely over the solar system and to produce modulation of the low energy part of primary cosmic rays. An interpretation is given for the characteristic shape of the low energy spectrums common to all of the heavy primary cosmic rays recently observed. The eleven-year variations are ascribed to the superposition effect of ordered magnetic fields distributed near the earth's orbit. The diurnal variations are shown to be a direct consequence of the model; the solar streams with uniform magnetic fields will cause the quiescent diurnal variations as well as the ones associated with magnetic disturbances.

Arguments are based upon the assumption of two kinds of solar streams: the continuously ejected streams and the more intense ones produced by solar eruptions. A quantitative estimate of the physical parameters to describe the present model is given. — V. S. N.

- 185-423. Hu, Yue-jen. On the 27 day periodicity of the magnetic activity [in Chinese with English abstract]: *Acta Geophys. Sinica*, v. 7, no. 2, p. 103-107, 1958.

From analysis of magnetic data for 32 years, 1923-54, Hu has found that the frequency of international magnetically disturbed days (5 for each month) has a 27-day periodicity corresponding to the sun's rotation. This periodicity is apart from that of the well-known 27-day recurrence of magnetic activity. — V. S. N.

- 185-424. Nicholson, Seth B., and Wulf, Oliver R[eynolds]. The diurnal variation of K indices of geomagnetic activity on quiet days in 1940-1948: *Jour. Geophys. Research*, v. 66, no. 4, p. 1139-1144, 1961.

Local- and universal-time components of the diurnal variation of the K-indices have been computed from the 8 daily K numbers for the 10 quiet days of each month in the 9 years 1940-48 for 6 observatories in moderately low latitudes and fairly evenly distributed longitudes. The universal-time component is less regular than the local-time component. There is a pronounced change in form of the apparent regularity of the latter when it is examined for each of the 9 years separately. This change probably arises mainly from disturbance and represents a change in the relative amounts of disturbance having different forms of diurnal variation. It may represent a change of this distribution with the solar cycle. — D. B. V.

- 185-425. Takahashi, Hachiro. Correlation between solar activity and sudden movements in geomagnetic disturbances: *Jour. Geophys. Research*, v. 65, no. 12, p. 4206-4209, 1960.

Geomagnetic and solar data obtained at the Kakioka Magnetic Observatory in Japan in 1924-58 were used in a statistical study of long-term variations. In this letter, discussion is limited to sudden movements of horizontal intensity (H) in geomagnetic disturbances; a total of 786 of these (SC, SC\*, and SI)

were used. The results are presented in graphs that show in different ways the correlations between duration and amplitude of  $\Delta H$  movements and relative sunspot numbers. — D. B. V.

- 185-426. Fournier, Hugo. Quelques aspects des premiers enregistrements magnétotelluriques obtenus à Garchy dans la gamme des variations très rapides [Some aspects of the first magnetotelluric records obtained at Garchy in the range of very rapid variations]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 7, p. 963-964, 1960.

The first results obtained with the new apparatus for recording very rapid geomagnetic variations (see Geophys. Abs. 184-463) are reported. Fluctuations of less than 1 sec period are very uniform as compared to those of more than 1 sec period. Remarkable periodicities of the order of 0.12 sec are always present. Earth-current variations correspond precisely with the geomagnetic variations.

Without special precautions, the induction magnetometers act as very sensitive seismographs, recording microseismic agitation due to such factors as wind in nearby trees, distant quarry explosions, thunder, passing aircraft, or a bulldozer working several hundred meters away. — D. B. V.

- 185-427. Veldkamp, J. A giant geomagnetic pulsation: Jour. Atmos. Terrest. Physics, v. 17, no. 4, p. 320-324, 1960.

A giant geomagnetic pulsation on July 17, 1958 was recorded by many European observatories between 50° and 60° geomagnetic latitude. The movements (with periods of about 100 sec) were coherent in only a small part of the area in which they were recorded. Maximum amplitudes (25 $\gamma$ ) occurred in a strip following the circles of geomagnetic latitude.

It is obvious that the direct cause of the pulsation cannot be the same at stations far apart. Examination of the theories of Obayashi and Jacobs (see Geophys. Abs. 181-372) and Scholte (see Geophys. Abs. 181-371) leads to the conclusion that the area over which this pulsation was recorded is an indication of the size of the area of the exosphere that was disturbed at its generation. The loss of coherence of the vibrations over a rather small distance and the shift of starting and ending times might be caused by the occurrences in the source; presumably the whole area was not disturbed at the same moment. — D. B. V.

- 185-428. Wescott, Eugene M. Magnetic variations at conjugate points: Jour. Geophys. Research, v. 66, no. 6, p. 1789-1792, 1961.

Magnetograms from Macquarie Island were compared with those from nine Alaskan International Geophysical Year stations, Fort Churchill, Canada, and Cape Chelyuskin, U.S.S.R. The magnetic variations at Macquarie Island were found to correspond remarkably well in universal time with those at several Alaskan stations. On the basis of this study an area lying roughly between Healy and Kotzebue, Alaska, can be defined as the area conjugate magnetically to Macquarie Island. — Author's abstract

- 185-429. Robertson, C. S. Magnetic bays at Macquarie Island: Australian Jour. Physics, v. 13, no. 3, p. 470-476, 1960.

Polar magnetic bays are the most striking feature of magnetic records obtained by the Australian National Antarctic Research Expeditions at Macquarie Island. Negative bays are more numerous than positive bays and have greater amplitudes and durations. As a rule negative bays commence about magnetic

midnight whereas positive bays commence about five hours earlier. A daily reversal in direction of the bay-producing currents is indicated, and the time at which this reversal takes place appears to vary with the seasons. During magnetically disturbed periods the ratio H-bay amplitude to Z-bay amplitude increases, indicating a northward movement of the bay-producing currents. At the same time auroras seen from Macquarie Island lie further north in the sky than usual. — Author's abstract

- 185-430. Rourke, G. F. Small-scale polar-cap absorption and related geomagnetic effect: *Jour. Geophys. Research*, v. 66, no. 5, p. 1594-1595, 1961.

The fact that on December 17, 1957 the level of geomagnetic activity was relatively more marked inside the polar cap than in the auroral zone (see *Geophys. Abs.* 184-467) may be related to the influx of corpuscular radiation. An intensification of the polar-cap current system due to energetic particles would result in a higher level of geomagnetic disturbance in the polar regions. The sudden commencement on December 19, reported at 37 stations, was followed by a period of slight disturbance ( $A_p=20$ ). — D. B. V.

Kertz, Walter. Conducting cylinder in the transverse alternating magnetic field. See *Geophys. Abs.* 185-172.

- 185-431. Singer, S. F. A new model of magnetic storms and aurorae: *Am. Geophys. Union Trans.*, v. 38, no. 2, p. 175-190, 1957.

A model is proposed that explains the cause of SC\*, the atmospheric nature of SC, the delay between SC and the main phase of a magnetic storm, and the formation and decay of the ring current. In this model, a shock wave from a solar eruption reaches the earth 22-24 hr later. High-velocity particles having smaller interaction precede the shock wave and cause pre-SC bay-like disturbances at high latitudes. The shock wave itself is retarded by body forces produced by the geomagnetic field but speeds up on entering auroral zones; in pushing out the lines of force it creates polar SC\* events. The storm decrease is produced by high-velocity particles following the shock wave, which become trapped in the normally inaccessible Störmer region and drift, producing the ring current. — D. B. V.

- 185-432. Akasofu, Syun-Ichi, and Chapman, Sydney. The ring current, geomagnetic disturbance, and the Van Allen radiation belts: *Jour. Geophys. Research*, v. 66, no. 5, p. 1321-1350, 1961.

The large decrease in the horizontal component of the earth's field during the main phase of magnetic storms has been ascribed to the formation or enhancement of a geomagnetic ring current. The motions of particles trapped in the earth's dipole field and the resulting ring current are calculated. The general equations for the current intensity, to obtain the total current and the magnetic field at the earth's center, are applied to the outer radiation belt and to a special "model" belt  $V_3$ . The results are considered in connection with magnetic records for several storms and with satellite data. It is inferred that during magnetic disturbance, protons of energy of the order of a few hundred kev are intermittently captured between 5 and 8 earth radii to produce a transient  $V_3$  belt. Differences in development of the ring current from one storm to another may be connected with irregular distribution of particles in the solar stream, which may contain tangled magnetic fields. — D. B. V.

- 185-433. Ferraro, V. C. A. An approximate method of estimating the size and shape of the stationary hollow carved out in a neutral ionized stream of corpuscles impinging on the geomagnetic field: *Jour. Geophys. Research*, v. 65, no. 12, p. 3951-3953, 1960.

Using a formula which he derived in 1952, Ferraro has developed an approximate method for estimating the size and shape of the stationary hollow carved out when a solar corpuscular stream impinges on the geomagnetic field. It is also shown that in a two-dimensional magnetic field, the width of the hollow at infinity is finite and is given by  $(2\pi I^2 / \rho v^2)^{1/2}$  where  $I$  is the current flowing in a permanent inducing system,  $\rho$  the density, and  $v$  the velocity of the stream. — D. B. V.

- 185-434. Piddington, J. H. A theory of polar geomagnetic storms: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 3, p. 314-332, 1960.

A hydromagnetic theory of geomagnetic storms is developed further (see *Geophys. Abs.* 179-294). The three phases of the longitude-dependent disturbance  $D_s$ , the first phase of  $Sc$ , the main phase, and the preliminary reverse are all accounted for in terms of hydromagnetic waves whose Poynting fluxes are directed along the magnetic lines of force. These disturbances originate from "electromagnetic friction" between the solar wind and geomagnetic lines of force near 06 h and 18 h local time. These lines of force are bent out of their meridian planes and cause two pairs of "twist" waves to reach the earth, focused into relatively confined regions at high latitudes. These twists are stable or force-free and result in space-charge accumulations in the lower atmosphere, where the resultant Hall current accounts for the observed disturbances.

During the main phase the twists are maintained by a deformation of the geomagnetic field, the geomagnetic "tail." Thus the tail theory accounts for both  $D_{st}$  and  $D_s$  main phase. It is difficult to see how any ring-current theory or other theory dependent on trapped corpuscular radiation could account for the asymmetric features of storms. The mechanism also provides the beginning of a theory for auroras. — D. B. V.

- 185-435. Simon, Paul. Les éruptions chromosphériques associées avec sursauts radioélectriques de type IV: effets ionosphériques et géomagnétiques [The chromospheric eruptions associated with radioelectric bursts of type IV: ionospheric and geomagnetic effects]: *Annales Astrophysique*, v. 23, no. 1, p. 102-110, 1960.

A study of ionospheric and geomagnetic effects associated with chromospheric eruptions leads to the conclusion that there is a close relation between chromospheric eruptions accompanied by type IV solar radioelectric bursts and sudden ionospheric disturbances (SID). A relation of the same sort exists with geomagnetic activity (characterized by the sum of daily K-indices), but here the correlation is more directly with the importance of the eruption. — D. B. V.

- 185-436. Durandea, Monique; Delloue, Jean; and Rocard, Yves. Oscillations de pression atmosphérique liées à un orage magnétique [Oscillations of atmospheric pressure related to a magnetic storm]: *Acad. Sci. [Paris] Comptes Rendus*, v. 251, no. 17, p. 1807-1809, 1960.

Simultaneous microbarographic oscillations recorded at three Pacific stations (Bora-Bora, Makatea, and Papeete) seem to have been caused by a wave of cosmic particles that were also manifested in the form of a magnetic storm. — D. B. V.

## MAGNETIC PROPERTIES AND PALEOMAGNETISM

- 185-437. Hall, J. M., and Neale, R. N. Stress effects on thermoremanent magnetization: *Nature*, v. 188, no. 4753, p. 805-806, 1960.

Experiments reported here show that the effect of stress on thermoremanent magnetization is not completely reversible in all cases as reported recently (see *Geophys. Abs.* 183-454). Tests made on a number of rocks containing different minerals in every case showed a rotation of moment induced by uniaxial pressure during magnetization, together with a reduction of moment. The observed rotation of moment depended on the pressure, on the angle between the magnetizing field and the pressure axis, and on the grain size of the magnetic constituents (composition being constant), but was apparently independent of the intensity of the magnetizing field in the range of 0.5-3.0 oersted.

The mechanism of these pressure effects is complex, but not irreconcilable with the known magnetostrictive properties of magnetite. There is a close similarity between the variation of rotation of moment with grain size and the variation of coercive force with grain size; if the latter variation results from a change in the mechanism of magnetization, it is obviously an important factor in the production of angular pressure effects.

A slight intrinsic anisotropy, together with the grain size factor, may have contributed to the experimental results that suggested complete reversibility of pressure effects. — D. B. V.

- 185-438. Stacey, F. D. Thermo-remanent magnetization (TRM) of multidomain grains in igneous rocks: *Philos. Mag.*, v. 3, no. 36, p. 1391-1401, 1958.

The magnetic moment of a multidomain grain at its blocking temperature is determined by the domain arrangement which gives the minimum magnetic energy; for a large grain the energy minimum is produced by a self-demagnetizing field equal and opposite to the external field. Below the blocking temperature the domain configuration is frozen in and the moment increases with the increasing spontaneous magnetization. This results in a TRM proportional to small inducing fields, as in the theory of single domain grains and as required for agreement with exponential observations. Artificial TRM's of 17 rocks for which analyses of magnetic minerals are available show good agreement with calculated values. The theory also gives a formula for the maximum possible initial susceptibility of rocks which agrees well with experimental observations. — Author's abstract

- 185-439. Irving, E. Robertson, W. A., Stott, P. M., Tarling, D. H., and Ward, M. A. Treatment of partially stable sedimentary rocks showing planar distribution of directions of magnetization: *Jour. Geophys. Research*, v. 66, p. 1927-1933, 1961.

It is shown how the viscous magnetization components in some Upper Carboniferous sediments may be removed by partial thermal demagnetization so that the initial planar distribution condenses around the direction of the stable magnetization. The demagnetization was carried out by heating in an inert atmosphere in a nonmagnetic oven followed by cooling in a zero field. Application of Graham's fold test shows that this stable magnetization is of very great antiquity, certainly pre-Triassic and probably pre-Permian in age. — D. B. V.

- 185-440. Opdyke, N. D. The paleomagnetism of the New Jersey Triassic: A field study of the inclination error in red sediments: *Jour. Geophys. Research*, v. 66, no. 6, p. 1941-1949, 1961.

It has previously been reported that on redeposition in the laboratory the magnetization of both red sediments and varves has a systematic error in inclination which could be a serious source of error in paleomagnetic work. To test whether such an error occurs in nature, the directions of magnetization measured in specimens from intrusions, extrusions, and red sediments of the Newark system have been compared. There is no significant difference between the stable directions in each type of rock, showing that no important error in inclination occurs in the sediments. — Author's abstract

- 185-441. Cox, Allan [V]. Anomalous remanent magnetization of basalt: U.S. Geol. Survey Bull. 1083-E, p. 131-160, 1961.

Anomalous remanent magnetization in igneous rocks is often characterized by varying intensity and direction throughout a magnetized body; regions within which a correlation exists between the remanent magnetization at any two points are known as cells of anomalous magnetization. Such cells are common to the Pliocene and Pleistocene basalts of Idaho; the magnetization is isothermal and probably is due to the intense magnetic field accompanying a lightning discharge with a peak current of 22,000 amps. The dimensions of the cells of anomalous magnetization in these lava flows are within the range of typical currents in lightning bolts, 20-100 feet. Viscous magnetization causes a much smaller anomalous magnetization in these rocks and is often masked by the isothermal magnetization due to lightning. The thermoremanent magnetization is relatively stable, but both types of anomalous magnetization can be selectively destroyed using alternating magnetic fields. — V.S.N.

- 185-442. Babkine, Jean, and Bolfa, Joseph. Contribution à l'étude des propriétés thermomagnétiques de quelques basaltes [Contribution to the study of the thermomagnetic properties of some basalts]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 13, p. 1979-1981, 1961.

Samples of the Etna flow of 1381 were studied in order to determine the precise mineralogic nature of the material responsible for the ferromagnetism of the lava. A sample from the center of the flow gave a thermomagnetic curve that shows a distinct discontinuity for a temperature of 120°C; the optical properties of its opaque elements are those of titanomagnetite. A sample from the upper part of the flow gave a curve similar to that of magnetite; its optical properties are heterogeneous and it shows typical epitaxial martitization. Five other samples from positions intermediate between these two gave intermediate curves. Similar results were obtained on three flows from the Velay region of France.

It is concluded that each flow is characterized by a group of curves, the type curve being that with the lowest Curie point. Unaltered internal zones and external zones oxidized by contact with the atmosphere can be distinguished within each flow. — D. B. V.

- 185-443. Pecherskiy, D. M. K voprosu o magnitnoy anizotropii sloistyykh gornykh porod [Problem of magnetic anisotropy of stratified rocks]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 10, p. 1490-1494, 1960.

The results of experimental studies on the relationship between the anisotropy of weakly and moderately magnetized rocks and their layering is reported. Cubic samples of sedimentary, volcanic, and metamorphic rocks, 1-6 cm<sup>3</sup> in size were thermomagnetized parallel and transverse to the layering up to 700°C in a field of 3 oersteds, and their remanent thermomagnetism measured on a Dolginov astatic magnetometer. It was found that magnetic anisotropy of rocks is correlated with secondary layering due to unilateral pressure under high temperature. This has been observed in magnetite quartzite and schist (see Geophys. Abs. 166-270, 176-267). A suggestion is made that the degree of magnetic anisotropy of metamorphic rocks should reflect the degree of their metamorphism. — A. J. S.

- 185-444. Lapina, M. I. Ob ispol'zovanii variatsiy magnitnogo polya dlya opredeleniya magnitnoy vospriimchivosti sil'nomagnitnykh gornykh porod v usloviyakh yestestvennogo zaleganiya [On the application of magnetic field variations for determination of magnetic susceptibility of strongly magnetic rocks under conditions of natural occurrence]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 418-422, 1961.

From earlier studies (Yanovskiy, 1936) of the character of variation of the geomagnetic field in an anomalistic region and as a result of model experiments, a method has been devised for determining the magnetic susceptibility  $K$  of rocks in their natural environment. It was found that  $K$  values can be determined in the field by measuring variations of the magnetic field over an anomalistic body of known size. The measurements must be performed simultaneously with a magnetic survey of the region investigated. — A. J. S.

- 185-445. Brodskaya, S. Yu. Magnitnaya stabil'nost' ostatochnoy namagnichennosti dvukhkompontentnykh smesey [Magnetic stability of remanent magnetization of two-component mixtures]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 423-427, 1961.

Model studies of two-component mixtures (pyrrhotite and magnetite) are described, and a discussion of the results of these studies is undertaken to establish whether the value  $H_d$  of the demagnetizing field can be used as a laboratory criterion for the magnetic stability of such two-component mixtures. It was found that the demagnetizing field  $H_d$  is a function of the concentration of the components and can therefore be used as a criterion of the direction of remanent magnetization, and that two-component samples having  $H_d > 40$  oersteds can be considered stable. — A. J. S.

Matthews, D. H. Lavas from an abyssal hill on the floor of the North Atlantic Ocean. See Geophys. Abs. 185-587.

Stacey, F. D., Lovering, J. F., and Parry, L. G. Thermomagnetic properties, natural magnetic moments, and magnetic anisotropies of some chondritic meteorites. See Geophys. Abs. 185-81.

- 185-446. Runcorn, S. K[with]. Magnetismo de las rocas [Rock magnetism]: Rev. Geofisica, v. 19, no. 75, p. 257-267, 1960.

This is a review of the history of the geomagnetic field as deduced from paleomagnetic measurements, and the significance of those measurements in terms of continental drift, polar wandering, and paleowind evidence. — D. B. V.



- 185-447. Irving, E. Paleomagnetic methods: A discussion of a recent paper by A. E. M. Nairn: *Jour. Geology*, v. 69, no. 2, p. 226-231, 1961.  
Nairn, A. E. M. Paleomagnetic results from Europe: A reply to E. Irving: *ibid*, p. 231-235, 1961.

It is Irving's contention that a tendency exists to publish paleomagnetic pole positions accompanied by little or no evidence (1) that the directions obtained in the laboratory are those of the geomagnetic field at the time the rocks were laid down; (2) that an adequate time coverage has been insured—the primary magnetism of samples from a representative rock unit should have been acquired over a period of time longer than  $10^4$  yr but not greatly exceeding  $10^7$  yr; and (3) that the results are obtained and analyzed in a consistent fashion appropriate to the assumptions made. Nairn's European results (see *Geophys. Abs.* 181-386) were chosen for analysis because they represent a substantial proportion of the paleomagnetic pole determinations from Europe. Irving claims that Nairn has measured the direction of natural remanent magnetization in specimens from certain rock formations and interpreted these without regard to the above requirements.

Nairn claims in reply that no reference was made to stability, with exception of the Triassic where an arbitrary and not wholly satisfactory technique was described. In "Paleomagnetic results from Europe" the attempt was made to show that, excluding the problem of the Carboniferous, there was general agreement between the measurements made on rocks of the same age from various parts of Europe, although some collections were small. Nairn does not feel it is necessary to modify the conclusions reached in his paper. — V.S.N.

- 185-448. Collinson, D. W., and Creer, K. M. Measurements in palaeomagnetism, in *Methods and techniques in geophysics*, v. 1: New York, Interscience Publishers, Inc., p. 168-210, 1960.

In part 1 of this paper, the only two instruments with the necessary high degree of sensitivity for measuring the magnetic fields associated with remanent magnetization of sedimentary and igneous rocks are described in detail. These are the spinner or rock-generator magnetometer and the astatic magnetometer. In part 2, the investigation of other magnetic properties of rocks is discussed as follows: measurement of susceptibility, measurement of saturation magnetization and hysteresis plotting at different temperatures, apparatus for study of temperature effects, and demagnetization by alternating magnetic fields. — V.S.N.

- 185-449. Cox, Allan [V.], and Doell, Richard R. Paleomagnetic evidence relevant to a change in the earth's radius: *Nature*, v. 189, no. 4758, p. 45-47, 1961.

The expanding earth hypothesis is tested by means of calculations based on paleomagnetic results. It is assumed that the continents have not increased in area and that the ancient geomagnetic field was a dipole. The method of finding the ancient radius is essentially the one originally used by Eratosthenes to obtain the present earth radius from astronomical data.

A radius of 6,310 km is calculated for the Permian period, using data from 16 igneous and sedimentary rocks from western Europe and 5 igneous rocks from Siberia. Comparison with the present radius of 6,370 km leads to the conclusion that the average Permian magnetic field shows no significant departure from the dipolar configuration and is consistent with a Permian earth

radius equal to the present one. An increase in radius as slow as that suggested by Egyed (see Geophys. Abs. 182-267) is neither confirmed nor rejected by paleomagnetic data now available, but an increase as large as that suggested by Carey (see Geophys. Abs. 178-217) appears unlikely. — D. B. V.

- 185-450. Rutten, M. G. Paleomagnetic study of younger volcanic series: Geol. Rundschau, v. 49, no. 1, p. 161-167, 1960.

Paleomagnetic dating of younger volcanic rocks is discussed on the basis of the direction (normal or reversed) of thermoremanent magnetization; the slower aperiodic drift of the magnetic pole is not considered. The direction of magnetization can be measured in the field with a geologic hand compass. As a correlation method it should be used in conjunction with geologic mapping, for the correlation of sections far apart on a paleomagnetic basis alone may lead to false conclusions. In the Auvergne, France, the reversals of the geomagnetic field have been correlated with a known stratigraphic column (see Geophys. Abs. 174-282). — D. B. V.

- 185-451. Kochegura, V. V. Paleomagnitnyye metody vozrastnoy korrelyatsii gornykh porod [Paleomagnetic methods of age correlation of rocks]: Sovetskaya Geologiya, no. 4, p. 47-59, 1961.

The path of migration of the magnetic poles of the earth is one method of stratigraphic correlation. This method can be used where the rocks are sufficiently stable magnetically and where the tectonic history is known. An approximate absolute age is obtained. A second method of correlation makes use of reversals in the magnetic field. Although this technique is well suited for stratigraphic correlation, no indication of absolute age is given. A third method is based on the demagnetization of rocks with time and yields an approximate absolute age. — J. W. C.

- 185-452. Rezanov, I. A. O dreyfe kontinentov (po paleomagnitnym dannym) [Drift of continents (according to paleomagnetic data)]: Sovetskaya Geologiya, no. 4, p. 25-46, 1961.

Magnetic and geographic pole transference in the course of geologic time appears to be well established. The first approximations of paleomagnetic pole measurements agree with the results of paleoclimatic reconstructions. Continental drift, however, cannot be proved on the basis of paleomagnetic data for the following reasons: The accuracy of paleomagnetic measurements is very low and is applicable only to shifts of 2,000 km and more. Sufficient data for statistical determinations is available only for North America, western Europe, and the European part of U.S.S.R. The discrepancy between the North American and European data is due to a systematic error proportional to time. This error arises from an imperfect stability of specimens—the appearance of magnetization caused by a later magnetic field with a resulting shift of 10°-15° toward the present magnetic field. The data for all the other continents is insufficient for use with the statistical method. — J. W. C.

- 185-453. Jaeger, J. C., and Irving, E. Palaeomagnetism and the reconstructions of Gondwanaland: Pan Indian Ocean Sci. Cong., 3rd, Tananarive, Proc., sec. C, p. 233-242, 1957 (1960).

The fundamental assumption is made that the earth's magnetic field when averaged over a period of a few thousand years is that of a dipole along its axis of rotation. Pole positions in the geologic past can be calculated, and both polar wandering and continental drift should be detectable. As longitude

cannot be determined by this method, many ambiguities arise in reconstructions. Much more data are required before the problem can be discussed adequately. — J. W. C.

- 185-454. Dauvillier, Alexandre. Paléomagnétisme et paléoclimatologie [Paleomagnetism and paleoclimatology]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 3, p. 371-373, 1961.

Dauvillier has suggested (see Geophys. Abs. 184-440) that geomagnetism is caused by and maintained by solar activity, and that the magnetic axis has never deviated very far from the axis of rotation. The pole positions deduced from paleoclimatic data agree well with those deduced by Roche from the magnetization of Auvergne lavas (see Geophys. Abs. 182-412) and by Nagata from that of the Miocene lavas of Japan (see Geophys. Abs. 180-290), but do not agree at all with the polar wandering curve of Opdyke and Runcorn (see Geophys. Abs. 176-275).

The paleoclimatic polar wandering curve shows 4 simple oscillations in the last 300 million years, rapidly damped toward an equilibrium position at a quasi-uniform rate (of the order of  $1^\circ$  per million years) with a final acceleration to  $20^\circ$  per million years. It is impossible to learn the geographic position of the axis of rotation 4.5 billion years ago when geomagnetism began because the 20-odd km of magnetized superficial rocks have undergone changes due to volcanism, sedimentation, orogenesis, and erosion since that time. Geomagnetism appears to be entirely renewed every 300 million years at least. — D. B. V.

- 185-455. Ma, Ting Ying H. A comparison of paleomagnetic latitudes and paleogeographical latitudes deduced from growth values of reef corals: Oceanographica Sinica, v. 6, no. 2, 5 p., 1960.

The relative positions of continents and the paleogeographical latitudes of different places and of pole positions from Ordovician to Permian and in Late Cretaceous based on the growth values and distribution of fossil reef corals are discussed. A comparison is made with the paleomagnetic latitudes and magnetic pole positions from the evidence of remanent magnetism; it is shown that the ecological determinations support the paleomagnetic determinations. — V. S. N.

- 185-456. Irving, E., and Banks, M. R. Paleomagnetic results from the Upper Triassic lavas of Massachusetts: Jour. Geophys. Research, v. 66, no. 6, p. 1935-1939, 1961.

The directions of magnetization at 5 sites in 2 lava members of the Newark group of Massachusetts have been measured and found to have fairly consistent northerly declinations but highly variable inclinations. This variation is shown to be due to the presence of a soft magnetic component of variable magnitude approximately parallel to the present earth's field; its effect is removed in alternating magnetic fields of 150 oersteds. The magnetization remaining after removal of this soft component has a mean direction of  $010^\circ$ ,  $+16^\circ$ , which is consistent with the paleomagnetic pole position at lat  $55^\circ$  N., long  $88^\circ$  E. This agrees well with other Triassic paleomagnetic pole determinations from the United States. — D. B. V.

- 185-457. Hood, Peter J. Paleomagnetic study of the Sudbury basin: Jour. Geophys. Research, v. 66, no. 4, p. 1235-1241, 1961.

In a reconnaissance paleomagnetic study of the Precambrian nickel irruptive of the Sudbury basin in Ontario, the remanent magnetism vectors of 226 specimen cubes cut from 60 oriented samples collected along 5 traverses were measured with a "spinner" magnetometer. The directions of magnetization for the south range are closely grouped on the Schmidt equal-area plot, indicating negligible rotary movement since the irruptive last cooled through the Curie point of its magnetic constituents. Directions for the north and south ranges differ by about  $40^\circ$ , suggesting that there has been relative tilting about an east-west axis through the middle of the basin. If the assumed rotation is equally divided between the two ranges, the resultant pole position is lat  $38.4^\circ$  N., long  $99.4^\circ$  W., in the central United States.

Magnetic susceptibility of the samples is higher in the north range than in the south, and in three of the south range traverses it is higher on the south end of the traverse than on the north end. The magnetic anomalies over the norite sections of both ranges appear to be due mainly to remanent magnetization, and only to a lesser extent to induced magnetization. — D. B. V.

- 185-458. Einarsson, Trausti. *Jardeldasvaedid um nordanverdan Skagafjord. Aldursakvördun á landslagi á Midnordurlandi [Pleistocene volcanism in the north of Skaga Fjord and the paleomagnetic dating of topography in middle northern Iceland (with English summary)]*: *Nattúrufræðingurinn*, v. 29, no. 3, p. 113-133, 1959.

The topography of middle northern Iceland is characterized by broad valleys and plains graded to a base level that now stands at 300 m elevation. A younger standplain occurs at 80-100 m elevation and is overlain by lava flows that exhibit both reverse and normal polarity. Where both types occur in the same section, the reverse is below and the normal is above. On the assumption that a change in the polarity of the earth's magnetic field from reverse to normal took place near the beginning of the Pleistocene, it is assumed that the standplain was fully developed in pre-Pleistocene time. — J. W. C.

- 185-459. Everitt, C. W. F. Rock magnetism and the origin of the Midland basalts: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 2, p. 203-210, 1960.

Paleomagnetic measurements on the Carboniferous igneous formations known as the Midland basalts, which occur in the vicinity of the Clee Hills in Shropshire, England, support Marshall's arguments that all are intrusive except Little Wenlock. Little Wenlock, which occurs in the Carboniferous limestone, must be older than the intrusions in the Millstone Grit. The mean direction of magnetization for Little Wenlock is  $355^\circ$  E. and  $7^\circ$  down, whereas that for the Clee Hill, Kinlet, Shatterford, and Pouk Hill sites is  $202^\circ$  E. and  $17^\circ$  down.

The sites at Barrow Hill and Rowley Regis have not been studied in detail; their magnetic directions agree well with those of the other intrusions, suggesting that they were formed at the same time. The overall mean direction for the intrusions,  $200^\circ$  E. and  $17^\circ$  down, agrees well with other paleomagnetic results for the Carboniferous period (Everitt and Belshé), confirming the dating of the formations as Carboniferous.

The measurements also suggest that intrusion occurred before folding of the country rock. At Shatterford they indicate that the accepted geologic interpretation should be reexamined. Some of the Shatterford rocks have probably undergone self-reversal. — D. B. V.

- 185-460. Creer, K. M., Irving, E., and Runcorn, S. K[ieith]. The palaeomagnetic poles for the Lower Jurassic of Europe: Royal Astron. Soc. Geophys. Jour., v. 3, no. 3, p. 367-370, 1960.
- Girdler, R. W. Comment by R. W. Girdler: *ibid.*, p. 371-373, 1960.

Girdler's conclusion that the direction of the Early Jurassic geomagnetic field was significantly different from the present dipole field, corresponding to a pole lying in the region of the Caspian Basin, based on his paleomagnetic study of some Lower Jurassic rocks of northwestern Europe (see Geophys. Abs. 179-319), is challenged by Creer, Irving, and Runcorn, who inferred quite a different pole position for that time (see Geophys. Abs. 173-296), as did Hargraves and Fischer (see Geophys. Abs. 177-300). Girdler's results are open to the alternative explanation that there is a secondary magnetization superposed on the present dipole field in addition to the primary or original magnetization. His use of a statistical method appropriate to a symmetrical distribution in checking magnetic stability is hardly appropriate in this case. His observations do not enable any significant statement to be made concerning the position of the geomagnetic pole relative to western Europe during the Early Jurassic.

Girdler defends his interpretation, giving several reasons why there is no good evidence that a secondary component of magnetization is important in the Midford and Cotswold sands. The easterly declination found for the Early Jurassic is slightly larger than that for the Triassic, and the fairly steep inclination of  $67^\circ$  is very close to that found by Nairn (see Geophys. Abs. 170-242); it is also pointed out that the rocks of Hargraves and Fischer come from a thrust area and are unusually tightly clustered. The smoothed polar wandering curve of Creer, Irving, and Runcorn assumes no continental movements or local movements of the earth's crust; as more and more results become available it is possible that their polar wandering curve will become much more complex. — D. B. V.

- 185-461. Dietzel, G. F. L. Geology and Permian paleomagnetism of the Merano region, Province of Bolzano, N. Italy (with Dutch and Italian summary): *Geologica Ultraiectina*, no. 4, 58 p., 1960.

The stratigraphy and structure of the Merano area are discussed, and it is concluded that the geologic data are in accord with van Bemmelen's concept of the east-alpine structural evolution. The paleomagnetic properties of the Permian quartz-porphyrries at the northwestern margin of the Bolzano volcanic province were studied. The Permian magnetic south pole position deduced from the average direction of magnetization is lat  $146^\circ$  W., long  $45^\circ$  N. Although the latitude agrees with that of pole positions for other Permian rocks of the European continent, the longitude deviates about  $40^\circ$ . This divergence of the north Italian Permian magnetic pole might be the result of secular variation. However, a tectonic cause, such as a counter-clockwise rotation of the Merano region around a vertical axis, might also explain it. — V. S. N.

- 185-462. Nijenhuis, G. H. W. A palaeomagnetic study of the Permian volcanics in the Nahe region (SW. Germany): *Geologie en Mijnbouw*, v. 40, no. 1, p. 26-38, 1961.

Pole positions calculated on the basis of paleomagnetic measurements of 57 samples from 2 Permian lava flows in the Nahe syncline in southwest Germany are lat  $48^\circ$  N., long  $168^\circ$  E. for the Grenzlager melaphyre and lat  $42^\circ$  N., long  $163^\circ$  E. for the Winnweiler Lager tholeiite. Together with measurements

on another flow, 3 sills, and a quartz porphyry intrusion, these measurements confirm the sequence established for the region by purely geologic means: intrusion of sills—intrusion of quartz porphyry—extrusion of lava—folding.

Comparison with Schmucker's results (see Geophys. Abs. 180-286) demonstrates the importance of magnetic cleaning in paleomagnetic research. — D. B. V.

- 185-463. Bukha, V. Nekotoryye rezul'taty paleomagnitnykh issledovaniy na pervichnykh isverzhennykh porodakh v Chekhoslovakii [Some results of paleomagnetic investigations on the primary volcanic rocks in Czechoslovakia]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 54-59, 1961.

Cambrian porphyries and porphyrites from the Tyrzhovitse, Skryy, and Zbiroga regions in Czechoslovakia were investigated for remanent magnetization. They show a variation of the earth's magnetic pole position as follows:  $\phi = 9^\circ - 66^\circ$  and  $\lambda = 134^\circ - 282^\circ$ . Values of  $K$  range from  $2,600 \times 10^{-6}$  to  $14,900 \times 10^{-6}$  gauss and  $I_r$  from  $1,100 \times 10^{-6}$  to  $1,300 \times 10^{-6}$  gauss. — A. J. S.

- 185-464. Kruglyakova, G. I. Rezul'taty paleomagnitnykh issledovaniy po Ukrainskomu kristallicheskomu massivu i prilegayushchim rayonam [Results of paleomagnetic investigations in the Ukrainian crystalline massif and adjacent regions]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 238-244, 1961.

The results of paleomagnetic investigations of the Ukraine crystalline massif are presented, and the methods of collection of the rocks are described. The path of migration of the earth's north magnetic pole is shown. It was established that the earth's magnetic pole has always been situated near the earth's geographic pole. Paleomagnetic investigations should be based on determination of both the vector of remanent magnetization and the value of the ratio  $Q = I_r / I_s$  and not on the value of remanent magnetization alone. Paleomagnetic determinations of the relative ages of rocks were found to agree with geological and absolute ages (see also Geophys. Abs. 184-53). — A. J. S.

- 185-465. Forsh, N. N., and Khramov, A. N. Paleomagnetizm i paleoklimaty na Russkoy platforme v karbone i permi [Paleomagnetism and paleoclimates on the Russian platform in the Carboniferous and Permian]: Akad. Nauk SSSR Doklady, v. 137, no. 1, p. 154-157, 1961.

The geomagnetic pole positions in 9 different epochs during Carboniferous and Permian time have been calculated from paleomagnetic measurements on different formations from the Russian platform. Results are presented in a table and in the form of paleomagnetic parallels superposed on paleoclimatic maps for 6 epochs. Correspondence between paleoclimatic and paleomagnetic results is good. Apparently displacements of geographic latitude have occurred not only between the Caledonian, Hercynian, and Alpine cycles but have been continual throughout geologic history, having occurred from epoch to epoch and within epochs. — D. B. V.

- 185-466. Lin'kova, T. I. Laboratornyye issledovaniya yestestvennoy ostatochnoy namagnichennosti pryamo i obratno namagnichennykh gornykh porod Devona [Laboratory investigations of natural remanent magnetization of directly and inversely magnetized Devonian rocks]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 91-95, 1961.

Laboratory paleomagnetic investigations of Devonian rocks of the Russian platform are reported (see also *Geophys. Abs.* 183-464). The purpose of the investigation was to obtain experimental facts in support of either the hypothesis of reversal of the earth's magnetic field or the hypothesis of self reversal due to physical-chemical processes in the rock. This was done by a determination of the stability of directly (N) and inversely (R) magnetized rock samples. It was found that the samples investigated are magnetically stable, and demagnetization in permanent and alternating magnetic fields does not show any difference in the behavior of the  $I_n$  vector. Thermomagnetic analysis shows that both the normal and reversed magnetic samples contain the same minerals, which is shown also by the petrographic and chemical analysis of the samples. The results of the investigation support the hypothesis of a reversal of the earth's magnetic field. — A. J. S.

- 185-467. Deutsch, E. R., and Watkins, N. D. Direction of the geomagnetic field during the Triassic period in Siberia: *Nature*, v. 189, no. 4764, p. 543-545, 1961.

The direction of magnetization of 5 oriented samples from Lower Triassic rocks in different parts of Siberia furnishes a Triassic north pole in Eastern Siberia at lat  $65^\circ$  N., long  $156^\circ$  E.; the semiaxes of the 95 percent confidence ellipse are  $\delta m = 15\frac{1}{2}^\circ$ ,  $\delta p = 14\frac{1}{2}^\circ$ . This result differs from 3 of 4 pole positions for North America and more drastically from the African and Australian poles.

Comparison of global non-Triassic data has revealed many similar discrepancies: the separation of the European and Indian curves exceeds  $90^\circ$  for the Jurassic, the earliest period for which Indian data are available. This can be explained by invoking large relative displacements between the two land masses, and by implication, between India and northern Asia. A direct comparison with the Siberian results must await examination of suitable Triassic exposures in India. — D. B. V.

- 185-468. Momose, Kan'ichi, Kobayashi, Kunio, and Yamada, Tetsuo. Paleomagnetic and geologic researches for the volcanic rocks around Lake Suwa. Paleomagnetic researches for the Pliocene volcanic rocks in Central Japan (2): Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 433-481, 1959.

Continuing the paleomagnetic study of the Pliocene lavas of central Japan (see *Geophys. Abs.* 178-298), the results of paleomagnetic measurements on numerous samples of the Enrei formation (chiefly andesitic lavas and tuff-breccias) are presented in detail. The magnetic pole seems to have circled westward about the present south geographic pole during Enrei time, which is assigned to Late Pliocene on the basis of the reversed magnetization. — D. B. V.

- 185-469. Coombs, D. S., White, J. R., and Hamilton, D. Age relations of the Dunedin volcanic complex and some paleogeographic implications—Part II: *New Zealand Jour. Geology and Geophysics*, v. 3, no. 4, p. 572-579, 1960.

Paleobotanical, geomorphic, and paleomagnetic evidence are considered in an attempt to establish the duration of the Dunedin volcanic activity in New Zealand. Lavas of the first, of the lower part of the second, and of the third major eruptive phases are normally magnetized; those of the upper part of the second are inversely magnetized. If worldwide correlations on paleomagnetic evidence are valid, the inversely magnetized lavas were erupted during the

Late Miocene-basal Pliocene period of reversal recognized in France (see Geophys. Abs. 148-13320 and 167-205), and the volcanism must have ceased before the mid-Pliocene reversals. — D.B.V.

- 185-470. Blundell, D. J. The palaeomagnetism of some igneous rocks from Antarctica: Polar Rec., v. 10, no. 67, p. 349-352, 1961.

Paleomagnetic studies were made on more than 600 oriented samples collected during 1955-58 in Antarctica as a part of a test of the hypothesis of continental drift carried out on continents that are supposed to be fragments of Gondwanaland. Results show that since the early Tertiary the earth's magnetic field has remained essentially constant in this part of the world; an exception is found in three mid-Tertiary lava flows of James Ross Island where the paleomagnetism is grouped exactly opposite to the present dipole field. Results from Jurassic intrusives show a mean direction significantly different from both the present field and the present dipole fields. Excellent agreement over a distance of continental magnitude shows that the earth's field in Jurassic times had the same dipolar character that it has had since the Oligocene. Pole positions plotted for Jurassic rocks from all the Gondwanaland continents have a wide scatter that can be explained only if a relative displacement of the continents is assumed to have occurred. — V.S.N.

#### MAGNETIC SURVEYS

- 185-471. Whitham, K[enneth], and Niblett, E. R. The diurnal problem in aeromagnetic surveying in Canada: Geophysics, v. 26, no. 2, p. 211-228, 1961.

Errors in aeromagnetic survey results due to geomagnetic time variations have been analyzed in two ways. In the first, properties of average magnetic disturbance have been calculated for 5 locations well distributed in latitude in Canada, and the autocorrelation functions of vertical magnetic field fluctuations have been used to estimate the errors as a function of the base loop length and length of the traverse lines or profiles for 5 latitudes. In practical applications, the root mean square (rms) errors are proportional to the square root of elapsed time. These results can be explained in terms of the shape of the autocorrelation functions, and models of disturbance that might produce them are discussed.

In the second part, experimental results are presented of a comparison of total field intensity fluctuations measured at two pairs of stations in western Canada south of the auroral zone. The rms differences in the time variations have been determined for each hour for both pairs of stations and found to be proportional to the rms level of magnetic activity and to the separation of the stations. The frequency distributions of the rms differences between the two pairs of stations for September 1959 have been determined.

Comparison of the two methods of correction indicates that in this region they are about equally accurate. Operational considerations are mentioned. — D.B.V.

- 185-472. Kutscher, Fritz. Erfahrung bei erdmagnetischen Untersuchungen auf Basaltvorkommen [Results of geomagnetic investigations on basalt occurrences]: Deutsche Geol. Gesell. Zeitschr., v. 112, pt. 1, p. 171-177, 1960.



The general results of geomagnetic investigations on basalt bodies to date are compiled. It is possible to find and to outline bodies of basalt or basaltic tuff by the magnetic method, but for unambiguous interpretation of the data the geologic evidence must be considered. Basaltic rocks are sometimes magnetized in the direction of the present earth's field, sometimes in other directions; the reason for this behavior can be attributed in some cases to the nature of the material, in others to the geomagnetic field at the time of formation of the body. The magnetic study of basalts is valuable not only for scientific purposes but also for practical purposes in the quarrying industry. — D. B. V.

- 185-473. Devitsyn, V. M., Lapina, M. I., and Shneyerson, B. L. O vliyanii neodnorodnoy namagnichennosti tela postoyannoy vospriimchivosti na rezul'taty interpretatsii magnitnykh anomalii prosteyshimi metodami [On the effect of nonuniform magnetization of a body of permanent susceptibility on the results of interpretation of magnetic anomalies by simplest methods]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 428-432, 1961.

An attempt is made to determine the magnetic field  $Z_a$  of the iron ore deposit at Shchigry in the Kursk magnetic anomaly by assuming a nonuniform magnetization under a constant susceptibility and by comparing the results obtained with the observed data. It was found that the assumed nonuniform magnetization cannot explain the value of the anomaly investigated when the observed value of  $K=0.2$  CGSM is given and the factor of remanent magnetization disregarded. — A. J. S.

- 185-474. Henderson, R[oland] G. Polar charts for evaluating magnetic anomalies of three-dimensional bodies, in Geological Survey research 1960: U.S. Geol. Survey Prof. Paper 400-B, p. B-112-B-114, 1960.

A new graphical method is presented for rapid computation of total-magnetic intensity anomalies of three-dimensional bodies. A single chart superimposed upon horizontal sections of the body reduces calculation to a simple counting of chart elements. The counting can be effectively performed on a commercially available optical analogue computer. — Author's abstract

- 185-475. Jacobsen, Peter, Jr. An evaluation of basement depth determinations from airborne magnetometer data (with discussion): Geophysics, v. 26, no. 3, p. 309-319, 1961.

This is virtually the same paper as previously published in Bol. Inf., v. 3, no. 7, p. 199-207, 1960 (see Geophys. Abs. 184-500). — D. B. V.

- 185-476. Veynberg, A. K. Graficheskiy sposob opredeleniya glubiny namagnichennykh tel [Graphical method of determination of the depth of magnetized bodies]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 60-68, 1961.

A graphic method for calculation of the depth to the upper edge of magnetically disturbing bodies, based on the form of their anomalies  $\Delta T$ ,  $Z_a$ , and  $H_a$ , is proposed and discussed. The method was tested on the magnetometric data of a  $\Delta T$  survey of the northern part of the Turgai depression and was found applicable for bulk standard treatment of  $\Delta T$  airborne survey data. Primary large scale magnetograms of high quality are essential for a satisfactory application of the method proposed. — A. J. S.

- 185-477. Bulakh, Ye. G. *Primeneniye elektronnykh vychislitel'nykh mashin dlya interpretatsii gravitatsionnykh i magnetnykh anomalii* [Application of electric calculating machines for interpretation of magnetic and gravity anomalies]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1778-1781, 1960.

Three basic directions in application of computers are discussed in this paper: (1) the computation of various kinds of master charts, tables, nomograms, and other interpretation aids; (2) programming and solving a definite problem for determination of the parameters of a disturbing body; and (3) construction of specialized calculating devices for interpretation of anomalies. Examples are given for (1) and (2). — A. J. S.

Bullard, E. C. The automatic reduction of geophysical data. See Geophys. Abs. 185-228.

Van Wambeke, L. Contribution to the study of the mineralogy, geochemistry, and methods of prospecting of pyrochlore-bearing carbonatites by means of X-rays. See Geophys. Abs. 185-498.

- 185-478. Rose, Edward R. Iron and titanium in the Morin anorthosite, Quebec: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Paper 60-11, 12 p., 1960.

The general geology, petrography, geochemistry, magnetic anomalies, and economic geology of the Morin anorthosite composite intrusion are discussed. Titaniferous magnetite and massive ilmenite deposits are associated with this intrusion. The ilmenite deposits produce weakly negative magnetic anomalies and the titaniferous magnetite strongly positive anomalies. The strength of an anomaly does not always indicate the grade or amount of iron-titanium oxide minerals present, but it does serve as a guide to the relative concentration of the iron minerals. — V. S. N.

- 185-479. Gregory, A[lan] F., Bower, Margaret E., and Morely, L. W. Geological interpretation of aeromagnetic profiles from the Canadian Arctic Archipelago: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Paper 60-6, 13 p., 1960.

The geological significance of the aeromagnetic data of a reconnaissance airborne survey conducted in the Arctic Archipelago in 1955 is discussed. The aeromagnetic profiles show irregular regional and small local anomalies over Archean and pre-Pennsylvanian basement, frequent local and often very intense anomalies over the fold and dike belt at the east end of the Sverdrup basin, and smooth, flat profiles over thick sedimentary sequences. Depths to basement were calculated. Ferromagnetic bodies occur in six types of geological environment in the area; the bodies in the Precambrian rocks and within the Sverdrup basin appear to be the most extensive and probably are the major influence on the magnetic anomaly field. — V. S. N.

Ghigone, João Ítalo. Gravity and magnetic reconnaissance in the Pelotas Basin. See Geophys. Abs. 185-318.

Scheffer, V[iktor]. Some contributions to the geophysical knowledge of the Carpathian basins. See Geophys. Abs. 185-323.

- 185-480. Varlamov, A. S., Mikhaylov, I. N., Nikitin, A. A., Puchkov, Ye. P., and Tarkhov, A. G. *Nekotoryye osobennosti metodiki obrabotki rezul'tatov geofizicheskikh issledovaniy pri pryamykh poiskakh*

almazov v Yakutskoy ASSR [Some features of the method of treatment of the results of geophysical investigations in direct exploration for diamonds in the Yakutsk A. S. S. R.]: Vyssh. Ucheb. Zavedeniya, *Izv., Geologiya i Razvedka*, no. 12, p. 88-97, 1960.

The discovery of the original diamond fields in the Yakutsk A. S. S. R. was accomplished by wide use of ground and air magnetic surveys. The kimberlite pipes contain a small amount of magnetite and are intrusive into limestones and dolomites. One of the principal tasks is to distinguish between these pipes and trap rocks. This can be accomplished by constructing rose diagrams for the direction of isodynamic lines of  $\Delta Z$ ; the patterns are distinctive for each rock type. Gravity surveying is not very effective because of the great range in density of the kimberlite. — J. W. C.

- 185-481. Bernshteyn, V. A. O magnitnom pole na vulkane Zavaritskogo (ostrov Simushir, Kuril'skiye ostrova) [On the magnetic field on Zavaritskiy Volcano (Simushir Island, Kurile Islands)]: *Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta.*, no. 30, p. 55-68, 1960.

A magnetic survey was made in the caldera of Zavaritskiy Volcano in the Kurile Islands in August 1958 following the eruption that began in November 1957. Results are tabulated and presented in profiles. In the eastern part of the caldera, vertical magnetic intensity ranges from +900 $\gamma$  to +2,400 $\gamma$ , and in other accessible parts from -1,400 $\gamma$  to -5,000 $\gamma$  with respect to points far outside the caldera. The vertical component of remanent magnetization of the most common rock (andesitic lava) reaches  $1.4 \times 10^{-2}$  gauss and thus accounts for the negative magnetic field in the central part of the core. Anomalies due to the eruptive apparatus in the caldera are not distinguishable. The vertical anomalies are interpreted as indicating a magnetic layer extending from about 40 to about 240 m in depth with a surface dipping at about 49.5°. This surface may be a fault contact. — D. B. V.

- 185-482. Agocs, W[illiam] B., Paton, J. R., and Alexander, J. B. Airborne magnetometer and scintillation counter survey over parts of Johore and Malacca (Area 5): *Federation Malaya Geol. Survey Econ. Bull.*, C-1.5, 25 p., 1959.

This is the fifth in a series of publications reporting the results of airborne-magnetometer and scintillation-counter surveys conducted during 1956-57 over nearly 16,000 sq mi of Malaya. The same outline is followed as that used in Bulletin C-1.1 (see *Geophys. Abs.* 180-314). Area 5 comprises 1,592 sq mi of the western coastal area of Johore immediately south of Malacca. It was selected for the determination of the igneous-sedimentary boundaries and to locate possible extensions of the small known iron-ore deposits. The survey revealed one anomaly with values comparable with that for the Bukit Besi area in Trengganu (see *Geophys. Abs.* 180-315); it may indicate ferriferous ore in the basic intermediate igneous rocks, and an investigation is recommended. A smaller anomaly northwest of Ayer Hitam may reflect ferriferous or manganiferous concentrations. — V. S. N.

- 185-483. McMurtrie, I. H., and Moorcroft, E. Gravity and magnetic traverses over aeromagnetic anomaly—hundred of Carina: *South Australia Dept. Mines Mining Rev.*, no. 110, p. 71-77, 1960.

The results of a magnetometer and gravimeter ground survey of an aeromagnetic anomaly near Minnipa, Eyre Peninsula, centered in sec. 40, hundred of Carina, are reported. A zone of rock 15,000X15,000 feet slightly

more dense than that of the surrounding area is indicated. Irregular occurrences of magnetic minerals are associated with the zone at depths of less than 400 feet. The zone of denser material apparently extends deeper. A drilling program is recommended. — V. S. N.

#### MICROSEISMS

- 185-484. Darbyshire, J. Microseisms and storms: *Adv. Sci.*, v. 17, no. 66, p. 149-157, 1960.

The origin of microseisms from pressure fluctuations on the sea bottom by the stationary or standing sea waves produced under storm conditions and techniques of locating storm bearings from microseisms are discussed in detail. A method is presented for estimating storm bearings by considering the actual nature of the microseismic wave. Assuming that microseisms consist of both Rayleigh and Love waves, the direction of storm approach is found by correlating the vertical, N-S, and E-W components. A new type of electronic seismograph used with a simple correlation amplitude and period meter that makes it possible to analyze and correlate the microseisms as they are recorded is described. The seismographs and correlation meters are portable, and it is proposed to set up mobile stations combining the older tripartite method of storm tracking with the correlation technique. — V. S. N.

- 185-485. Bernard, P[ierre]. Un séismographe étalon pour l'étude des micro-séismes [A standard seismograph for the study of microseisms]: *Annales Géophysique*, v. 16, no. 3, p. 419-421, 1960.

Records of the vertical Galitzin seismograph at the Parc Saint-Maur station in France have been used as the standard of comparison of relative amplitude of microseisms at different stations. Because it is difficult in practice to maintain the period of the vertical Galitzin at the theoretical value of 12 sec, a short-period seismograph has been adapted to serve the purpose. This "false Galitzin" has the characteristics of a 12-sec Galitzin instrument with a maximum amplification of 6.9 sec that is perfectly suited to the study of microseisms.

The constants of the instrument are given, and the components and their hook-up are described briefly. The optical amplification system is described in somewhat greater detail. With this instrument the amplification curve is known exactly, and its scale varies according to the amplitude of the microseisms (which follows the seasons) in such a way that the greater part of the records can be obtained without any adjustment of the seismograph. — D. B. V.

- 185-486. Jensen, Henry. Statistical studies on the IGY microseisms from København and Nord: [Denmark] *Geod. Inst. Medd.*, no. 39, 67 p., 1961.

This paper concerns microseisms of 3-8 sec period recorded at Copenhagen, Denmark, at Ivigtut, Scoresbysund, and Nord in Greenland. The different parameters of microseisms—amplitudes and periods, TN-TE differences, beat interval, and direction of approach—are discussed. Methods of determining direction of approach are described; that of the empty half-plane, used in this paper, is treated in some detail. This method is independent of the possible content of other than Rayleigh waves in the microseisms.

It is suggested that much more information could be collected if determination of direction of approach were included in the routine observations. To support this suggestion, statistical results of the use of directions at Copenhagen and at Nord are discussed. Most of the microseisms at Copenhagen reach the station from a northerly direction, but some of them come from the

southeast, mainly in the summer months and with a shorter period. Due to instrumental limitations, the Nord material is less homogeneous than that obtained at Copenhagen, and that at Scoresbysund is unsuitable for treatment. The prevailing direction at Nord is from the southwest across Greenland; some microseisms originate to the northwest, probably in the shelf waters north of Canada. Very few come from the southeast, from the center that accounts for the majority of microseisms recorded at Copenhagen, suggesting that this source area lies nearer the Norwegian shelf than to the East Greenland shelf; this is in accord with recent Norwegian and Russian results. — D. B. V.

185-487. Hatherton, T. Microseisms at Scott Base: Royal Astron. Soc. Geophys. Jour., v. 3, no. 4, p. 381-405, 1960.

The seasonal variation of the pack ice surrounding the Antarctic continent has a great effect on the levels of microseismic activity at Scott Base. Microseismic storms are in general of two types, one with periods 1-3.5 sec, the other with periods 4-10 sec. The short-period activity is due to events within the Ross Sea and is at a maximum during January and February when the Ross Sea is clear of ice. The long-period activity has a maximum during March and April and this is thought to be due to swell from peripheral cyclones penetrating the Ross Sea and creating microseisms after passing the continental shelf.

It is found that the microseisms of any period ( $T$ ) have a limiting amplitude ( $A_{\max}$ ) and that for the short-period microseisms  $A_{\max} \propto T^{4.2}$  while for the long-period microseisms  $A_{\max} \propto T^{6.0}$ . The difference between these two relationships can be satisfactorily explained on the basis of frequency selective decay of the waves causing the long-period microseisms as these waves travel from the cyclone area to the continental shelf. The fourth-power relationship between maximum amplitude and period is similar to that obtained for single storms in America by Romney. It is suggested that this relationship might provide a useful test for a quantitative theory of microseisms, such as the standing wave theory, or alternatively that it can be used to investigate transmission and absorption processes in the crust.

The data appear to confirm the requirement of sea roughness for the generation of microseisms, the half-period relationship between microseisms and sea wave periods, and the role of the continental shelf and other crustal features as barriers to microseisms of periods less than  $7\frac{1}{2}$  sec. — Author's summary

## RADIOACTIVITY

185-488. National Bureau Standards. Redetermination of the half life of carbon-14: U.S. Natl. Bur. Standards Tech. News Bull., v. 45, no. 2, p. 21, 1961.

A more accurate value for the half life of carbon-14 is reported. The new value is 5,760 years with an overall probable error of 1 percent and is about 4 percent greater than the previously adopted value of 5,568 years. It is concluded that the spread in values obtained previously may have arisen from adsorption effects. — V.S.N.

185-489. Bauminger, E. R., and Cohen, S. G. Natural radioactivity of  $V^{50}$  and  $Ta^{180}$ : Phys. Rev., v. 110, no. 4, p. 953-957, 1958.

The methods of proportional counter and scintillation spectroscopy have been used to examine the possible radioactivity of the naturally occurring nuclides  $V^{50}$  and  $Ta^{180}$ . Some positive evidence is obtained that  $V^{50}$  decays by

K capture to the 1.58-Mev excited state for  $\text{Ti}^{50}$  with a half life of  $(4.8 \pm 1.2) \times 10^{14}$  yr. A search for titanium K X-rays gave negative results. For  $\text{Ta}^{180}$  a lower limit of  $(2.3 \pm 0.7) \times 10^{13}$  yr was found for the half life against decay by K capture and a lower limit of  $(1.7 \pm 0.6) \times 10^{13}$  yr against beta decay. — Authors' abstract

- 185-490. Macfarlane, Ronald D. Natural occurrence of samarium-146: Nature, v. 188, no. 4757, p. 1180-1181, 1960.

Macfarlane and Kohman (in press) obtained a negative result in a search for  $\text{Sm}^{146}$   $\alpha$ -activity in natural samarium and set an upper limit of 0.01 disintegrations per g per sec for the specific activity in natural samarium. Recently, Vorob'yev and others (1959) reported an indication of the existence of natural  $\text{Sm}^{146}$  activity at a level they considered to be statistically insignificant, and established an upper limit of 0.3 disintegrations per g per sec for the specific activity. By increasing the sensitivity over these previous measurements (by counting a sample enriched in  $\text{Sm}^{146}$ ), a limit of 0.003 disintegrations per g per sec is placed on the specific activity of samarium. Using a half-life value of  $5 \times 10^7$  yr, the upper limit for the isotopic abundance of  $\text{Sm}^{146}$  in natural samarium is calculated as  $2 \times 10^{-7}$  percent.

Theoretical considerations, based on the recently rechecked value of 2.55 Mev for the  $\alpha$ -particle energy of artificially produced  $\text{Sm}^{146}$ , favor an alpha half life of about  $6 \times 10^7$  yr; if this is the correct half life, all primordial  $\text{Sm}^{146}$  should now be  $\text{Nd}^{142}$ . — D. B. V.

- 185-491. Parker, P. L., and Kuroda, P[aul] K. The occurrence of molybdenum-99 in natural and depleted uranium salts and the spontaneous fission half-life of uranium-238: Jour. Inorg. Nucl. Chemistry, v. 5, no. 3, p. 153-158, 1958.

Measurements of the  $\text{Mo}^{99}/\text{U}^{238}$  equilibrium ratios in aqueous solutions of nonirradiated uranium salts gave the following results:  $(4.4 \pm 0.4) \times 10^{-4}$  and  $(4.4 \pm 0.3) \times 10^{-4}$  disintegrations per sec of  $\text{Mo}^{99}$  per g  $\text{U}^{238}$  in natural and in depleted uranium, respectively. From this the spontaneous fission half life of  $\text{U}^{238}$  is calculated to be  $(8.0 \pm 0.5) \times 10^{15}$  yr. — D. B. V.

- 185-492. Hamilton, E. The distribution of radioactivity in the major rock forming minerals: [Denmark] Medd. om Grønland, v. 162, no. 8, 41 p., 1960.

This is the same paper as that published in Univ. Copenhagen Mus. Minéralogie Géologie, Commun. Géol. No. 93, 35 p., 1959 (see Geophys. Abs. 181-410). — V. S. N.

- 185-493. Morais, Marília Xavier de. Radioatividade de um monzonito da Foz do Douro (Porto) [Radioactivity of a monzonite from Foz do Douro (Porto)]: Univ. Coimbra Mus. e Lab. Mineralog. Geol. Mem. e Notícias, no. 48, p. 59-74, 1959.

The radioactivity of a monzonite from Foz do Douro, Portugal, was determined by means of nuclear emulsion plates. From this the uranium content was calculated to be  $0.15 \times 10^{-5}$  percent, which is about average for granitic rocks, and the thorium content was found to be  $6.15 \times 10^{-5}$  percent, which is somewhat higher than the average. The thorium is present almost entirely in zircon and its alteration product malacon, particularly the latter. The uranium is present in sphene, zircon, and malacon. — D. B. V.

- 185-494. Steinberg, Michel. Utilization de la mesure de la radioactivité naturelle des roches sédimentaires dans l'étude du Sidérolithique du Poitou [Use of the measurement of the natural radioactivity of sedimentary rocks in the study of the Siderolithic of the Poitou]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 25, p. 3022-3024, 1960.

The natural  $\beta$  and  $\gamma$  radioactivity of sediments in the Poitiers and Bressuire quadrangles of the geologic map of France has been measured. The results show that different units within the Siderolithic of the Poitou region can be distinguished according to their radioactivity, and that the rocks of the Bressuire quadrangle are distinctly different from those of the Poitiers. The Siderolithic of the Bressuire quadrangle is actually a more or less reworked Cenomanian formation. The possibilities of using natural radioactivity as a stratigraphic correlation tool are demonstrated by these studies. — D. B. V.

- Krylov, A. Ya., Lisitsyn, A. P., and Silin, Yu. I. Significance of the argon-potassium ratio in ocean sediments. See Geophys. Abs. 185-590.

Mahadevan, C., Sastry, A. V. R., and Aswathanarayana, U. Some aspects of nuclear geology in India. See Geophys. Abs. 185-67.

- 185-495. Turner, R. C., Radley, J. M., and Mayneord, W. V. Naturally occurring alpha-activity of drinking waters: Nature, v. 189, no. 4762, p. 348-352, 1961.

The results of measurement of the natural alpha activity due to  $\text{Ra}^{226}$  in 71 drinking waters in Great Britain, together with values for short-lived  $\text{Rn}^{222}$  and  $\text{Ra}^{224}$  (ThX) where present, are tabulated. The highest values of long-lived alpha-activity are in spa waters. Next highest are those in waters from boreholes in strata other than chalk. Waters from chalk are still lower, and the least active are surface waters even though many are derived from areas of Precambrian or granitic rocks. — D. B. V.

- 185-496. Tóth, Árpád. Vízben oldott rádium- és radontartalom meghatározása torziós szálas elektrométerű emanométerrel [Determination of the amount of radium and radon dissolved in water with an emanometer on the principle of a torsion fiber electrometer (with German summary)]: Geofiz. Közlemények, v. 8, no. 4, p. 279-290, 1960.

A method and apparatus are described that can be used in the field for determining the dissolved radon content of water and in the laboratory for determining both radium and radon. The apparatus consists of an ionization chamber coupled to a torsion electrometer and a compensator. — D. B. V.

- Pandow, M., MacKay, C., and Wolfgang, R. The reaction of atomic carbon with oxygen: significance for the natural radiocarbon cycle. See Geophys. Abs. 185-381.

## RADIOACTIVITY SURVEYING AND LOGGING

- 185-497. Balyasnyy, N. D., Boltneva, L. I., Dmitriyev, A. V., Ionov, V. A., and Nazarov, I. M. Opredeleeniye soderzhaniya radiya, toriya

i kaliya v gornykh porodakh s samoleta [Determination of the content of radium, thorium, and potassium in rocks with an airplane]: Atomnaya Energiya, v. 10, no. 6, p. 626-629, 1961.

Experimental investigations were made on the determination of radium, thorium, and potassium in rocks by the spectrum of gamma radiation measured from an airplane. A three channel radiometer was used which permits the measurements to be made in three energy areas of the spectrum with automatic compensation for background. The tests were made over an area 5.5X 10 km which is underlain by sedimentary, igneous, and metamorphic rocks. The traverses were 100 m apart, and the flight altitude was 25 m.

The content of radium determined by the airborne method is 28 percent higher than that determined chemically, and that of thorium is 21 percent higher. No chemical analyses were made for comparison with the value for potassium; however, this value is in good agreement with values in the literature for these rocks. — J. W. C.

185-498. Van Wambeke, L. Contribution à l'étude de la minéralogie, de la géochimie, et des méthodes de prospection des carbonatites à pyrochlore au moyen des rayons X [Contribution to the study of the mineralogy, geochemistry, and methods of prospecting of pyrochlore-bearing carbonatites by means of X-rays]: Soc. Belge Géologie, Paléontologie, et Hydrologie Bull., v. 68, no. 2, p. 178-225, 1959.

The second part of this work deals with methods of prospecting for niobium deposits associated with carbonatites. The preliminary phase of exploration makes use of radioactive (scintillometer) and geochemical methods to discover primary or secondary anomalies that might correspond to pyrochlore-bearing carbonatite bodies. The extent and intensity of such an anomaly are then investigated by soil analyses. Because carbonatites often contain magnetite, ilmenite, or pyrrhotite, magnetic surveys can be used to advantage in this second phase. At Barreiro, Brazil, the internal structure of the deposit was revealed by a magnetic survey. — D. B. V.

185-499. Christman, David R. Counting soft betas: Nucleonics, v. 19, no. 5, p. 51-55, 64, 1961.

Factors to be considered in choosing a method for counting soft betas of  $C^{14}$ ,  $S^{35}$ , and tritium are discussed. Each of these nuclides can be measured as a solid, liquid, or gas. The precision, sensitivity, intensity limits, and approximate cost of the nonflow counting methods are compared. With each method some counting problem arises that cannot be solved directly without one of the other methods. The bibliography contains 57 references. — J. W. C.

185-500. Kent, R. A. R. Scintillation alpha detection probes: Richland, Washington, General Electric Co., Hanford Plutonium Works, U. S. Atomic Energy Commission Research and Development Rept. HW 66837, 23 p. 1960.

Large and small area alpha survey probes employing photomultiplier tubes and scintillation detectors have been developed. These probes have a uniform alpha detection efficiency over the active screen area and are unaffected by operation in 4.5 r/hr gamma fields. — Author's abstract



- 185-501. Berbezier, J. Quelques appareils récents utilisés pour la recherche et l'étude des minerais radioactifs [Some new devices used for the investigation and study of radioactive ores]: [France] Comm. Énergie Atomique Bull. Inf. Sci. Tech., no. 38, p. 44-47, 1960.

Brief descriptions with photographs are given of an ultraviolet lamp, a direct current potentiometer, a solar battery, and an apparatus for measuring directly the thorium content of uranium-thorium minerals, all of which can be used in addition to the familiar Geiger-Müller or scintillation counters for prospecting or appraisal of radioactive ore deposits. — D. B. V.

- 185-502. Ligneris, X. des, and Bernazeaud, J[acques]. Le gisement de Mounana (Gabon) [The Mounana deposit (Gabon)]: [France] Comm. Énergie Atomique Bull. Inf. Sci. Tech., no. 38, p. 4-19, 1960.

The geographic and geologic setting, methods of prospecting and development, mining operations, present knowledge of the deposit, development program, and technical and personnel problems concerning the Mounana uranium deposit in Gabon, French Equatorial Africa, are summarized. This deposit was discovered in 1956 in the course of a detailed carborne scintillometer survey of the region. Systematic radiometric and geochemical prospecting of the anomaly involved a closely spaced network of measurements (10 m, sometimes 1 m station density), together with diamond drilling, to outline the form of the ore body. Geologic control during operations included radioactivity measurements in the mine tunnels and logging of hammer-drill holes. — D. B. V.

- 185-503. Théréné, Pierre, and Bigotte, Georges. La prospection des substances radioactives en Afrique par le Commissariat [The prospecting for radioactive substances in Africa by the Commissariat]: [France] Comm. Énergie Atomique Bull. Inf. Sci. Tech., no. 38, p. 48-53, 1960.

This is a review of the radioactive mineral exploration program now in progress in French Africa. Airplanes are used for reconnaissance scintillometer surveys and for transport of ground parties; in the Sahara use of the helicopter permits immediate exploration up to the sampling stage of any interesting anomaly. Carborne scintillometers are used in suitable terrain in the Sahara. Various geochemical methods are used for more detailed study of anomalies. — D. B. V.

- 185-504. Reeve, W. H. Radiometric survey, Northern Province: Northern Rhodesia Geol. Survey Recs. for 1958, p. 26, 1960.

Approximately 2,400 miles of roads and tracks in the Northern Province, Northern Rhodesia, were traversed in September 1958 with a carborne scintillometer. Most of the routes were over rocks of the Plateau Series, and the radiometric profiles obtained are relatively uniform with a notable absence of marked anomalies. In one locality only does the anomaly exceed three times background; this is where large masses of granite crop out close to the road. — V. S. N.

- 185-505. O'Brien, P. L. A. Report on a car-borne scintillometer survey of the Gwembe Valley: Northern Rhodesia Geol. Survey Recs. for 1958, p. 27-28, 1960.

A carborne scintillometer survey was made in July 1958 covering an area of 3,200 sq mi, from Chirundu in the northeast to lat 17°45' S. and long 27° E., Northern Rhodesia. The primary object was to find any radioactivity connected with the Karroo and post-Karroo faulting in the Gwembe Valley. One of the most noticeable features of the survey was the almost complete lack of any radioactivity connected with the major Karroo faulting with the possible exception of the Bunga Hill fault block.

Two main areas of anomalies were recorded: the Munyumbwe area with 6 and the Bunga Hill area with 5; one isolated anomaly occurs in the Sigongo area. In the Bunga Hill area the 5 anomalies are in an area of 100 sq mi and surround the Bunga Hill fault block; they are by far the strongest in the Gwembe Valley.

Without exception all anomalies appear to occur in the lower beds of the Karroo Escarpment grit. Radiometric analysis showed that the radioactivity is due to uranium and thorium contained in goethite, which forms the feruginous cementing material of the grit. Further investigation is recommended. — V.S.N.

- 185-506. Schoeneich, Krzysztof. Radiogeologiczne metody rozpoznawania z powierzchni nieciągłości tektonicznych nad nie rozciętymi złożami kopaliny [Radiogeological methods of surficial detection of tectonic discontinuities over unfaulted mineral deposits]: *Przegląd Geol.*, v. 8, no. 12, p. 649-651, 1960.

Radiogeologic methods are particularly useful in detecting faults within horizontal sediments that are overlain by thin Quaternary deposits. An emanometer of the type used in exploration for radioactive minerals was used to locate such faulting in the phosphorite at Annopol on the Vistula River. — J.W.C.

- 185-507. Babynets', A. E. [Babinets, A. Ye.], and Zvol'skiy [Zvol'skiy], S. T. Rezul'taty vykorystannya metodu rozsiyanykh neytroniv i hamma-promeniiv pry vyochenni rezhymu volohosti i shchil'nosti gruntiv [Results of the use of the method of scattered neutrons and gamma-rays in the study of the regime of the moisture content and compaction of soils (with Russian summary)]: *Akad. Nauk Ukrain. RSR Heol. Zhur.*, v. 20, no. 4, p. 45-53, 1960.

The successful use of radioactive isotopes to trace ground water migration and to study the compaction and moisture content of the ground near Kiev and Odessa in the Ukrainian S. S. R., in connection with landslip and hydrogeologic investigations, is described. — D.B.V.

- 185-508. Sano, Shun'ichi. Distribution of radioactivity of granitic rocks in the Takanawa Peninsula, Ehime Prefecture by car-borne radiometric survey (in Japanese with English abstract): *Japan Geol. Survey Bull.*, v. 11, no. 6, p. 369-384, 1960.

A carborne radiometric survey was made to study the distribution of radioactivity in the granitic rocks of the Takanawa Peninsula, Ehime Prefecture, Japan. The maintenance of the equipment and the dynamic character of the special ratemeter system used in the survey are discussed. The biotite granite and hornblende-biotite granite were found to be the most radioactive. The effect of weathering on the radioactivity of the rocks and the geometric effect in the measurement of the gamma-ray intensity are also discussed. — V.S.N.

- 185-509. Kiyoshima, Nobuyuki, and Shimodaira, Fumio. A radiometric survey at the western part of the Ube district, Yamaguchi Prefecture (in Japanese with English abstract): Japan Geol. Survey Bull., v. 11, no. 6, p. 385-389, 1960.

A radioactivity survey of the western part of the Ube district, Yamaguchi Prefecture, Japan, located a radioactive anomaly of 5 times the natural count in part of the Eiwa mine, a wolframite-bearing quartz vein deposit. Chemical analyses show that the uranium content of this area is generally between 0.002 and 0.009 percent. — V.S.N.

- Agocs, William B., Paton, J. R., and Alexander, J. B. Airborne magnetometer and scintillation counter survey over parts of Johore and Malacca (Area 5). See Geophys. Abs. 185-482.

- 185-510. Grammakov, A. G., Ovchinnikov, A. K., Lyubavin, Yu. P., Ovchinnikov, V. M., and Sazonov, A. M. Vliyaniye veshchestvennogo sostava uranovykh rud na stsintillyatsionnyy spektr ikh  $\gamma$ -izlucheniya [Effect of composition of uranium ores on the scintillation spectrums of their  $\gamma$ -radiation]: Atomnaya Energiya, v. 10, no. 6, p. 624-625, 1961.

Quantitative interpretation of the results of gamma logging of uranium deposits must take into account the dependence of the energy composition of the radiation on the physical properties of the ore, characteristics of the logging instrument, the state of the borehole, and the drilling conditions. In this paper the results of an experimental study of the energy characteristics of the radiation of uranium ore are described. Differential spectrums of gamma radiation of ore in models show that the intensity of the radiation varies greatly, particularly in the area of small energies. This variation is dependent largely on the effective atomic number of the ore; as this number increases, the peaks on the differential spectrum curves decrease in height. The effect of the composition of the ore on the energy composition of the gamma radiation decreases sharply for energies above 300 Kev but can still be detected at energies on the order of 700 Kev. — J.W.C.

- 185-511. Schrader, C. D., and Stinner, R. J. Remote analysis of surfaces by neutron-gamma-ray inelastic scattering technique: Jour. Geophys. Research, v. 66, no. 6, p. 1951-1956, 1961.

The feasibility of applying neutron-gamma-ray inelastic scattering techniques to the remote chemical analysis of unknown materials has been studied. The spectrums of gamma-rays produced by neutrons in a large sandpile containing various known percentages of the elements O, Mg, Al, Si, and Fe have been measured. It was found that a 5 percent abundance of any of these elements could be determined quantitatively to a precision of better than 10 percent. The method, using fast gating and timing circuits to select only the gamma-rays originating unambiguously from the neutron inelastic scattering process, appears so promising that a miniature pulsed accelerator is now being tested and packaged. Applications to the analysis of the lunar surface, planetary atmospheres, and the earth's crust and mantle are discussed. — D.B.V.

- 185-512. Sano, Shun'ichi. A portable gamma ray logger and the estimation of grade and ore reserves in radioactive deposit with reference to the logging at Ouchi district, Miyagi Prefecture (in Japanese with English abstract): Japan Geol. Survey Bull., v. 11, no. 6, p. 337-356, 1960.

The variations of distribution of gamma-ray intensity in a drill hole with the length of the detector, the thickness of the radioactive bed, and the diameter of the hole are discussed. Using a portable gamma-ray logger with a scintillation detector of only 30 mm designed especially for prospecting in mountainous areas, a method was developed for estimating the thickness of a horizontal ore bed and the grade of ores from theoretical calculations utilizing a constant determined by experiments in the drill hole. It was found that the area between the counting rate curve and the base line on the radioactivity log is proportional to the product of the grade and thickness independent of the drill hole diameter and the logging speed. Thus, when the correct value of the thickness is given, ore reserves may be estimated easily and the mean grade calculated.

Results of gamma-ray and electric logging in four drill holes at Ouchi district are discussed. — V. S. N.

- 185-513. Scott, J. H., Dodd, P. H., Drouillard, R. F., and Mudra, R. J. Quantitative interpretation of gamma-ray logs: *Geophysics*, v. 26, no. 2, p. 182-191, 1961.

A quantitative method for determining the concentration of gamma-ray emitting elements in layered rocks penetrated by boreholes has been developed, based on the relationship  $\bar{G}T = k \int_{-\infty}^{+\infty} I dz$ , where  $\bar{G}$  is the mean concentration of a radioactive element by weight,  $T$  is the thickness of the layer containing the radioactive element,  $k$  is a proportionality constant,  $I$  is the intensity of the gamma-ray field at a point on the borehole axis, and  $z$  is the distance of this point from a reference point on the axis. This relationship has been confirmed both theoretically and empirically.

In application, the grade-thickness product of a mineralized zone intersected in the borehole is determined by multiplying the area under the gamma-ray log curve by a proportionality constant. The mean grade of the zone is determined by dividing the grade-thickness product by the zone thickness. Corrections applied for nonstandard conditions in the borehole reduce the data to equivalence with standard calibration conditions. Because the volume sampled in this logging method is significantly larger than that of core samples, the resulting data are more representative than data from chemically assayed core. — D. B. V.

- 185-514. Fabre, P. Pollutions radioactives dans les forages horizontaux exécutés au marteau perforateur [Radioactive contaminations in horizontal drillholes made with the hammer drill]: [France]Comm. Énergie Atomique Bull. Inf. Sci. Tech., no. 38, p. 20-26, 1960.

Interpretation of gamma-radiation measurements made in horizontal hammer-drill holes in uranium mines for ore evaluation purposes may be distorted by contamination due to the presence of radon or to factors such as irregular settling of drilling muds. The difficulty can be partially avoided by logging the hole at least 24 hr after it is opened, but the only way to determine the amount of contamination accurately is to make supplementary measurements, such as  $\beta$ -radiation measurements. If a  $\beta$  and  $\gamma$  sonde is used instead of the usual  $\gamma$  sonde, the  $(\beta + \gamma)/\gamma$  ratio will reveal the degree of contamination whenever the results of  $\gamma$ -ray logging do not correspond to the geologic context. — D. B. V.

- 185-515. Holgate, M. M. A study of the microlog as a porosity datum for the neutron log in Swan Hills, Alberta: *Oil in Canada*, v. 13, no. 3, p. 22-27, 1960.

This is virtually the same paper as that published in Canadian Mining Metall. Bull., v. 53, no. 579, p. 502-506, 1960. (See Geophys. Abs. 182-460.)—V.S.N.

Walker, Terry. Simplified log interpretation. See Geophys. Abs. 185-203.

## SEISMIC EXPLORATION

185-516. Sengbush, R. L., Lawrence, P. L., and McDonal, F[rank] J. Interpretation of synthetic seismograms: Geophysics, v. 26, no. 2, p. 138-157, 1961.

The fundamentals of synthetic seismograms are treated from the point of view of linear filter theory. A linear filter model of the seismic process in the earth is described in detail, and reflections from simple velocity layering are discussed. Depth-time correspondence between the earth and the related seismogram is also discussed, and some examples are given comparing field records and synthetic seismograms.

The treatment is descriptive rather than mathematical and emphasizes the qualitative and in some cases the quantitative usefulness of the model in interpreting field records. An appendix gives the pertinent steps and formulas for the mathematical treatment of the question. — D.B.V.

185-517. Aynard, C., Mitrani, H., and Dhinnin, R. Variation des vitesses en rapport avec l'âge en la lithologie. Application de la loi de Faust [Variation of velocities with respect to age in lithology. Application of Faust's law (with English abstract)]: Geophys. Prosp., v. 9, no. 1, p. 30-45, 1961.

Faust's first law (see Geophys. Abs. 145-12825) is considered the best guide in classifying data concerning velocities and their correlation with lithology, even if locally other laws better fit observed values. Data from both conventional and continuous velocity logs and from some particularly reliable velocity profiles have been reexamined, and "Faust's coefficient" (the ratio of true velocity to the value resulting from Faust's law, according to the age and present depth of the formation) has been computed for a series of geological formations in the Sahara and in the Aquitanian basin of France. Four maps of the basin showing the Faust coefficients for the Oligocene, Eocene-Paleocene with and without Danian, and Upper Cretaceous exclusive of Danian, and a cross section showing the relation to lithology are given.

It is too soon to tell whether such studies can be carried out at the beginning of exploration of a basin on the data of only a few logged wells. In the Aquitanian basin, velocity profile data are in close agreement with those from wells for the Tertiary, but information on the Mesozoic is meager. In basins of the Sahara type interference by multiple reflections is a major drawback. On the other hand, the possibilities of combined use of reflection and refraction to define lateral velocity variations may not have been fully appreciated. — D.B.V.

185-518. Khuan, Khun-Dzy. Plane problem of kinematic seismics under the condition where the velocity  $v=v(w)$  is a continuous-rupture function (in Chinese with Russian summary): Acta Geophysica Sinica, v. 7, no. 2, p. 136-151, 1958.

Under conditions where the velocity  $v=v(w)$  is a continuous-rupture function, formulas for general solution of the traveltime curve of reflected waves of a multilayered medium can be expressed in parametric form. This paper de-

rives such formulas, by means of which the equations of the traveltime curves can be written quickly for multilayered mediums that have velocity boundaries with an arbitrary angle of dip. A method of plotting traveltime curves of refracted waves in similar geologic conditions is also examined. These equations can give a strictly point solution. — J. W. C.

- 185-519. World Oil. Vibratory seismic method is important breakthrough: World Oil, v. 152, no. 5, p. 85, 1961.

The vibratory seismic method permits full control of the signal loaded into the earth and allows use of several energy sources (slave hydraulic vibrators) simultaneously. The resultant received signal can be correlated against the signal introduced into the earth, thereby reducing or eliminating extraneous noise. — J. W. C.

- 185-520. Gurvich, I. I., and Dukach, D. Sh. O statisticheskom effekte grupirovaniya v seismorazvedke [On the statistical effect of grouping in seismic exploration]: Prikladnaya Geofizika, no. 22, p. 53-62, 1959.

Considering a group of geophones as an interference system, it was possible to improve the data recorded by the group by eliminating or smoothing down the background of regular and irregular interferences. The method used for the suppression of these interferences is based on the directional selectivity effect studied by Napalkov (see Geophys. Abs. 179-375) and on the statistical effect. This paper discusses the influence of different sensitivities of individual geophones comprising the system on the statistical effect of the group; direction selectivity is taken into account. It was determined that the statistical average of the signal received by a group of geophones depends but little on the degree of their sensitivities (amplitudes). Therefore, a group of geophones having sensitivities different by a factor of 1.5-1.6 can be formed without affecting the group sensitivity as a whole. — A. J. S.

- 185-521. Eventov, Ya. S. K voprosy o metodike obshchego geologicheskogo izucheniya zakrytykh rayonov [Problem of the method of general geological study of covered regions]: Geologiya Nefti i Gaza, no. 4, p. 32-41, 1959.

Where it is necessary to study in detail a region that is masked by a sedimentary cover, the work should proceed in the following sequence: (1) compilation of a geologic map of the sediments that are exposed at the surface by aerogeological surveys and a minimum of ground traverses; (2) seismic survey; (3) drilling of shallow boreholes along the seismic profiles—an area of 500 sq km should have 15-20 boreholes; (4) compilation of seismogeologic maps; and (5) compilation of a stratigraphic section on the basis of the drilling and seismic data. — J. W. C.

- 185-522. Richards, T. C. Motion of the ground on arrival of reflected longitudinal and transverse waves at wide-angle reflection distances: Geophysics, v. 26, no. 3, p. 277-297, 1961.

The horizontal and vertical motions of the surface of the ground on the arrival of reflected longitudinal and transverse waves from an elastic discontinuity are determined theoretically, with special reference to those parameters encountered in exploring for limestone structures in the foothills of Western Canada by wide-angle reflection techniques. The results, which cover a wide range of possible overburden velocities, are expressed by means of curves from

which the displacement for any practical elastic contrast, depth, and observation distance may be readily determined. Properties of these curves are examined empirically. The theory assumes plane waves in determining the amplitude ratios at the structural or free surface discontinuities and spherical waves in deriving spread factors. Corrections to the curves on account of a nonuniform overburden velocity are considered in the case of a typical central foothills well. The evidence for PP and PS in model, and to a less extent in field work and the significance of phase changes on reflection are discussed. It is concluded that the horizontal geophone should prove to be a useful additional tool in wide-angle reflection surveys in disturbed foothills zones. Here, it could confirm or refute the arrival of a reflection registered by the vertical geophones in the many cases where doubt exists. — Author's abstract

- 185-523. Boulware, Robert A. How to analyze reflection data in permafrost areas: *World Oil*, v. 152, no. 5, p. 80-84, 1961.

In seismic computations the presence or absence of permafrost, the thickness where present, and uncertainty of velocity cause problems in determination of depth to reflecting interfaces. The refraction technique normally cannot be applied to measure the depth of the frozen zone because the velocity of the underlying material is usually lower than that of the permafrost. In some places it is possible to obtain reflected energy from the base of the permafrost, and depth to this surface can then be determined if accurate velocity information within the permafrost is available. Where the velocity is uncertain, the depth to the interface can be determined by a series of formulas which take into account the shot point elevation, a reference surface near the shot elevation, and shot depth. — J. W. C.

- 185-524. Starodubrovskaya, S. P. Eksperimental'noye izucheniye osobennostey prodol'nykh voln, otrazhennykh ot tonkogo sloya. [Experimental study of peculiarities of longitudinal waves reflected from a thin layer]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 10, p. 1466-1473, 1960.

Special investigations were made of reflected waves corresponding to one horizontal thin layer of uniform thickness with a high velocity of propagation. The studies were made in the Carpathian forward downwarp in two areas of known seismogeological structure containing one horizontal thin high velocity layer, a gypsum-anhydrite horizon with  $v=4,500-5,000$  m per sec. With varying depth of occurrence of the thin layer  $h/\lambda_2=0.15$ ,  $h/\lambda_1=0.3$  ( $f_{pr}=50c$ ) and  $v_1/v_2=0.5$  along the interval from  $x=0$  to the nearest geophone, the following can be concluded: The wave reflected from a thin layer in both areas of investigation is dominant and can be correlated easily on the records. The dynamic features of the wave, the shape of the recorded wave, the duration of the oscillations, and predominant periods do not change with distance from the source of excitation. Averaged amplitudes gradually attenuate with distance. The waves recorded in areas with varying depths of occurrence of the thin layer have different predominant frequencies and different rates of attenuation of the amplitudes with distance. — J. W. C.

- 185-525. Michon, D. Phénomènes anormaux en sismique reflection [Abnormal phenomena in seismic reflection (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 1, p. 19-29, 1961.

Abnormal phenomena such as refractions and diffractions are more clearly seen on corrected sections produced in magnetic processing offices than on

single reflection records, making their understanding increasingly important. This paper discusses the geometric properties pertaining to such phenomena and attempts to distinguish between what is useful for interpretation and what is not.

Diffractions and refractions that indicate faults and diffractions caused by irregularities of the boundary between heterogeneous mediums are treated. Classified as parasite phenomena are: (1) refractions following very shallow horizons, mainly related to topographic irregularities; (2) diffractions on the upward path caused by shallow faults; and (3) diffractions in the horizontal plane, encountered either in marine surveys or in the case of inclusions in otherwise homogeneous mediums. — D. B. V.

- 185-526. Laherrère, J. Utilization pratique des films synthétiques dans le Sahara Nord [Practical use of synthetic seismograms in the northern Sahara (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 1, p. 46-59, 1961.

Nineteen synthetic seismograms compiled from data on 12 wells, field seismograms, and continuous velocity logs in the northern Sahara by different methods (by analogy and by computation) developed by 4 French companies are compared. Comparison with field records shows that best results are not always obtained with a synthetic seismogram including multiples. In the northern Sahara, however, where multiple reflections are of considerable importance and impossible to detect by velocity studies, and where interpretation is based primarily on continuity, the study of synthetic records including multiples on all exploratory wells would appear to be indispensable. — D. B. V.

- 185-527. Schriever, William. Reflection seismograph prospecting, how it started: *Shale Shaker*, v. 11, no. 7, p. 18-21, 1961.

The history of the development of seismic reflection prospecting from its inception in 1921 in Oklahoma until 1952 is reviewed. — V. S. N.

- 185-528. World Oil. Salt dome refraction survey aided by double-jug layout: *World Oil*, v. 152, no. 7, p. 106, 1961.

A widely used technique for mapping salt domes makes use of a geophone at the bottom of a drill hole. A modification of this method provides for a second geophone in the hole 500 or 1,000 feet above the first. Both geophones operate simultaneously. The difference in arrival time at the two geophones measures the angle at which the waves arrive at the well and hence identifies in elevation the points of entry into the salt dome. This method is particularly useful in offshore work for determining the configuration of overhangs in salt domes. — J. W. C.

- 185-529. Lavergne, M. Etude sur modèle ultrasonique du problème des couches minces en sismique refraction [Ultrasonic model study of the problem of thin layers in seismic refraction (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 1, p. 60-73, 1961.

Seismograms obtained by means of ultrasonic model techniques have led to some results concerning the properties of waves refracted along thin layers. Velocities have been determined as a function of layer thicknesses. When thickness is small compared to wave length, the velocities of refracted waves may be as much as 6 percent less than along thick layers; amplitude attenuation with distance is large, and depth determination from measurements of



delay times is unreliable. The experiments were made on two-dimensional models, but the results can be extended to three-dimensional cases. — D. B. V.

- 185-530. Behrens, Jörn. Refraktionsseismische Messungen auf See [Seismic refraction measurements at sea (with English abstract)]: *Zeitschr. Geophysik*, v. 26, no. 4, p. 161-176, 1960.

A new method of marine refraction surveying is described. Geophones on the sea bottom are connected to a buoy which contains instruments for wireless communication of the measurements to the recording ship. Frequency modulation of low carrier frequencies is used. The results are recorded on magnetic tape in addition to the usual direct recording. The procedure is described and some preliminary results are discussed. — D. B. V.

- 185-531. Kilczer, Gyula. A rétegvastagság és mélység meghatározásának a kissebességű réteg elhanyagolásából eredő hibája szeizmikus refrakciós mérésnél [The errors in determinations of layer thickness and depth in seismic refraction measurements due to neglecting the weathered layer (with German summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 197-200, 1960.

It is shown theoretically and illustrated by a numerical example that neglecting the weathered layer in seismic refraction calculations does not result in any significant error in the value obtained for depth and thickness of the deeper layers in a multilayered case. — D. B. V.

- 185-532. Kilczer, Gyula, and Elek, Ilona. Dombos terepen végzett szeizmikus refrakciós mérések javítása [Correction for seismic refraction measurements made in hilly terrain (with German summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 201-207, 1960.

First arrivals in a seismic profile are delayed in crossing a hill, producing a "hump" in the velocity branches of the traveltime curve. A simple correction method is described, by means of which the average seismic velocity of the hill can be calculated without special measurements, using the area of the hump (measured with a planimeter) and the cross section of the hill. The method is illustrated by a practical example. — D. B. V.

- 185-533. Szénás, György. A szeizmikus módszer kifejlesztésének és alkalmazásának egyes kérdései [Some problems of the development and application of the seismic method (with German and English summaries)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 255-278, 1960.

Use of the refraction method is increasing today because in many areas, mainly sedimentary basins, the reflection method does not yield sufficient information. This revival implies further development as a result of analysis of the so-called "later arrivals." — Author's German summary, D. B. V.

- 185-534. Sarmiento, Roberto. Geological factors influencing porosity estimates from velocity logs: *Am. Assoc. Petroleum Geologists Bull.*, v. 45, no. 5, p. 633-644, 1961.

The close relation between acoustic velocity and porosity makes it possible to use velocity logs to determine porosity. However, velocity also depends on other geologic factors which, if known, permit more accurate log interpretation. In sandstones these factors are age, composition, depth, compaction, shaliness, and nature of pore fluid; of these, depth and shaliness are most

important. Equations based on statistical computation of traveltime-porosity relations that take these variables into account give more accurate porosity estimates than the widely-used time-average equation.

In carbonate rocks velocities are less affected by depth, but mineralogic composition and the presence of vugs are more important. Statistical traveltime-porosity equations computed for Paleozoic limestones and dolomites are closer to the time-averaged model than are the sandstone relations. — D. B. V.

- 185-535. Neyshadt, N. M. Poiski pegmatitov pri pomoshchi seismoelektricheskogo efekta vtorogo roda [Exploration of pegmatites by means of the seismoelectric effect of the second variety]: *Soviet-skaya Geologiya*, no. 1, p. 121-127, 1961.

The seismoelectric effect of the second variety includes all phenomena of natural electrical potential arising in rocks under the action of elastic vibrations or static pressure, independently of the nature of these phenomena. Experiments in the use of this effect in exploration for pegmatites were made in the Kola Peninsula. The pegmatites investigated could not be distinguished by seismic or electrical observations. Profiles of the seismoelectric effect, however, reflected the presence of the pegmatites very sharply. — J. W. C.

- 185-536. Tullos, F. N., and Cummings, L. C., Jr. An analog seismic correlator: *Geophysics*, v. 26, no. 3, p. 298-308, 1961.

An analog computer has been built to compute the cross-correlation coefficients of multitrace seismograms. The evaluation program has shown that the computer has greater accuracy than is normally required to compute the cross-correlation functions of short samples of data. Points on the correlation curves are computed and plotted at the rate of approximately 50 points per minute. Scanning is in difference of arrival times ( $\Delta t$ ) across the record, with increments of  $\frac{1}{2}$  to 16 millisecond. The correlation process is completely automatic with the exception of normalization, which is approximated by holding the total average signal power constant with a ganged attenuator. Analysis of synthetic and actual seismic data indicates that the correlation will be an interpretational aid in areas where the data are poor. — Authors' abstract

- 185-537. Officer, Charles B. The Gas Exploder, Sparker and Harru: Offshore, v. 14, no. 4, p. 19-21, 1961.

Three systems for geophysical exploration in water-covered areas, introduced within the past three years, are described. They are the continuous seismic profilers, the Gas Exploder and the Sparker, and a precision radar location system, the Harru. The Gas Exploder and Sparker differ primarily in their sound source; the former uses an explosive mixture of propane and oxygen detonated in an open chamber beneath the water, and the latter uses the underwater detonation of a 12,000 v spark. The Harru gives offshore locations by two accurate radar ranges monitored continuously from two known targets. The survey boat's location is plotted automatically. — V. S. N.

- 185-538. McDonal, F[rank] J. New marine seismic system: Offshore, v. 14, no. 4, p. 23-25, 1961.

A marine seismic system for surveying over water-covered areas is described. The seismic source is provided by the underwater explosion of a mixture of propane and air, or propane, air, and oxygen. This is essentially the same system as that used in the Gas Exploder (see *Geophys. Abs.* 185-537). — V. S. N.

- 185-539. Fritz, Axel M. The MD engineering seismograph and its application to highway engineering, in 11th Annual Symposium on Highway Engineering Geology Proceedings: Florida Geol. Survey, p. 55-65, 1960.

The MD seismograph, which measures the traveltime for the fastest wave whatever its path, has widespread application in highway engineering. The types of subsurface problems that can be solved are described, the principles of operation are explained, and some examples of application to highway construction are given. — V.S.N.

- 185-540. Moss, John H., and Bonini, William E. Seismic evidence supporting a new interpretation of the Cody terrace near Cody, Wyoming: Geol. Soc. America Bull., v. 72, no. 4, p. 547-556, 1961.

Seismic studies suggest that the Cody terrace complex bordering the Shoshone River near Cody, Wyo., is an alluvial terrace, not a rock-cut terrace as previously proposed. The results underscore the usefulness of seismic studies in geomorphic work. — D.B.V.

- 185-541. Berg, Joseph W., Jr., Cook, Kenneth L., Narans, Harry D., Jr., and Leamer, Richard J. Seismic profiles in northwestern Utah: Pilot Range and Grouse Creek Range area: Jour. Geophys. Research, v. 66, no. 4, p. 1255-1263, 1961.

Two seismic refraction profiles, 55 and 95 km long, were established in the area between Wendover and Grouse Creek in northwestern Utah. The two profiles were reversed for about 47 km of the distance. Commercial seismic prospecting equipment, modified to pass frequencies between about 3 and 50 cycles per second, was used. Results show that materials having velocities of about 2.0, 5.5, 6.2, and 7.4(?) km/s exist at depths of about 0, 0.8, 4, and 24 km, respectively. The apparent dips of the 5.5- and 6.2-km/s horizons are about  $\frac{1}{4}^{\circ}$  N. and  $2\frac{1}{2}^{\circ}$  N., respectively. Reflections from the 24-km horizon were identified on seismograms taken at 5 locations; a second reflection, which could result from a reflecting horizon at a depth of about 27 km, was identified on 4 of the 5 seismograms. — D.B.V.

- 185-542. Paterson, Norman R., and Gregotski, Edward L. Application of underwater profiler (Sparker) to geophysical exploration under Lake Erie: Oil in Canada, v. 13, no. 19, p. 24-27, 1961.

In 1958 and 1959 an underwater seismic survey using the Sparker underwater profiler was made on Lake Erie offshore from the Tilbury gas field. Results show that (1) bottom and bedrock surfaces can nearly always be accurately mapped; (2) at least one sub-bedrock geological horizon can be mapped continuously in more than half the areas traversed; (3) where no continuous sub-bedrock reflection exists, events can be followed locally; and (4) faults are easily detected. The lack of good, continuous reflections from deeper geological horizons (500-1,000 feet) is due mainly to lack of elastic property contrast; more powerful equipment, such as the Gas Exploder, may provide improvement. — V.S.N.

- 185-543. Shor, George G., [Jr.], and Fisher, Robert L. Middle America Trench: Seismic-refraction studies: Geol. Soc. America Bull., v. 72, no. 5, p. 721-730, 1961.

Seismic-refraction profiles in the Middle America Trench show that the main crustal layer ranges from normal oceanic thickness (about 5 km) to half again as thick. Sediments are thicker than in the Pacific Basin. Because of the increased depth of water and sediment at all stations and thickening of the main crustal layer at some stations, the M-discontinuity bows down beneath the trench. At the outer edge of the continental shelf near Guatemala, the water is replaced by sediments and rock which may be either consolidated sediments or volcanic rocks; the M-discontinuity is at little greater depth than beneath the trench. — Authors' abstract

Fisher, Robert L. Middle America Trench: Topography and structure. See Geophys. Abs. 185-588.

Shurbet, D. H. Determination of sedimentary thickness in the Mexican geosyncline by Rayleigh wave dispersion. See Geophys. Abs. 185-142.

185-544. Evrard, Pierre. Sismique [Seismic surveys]: Mus. Royal Congo Belge Annales, Ser. 8, Sci. Géol., v. 33, 88 p., 1960.

This is a report on seismic surveys made in the Congo Basin between 1952 and 1956. Both reflection and refraction methods were used. The organization of the three expeditions and methods of operation and interpretation are described. Detailed results are presented in tables and profiles.

The maximum thickness of the cover (Mesozoic and younger) was found to be 1,200 m. The finding of sedimentary formations in the basement that are older than the Lower Permian-Upper Carboniferous Lukuga Series, several thousand meters thick, subsiding, and relatively shallow poses several new problems in the geologic study of the area. — D. B. V.

Tryggvason, Eyesteinn, and Båth, Markus. Upper crustal structure of Iceland. See Geophys. Abs. 185-351.

185-545. Maries, A. C., and Beckmann, W[alter] C. A new geophysical method for the exploration of undersea coalfields: Mining Engineer, no. 4, p. 262-274, 1961; Inst. Mining Engineers Trans. 1960-61, v. 120, Paper no. 3847, 1961.

The equipment and techniques of operation used in a seismic reflection survey of undersea coalfields off the Northumberland and Durham coast, the Cumberland coast, and in Firth of Forth, England, are described. The Sparker method was used. More than 2,000 miles of traverses were made covering 400 sq mi at the cost of one moderately deep borehole on land or  $\frac{1}{2}$  the cost of an offshore borehole. The depth of penetration was sufficient to show depth to the sea floor, depth to bedrock below unconsolidated sediments, inclination of the uppermost bedrock, and the presence of faults, igneous intrusions, and submarine outcrops. — V. S. N.

185-546. Millouet, J. Problèmes posés à la sismique dans la région parisienne [Problems facing seismic surveying in the Paris region (with English abstract)]: Geophys. Prosp., v. 9, no. 1, p. 1-18, 1961.

Two major difficulties in seismic surveying in the Paris area are: The presence of high-velocity silicified limestone beds that are hard to drill make it difficult to obtain surface corrections and carry strong ground roll; and slight structural variations call for very accurate time control. The drilling difficulties and the need to eliminate parasite waves have led to the adoption of

pattern shooting from hammer-drill holes. Shooting with a lateral offset of 600 m has eliminated ground roll effectively enough to permit work in regions where formerly no reflections could be obtained. Surface corrections are obtained by means of uphole velocity surveys in deep holes at particularly important points, and at other points by calculation from structural maps of surface strata or from velocity-depth curves.

Determination of lateral velocity variations by surface velocity shooting is not feasible in this part of the Paris basin. The control of reflection times must take into account the deformation of the signal as a function of the type of recording equipment and filters used, and also the modification of the character of the reflection due to lateral stratigraphic variations. These variations can be observed by comparing the different velocity logs. — D.B.V.

- 185-547. Carron, Jean-Paul, and Nozières, Philippe. Les variations du bruit de fond sismique dans le bassin parisien [The variations of seismic background noise in the Paris basin]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 25, p. 3019-3021, 1960.

The effect of the nature of the ground on the amplitude of seismic background noise (of the order of 1 cycle per second frequency) was investigated using the records of 18 stations in the Paris basin. A very clear correlation was found between amplitude of the noise and thickness of the sediments overlying the Permian. These results cannot be explained in any simple fashion, but a relation to settling and compaction of young sediments is suggested. — D.B.V.

- 185-548. Vallon, Michel. Épaisseur du glacier du Tacul (massif du Mont-Blanc) [Thickness of the Tacul glacier (Mont Blanc massif)]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 12, p. 1815-1817, 1961.

The results of a seismic reflection survey made in 1960 on the Tacul glacier on the Mont Blanc massif in the Alps are presented in two maps, one showing the plan of seismic operations and the other the bedrock configuration. The valley is U-shaped in transverse profile and shows two steps in longitudinal profile. Maximum ice thickness is slightly more than 400 m. — D.B.V.

- 185-549. Drake, C[harles] L., Gaibar-Puertas, C., Nafe, J[ohn] E., and Lanseth, M. Estudios de prospección sísmica por refracción en el Golfo de Cádiz [Seismic refraction prospecting studies in the Gulf of Cádiz (with English abstract)]: Rev. Geofísica, v. 18, no. 70, p. 143-162, 1959.

Six refraction profiles surveyed in the Gulf of Cádiz, Spain, in the summer of 1956 showed four distinct units with mean longitudinal wave velocities of 1.85, 2.37, 3.67, and 5.64 km/s. These correspond, respectively, with Pliocene-Miocene sediments, Upper Mesozoic limestones, the Triassic (almost entirely Keuper marl), and a Variscan basement.

Structural contour and isopach maps are drawn on these units, and their relations to regional geology are inferred. The propagation of sound in the water-sediment system is also discussed. — D.B.V.

- 185-550. Seelis, Karl-Heinz. Das reflexionsseismische Bild des Bentheimer Sandsteines im Raum von Meppen [The seismic reflection picture of the Bentheim sandstone in the Meppen area]: Erdöl u. Kohle, v. 12, no. 12, p. 953-957, 1959.

Disturbing reflections in seismograms obtained in the Hebelermeer oil concession near Meppen on the Ems, Germany, were suppressed by using unequal charges (12 shotholes in a special pattern, with stronger charges in central holes) and by opening the filter wide, especially to the high frequencies. The records thus obtained showed very clear reflections that could be correlated according to the character of their vibration features. In particular, the abrupt negative change of velocity at the base of the Bentheim sandstone and the resulting "negative" reflection were used to identify that horizon and trace its decrease in thickness. — D. B. V.

- 185-551. Janetsky, Donald. Refraktionsseismische Untersuchungen am Abbruch von Wittenberg [Seismic refraction investigations on the Wittenberg fault (with English and Russian summaries)]: *Zeitschr. Angew. Geologie*, v. 6, no. 4, p. 170-172, 1960.

Reconnaissance refraction surveys north and northeast of Zerbst in East Germany showed a concentration of isochrones trending in a northwest-southeast ("flat Hercynian") direction, reflecting a sharp change in velocity on the Wittenberg fault. A profile across the fault showed that the cause of this change is not a thickening of the Cenozoic, but must be attributed to differences in velocity at the upper surface of the pre-Tertiary. Three distinctly different velocities appeared in the south, central, and north sections of the profile; these are, respectively, 4.8 km/s, interpreted as Paleozoic (Carboniferous and Zechstein), 3.6 km/s, Mesozoic (Buntsandstein?), and 2.7 km/s, younger Mesozoic (Upper Cretaceous?). Borings showed the three different formations underlying the Cenozoic. — D. B. V.

- 185-552. Gálfi, János, and Pálos, Miklós. Refrakciós kéregkutató szelvény a Magyar Medencében [Crustal-study refraction profile in the Hungarian Basin (with English abstract)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 177-187, 1960.

A 120-km refraction profile was established in the eastern part of the Great Hungarian Plain between Hajdúszoboszló and Törtel. Good arrivals were obtained from the surface of the granitic layer and weaker ones from the M-discontinuity. Average thicknesses are calculated as follows: depth to granitic layer, 2.47 km; thickness of granitic layer, 11.13 km; thickness of gabbroic layer, 4.77 km; and total thickness, 22.22 km. There is a regional dip from Hajdúszoboszló to Törtel. — D. B. V.

- 185-553. Gálfi, János, and Stegena, Lajos. Mélységi reflexiók és a földkéreg szerkezete a Magyar Medencében [Deep reflections and crustal structure in the Hungarian Basin (with English summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 189-195, 1960.

The results of earlier and recent seismic reflection investigations in Hungary indicate a crustal thickness of 24 km; the gabbro layer averages 4-5 km. Along an east-west profile, the crust thickens toward the center of the Great Hungarian Plain. The reflection results agree well with those calculated from refraction measurements and earthquake data. — D. B. V.

- 185-554. Miynarski, Stefan. Prace sejsmiczne na Niziu Polskim [Seismic work in the Polish Lowland]: *Przegląd Geol.*, v. 9, no. 1, p. 34-36, 1961.

The development of seismic surveying in the Polish Lowland is described, and examples are given of the changes in methods over the years. — J. W. C.

- 185-555. Kharechko, G. E. Do pytannya pro tektoniku Rus'koyi platformy v rayonі mіst Berdyans'k-Nohays'k (za danymy heofizychnykh doslidzhen') [On the problem of the structure of the Russian platform in the area of the cities Berdyansk and Nogaysk (according to the data of geophysical investigations)]: Akad. Nauk Ukrainy. RSR Heol. Zhur., v. 20, no. 1, p. 73-81, 1960.

The basement relief and structure in the vicinity of Berdyansk (Osipenko) and Nogaysk on the Sea of Azov have been determined seismically. Results are given in graphs, two profiles (along the Berdyanska and Obitochna Peninsulas), and a sketch map that shows basement contours, major faults, and areas of positive and negative gravity field. The crystalline basement slopes southward under the sea, roughly parallel to the overlying sedimentary cover but broken by faults. — D. B. V.

- 185-556. Sollogub, V. B., Lossovskiy, Ye. K., Khilins'kiy, L. A., Sokolov, B. K., and Nikiforuk, B. S. Dosvid zastosuvannya visokochotnoyi seysmorozvіdkі z metoyu rozchlenuvannya metamorfіchnogo kompleksu porіd Bilozers'koho zalіzorudnoho rodovishcha [Experience in the use of high-frequency seismic surveys for the purpose of differentiating metamorphic rock complexes of the Belozerskiy iron deposits (with Russian and English summaries)]: Akad. Nauk Ukrainy. RSR Dopovіdī, no. 1, p. 16-21, 1961.

High-frequency seismic surveying was used to differentiate the metamorphic rocks of the Belozerskiy iron deposits of the Ukraine S.S.R. These rocks dip vertically and are covered by 250-400 m of sedimentary rocks. Not only is differentiation possible, but also ore zones can be recognized. The effect of defocusing the energy by curvilinear refracting boundaries is taken into account in distinguishing the ore zones. — J. W. C.

- Neprochnov, Yu. N., Goncharov, V. P., and Neprochnova, A. F. Seismic data on crustal structure in the central part of the Black Sea. See Geophys. Abs. 185-357.

- 185-557. Yelanskiy, L. N., and Tolkachev, M. I. Nekotoryye voprosy geologii yugo-vostoka Kuybyshevskogo Zavolzh'ya [Some problems of the geology of the southeast of the Kuybyshev Trans-Volga region]: Geologiya Nefti i Gaza, no. 5, p. 44-49, 1959.

The problem of distinguishing the terrigenous unit of the Lower Carboniferous in the Kuybyshev Trans-Volga region is treated, and a map of the distribution of this unit, based on seismic survey and drilling, is presented. Reflections could be recorded from the base of the unit only where its thickness is greater than 75-100 m. The seismic surveys confirm earlier magnetic and gravity surveys as to the distribution of projections on the basement surface. — J. W. C.

- Balavadze, B. K., and Tvaltvadze, G[uri] K. Crustal structure of the Transcaucasian-Caspian depression according to geophysical data. See Geophys. Abs. 185-324.

- 185-558. Veytsman, P. S., Gal'perin, Ye. I., Zverev, S. M., Kosminskaya, I. P., Krakshina, R. M., Mikhota, G. G., and Tulina, Yu. V. Nekotoryye rezul'taty izucheniya stroyeniya zemnoy kory v oblasti Kuril'skoy ostrovnnoy dugi i prilegayushchikh uchastkov Tikhogo

okeana po dannym glubinnogo seismicheskogo sonirovaniya [Some results of investigation of crustal structure in the region of the Kurile Island Arc and adjacent parts of the Pacific Ocean according to seismic depth sounding data]: Akad. Nauk SSSR Izv. Ser. Geol., no. 1, p. 81-86, 1961.

According to the data of seismic depth sounding, the crustal structure in the Kurile Island Arc and adjacent parts of the Pacific Ocean is complex. The zone between the islands and the deep Kurile-Kamchatka trench is not a structural unit. The northern section is completely continental and the southern section is partly continental, and these parts are related to the continental structures of the Kamchatka Peninsula and Japanese islands. The central section is of intermediate type, apparently the extension of the deep part of the Sea of Okhotsk.

These results agree with gravimetric data. The sea bottom topography, development of volcanism, seismicity, and recent movements also reflect this threefold division. — D. B. V.

185-559. Central Water and Power Research Station Poona. Geophysical investigations at Mohana dam site: India Ministry of Irrigation and Power, Central Water and Power Research Sta. Poona Ann. Research Mem., p. 64-66, 1959.

Seismic refraction and electrical resistivity surveys were made at the site of the proposed dam on the Mohana River, northwest of Itkhori, Hazaribagh district, Bihar State, India, to assess the depth of the overburden. Sixty depth estimates were made and on the basis of the bedrock structures determined from these estimates, a new dam site was proposed. The new site is shorter than the original site and approximately at right angles to the trend of the structures. — V. S. N.

185-560. Central Water and Power Research Station Poona. Geophysical investigations along surplus channel, Gudari dam site, Vamsadhara project: India Ministry of Irrigation and Power, Central Water and Power Research Sta. Poona Ann. Research Mem., p. 69-70, 1959.

A seismic refraction survey was made of the spillway section and along the surplus channel of the proposed Gudari dam across the Vamsadhara River, India, to determine depths to bedrock. Large acoustic contrasts between the bedrock and the overburden made interpretation easy; it was found that the bedrock dips steeply near the spillway section and gently along the surplus channel. Bedrock velocities were from 16,000 fps to 18,000 fps, and from these the formation was identified as a metamorphosed variety of the sediments (Khondalite) exposed on the two dam abutments. — V. S. N.

185-561. Khuan, Khun-Dzy. Seismo-geologic characteristics of the Dzhungar depression (in Chinese with Russian summary): Acta Geophys. Sinica, v. 7, no. 2, p. 116-135, 1958.

Large-scale seismic surveys, made in 1952-57 in the entire Dzhungar depression in Sinkiang province, yielded provisional ideas on the seismo-geology of the area. The methods of operations are described briefly, and several examples of seismograms are reproduced. Research is to be directed toward methods of study of gentle structures, ways to eliminate interference, and methods of operations in areas of barchans. — J. W. C.



- 185-562. Tseng, Yung-sheng, K'an, Yung-shu, and Ho, Ch'uan-ta. Low frequency seismic work in Tsaidam Basin [in Chinese]: K'o-hsueh T'ung-pao [Scientia], no. 10, p. 313-316, 1960. Translation by U.S. Dept. Commerce, Office Tech. Services, JPRS 5706, 16 p., 1960.

In the summer of 1958 an experimental low frequency seismic survey of the Tsaidam Basin, Tsinghai, China, was undertaken to determine the depth to the basement and the major boundaries of the overlying Paleozoic sedimentary series. Medium frequency seismic surveys are not successful in this area because in parts of the basin the Paleozoic limestones and metamorphic rocks exhibit very high elastic wave velocities that produce a screening effect and prevent successful mapping of the basement. Using the low frequency method, boundaries at depths of more than 10 km were determined. The instruments and techniques used are described, and the complex characteristics of the low frequency seismic waves obtained are discussed. — V.S.N.

- 185-563. Sasa, Yasuo, and Izaki, Akira. Analysis and geologic interpretation of sonic survey on the western passage of Tsugaru Strait, Japan (1) (in Japanese with English abstract): Jour. Geography [Tokyo] v. 70, no. 1, p. 3-18, 1961.

The results of a sonic survey in which a continuous seismic profiler (Sparker) was used to determine the geology underlying Tsugaru Strait between Hokkaido and Honshu, Japan, are discussed. Methods used to analyze the sonic data are presented, and the geologic interpretations of the data are shown in cross sections. — V.S.N.

Zverev, S. M. On the structure of the sedimentary layer of some parts of the Pacific Ocean according to seismic reflection data. See Geophys. Abs. 185-589.

- 185-564. Crary, A. P. Marine-sediment thickness in the eastern Ross Sea area, Antarctica: Geol. Soc. America Bull., v. 72, no. 5, p. 787-790, 1961.

Ocean sediment thicknesses were obtained at two locations in the eastern Ross Sea during the International Geophysical Year by seismic refraction and reflection methods. At the Little America station the sediment thickness is about 1,325 m, and at site 49, about 35 km to the southeast on an inland traverse, about 754 m; depths to bedrock are about 1,953 and 1,354 m, respectively. Most of the sediment may have been deposited by ice. — D.B.V.

- 185-565. Thiel, Edward. Antarctica, one continent or two?: Polar Rec., v. 10, no. 67, p. 335-348, 1961.

The Antarctic continent crudely resembles a pear. The top of the pear, which includes the Palmer Peninsula, the Ross Ice Shelf, the Filchner Ice Shelf, and the intervening grounded ice area of Marie Byrd Land and Ellsworth Highland, may be designated as "Lesser Antarctica." "Greater Antarctica" is the bottom of the pear and includes the greater part of the continent, largely high plateau. The demarcation line lies on the Pacific Ocean side of mountains that extend across the continent from Cape Adare to Coats Land. Three field seasons of geophysical traverse activity in Lesser Antarctica have led to the conclusion that there is no broad depression in the rock floor between the Ross Sea and the Weddell Sea. Antarctica is one continent, although the area

is not as great as the ice sheet would suggest. Several mountainous areas, such as that to the northwest of the broad ice-filled depression running from the Ross Ice Shelf towards the Amundsen and Bellingshausen Seas, would be islands were the ice to melt. .

The major results from the seismic traverses in Lesser Antarctica during the three year period are given in tables and illustrated in profiles. — V.S.N.

- 185-566. Pratt, J. G. D. Seismic soundings across Antarctica: Trans-Antarctic Exped., 1955-1958, Sci. Repts., no. 3, 69 p., 1960.

The results of seismic soundings across Antarctica are presented in four parts. Part 1 discusses the seismic equipment and field techniques. In part 2 the methods used in the reflection survey of the ice cap from Southice through the South Pole to Plateau Depot are discussed, and depth results are given in a table. Part 3 discusses the refraction shooting program at Southice which had the primary aim of obtaining information about the velocity of seismic waves in ice, especially in the weathered layer. Results are given in tables and graphs. In part 4, the methods used to determine the thickness of the Filchner Ice Shelf from data of a reflection survey at Shackleton are discussed, and the results are given in tables and graphs. Lastly, three appendices present a glossary, the metric units employed, and a table of ray-tracing results to be used in computing weathering corrections as discussed in part 3. — V.S.N.

#### STRENGTH AND PLASTICITY

- 185-567. Reiner, Markus. Deformation, strain and flow—an elementary introduction to rheology: New York, Interscience Publishers, Inc., 347 p., 1960.

This textbook is a revision and enlargement of the first edition published in 1949. Chapters 1 through 6 discuss the mechanics of continua, that is, mechanics of material points, systems of material points, rigid bodies, and systems of rigid bodies. Chapters 8 to 13 show how essential rheological properties can be reduced to the 3 fundamental properties of elasticity, plasticity, and viscosity. Chapters 14 through 19 treat problems of physical nonlinearity, the phenomena of work hardening, and second-order phenomena. The text is concluded with a chapter on notations and with a bibliography. — V.S.N.

- 185-568. Pearson, Carl E. Theoretical elasticity: Cambridge, Harvard University Press, 218 p., 1959.

The fundamental concepts of stress, deformation, and linear elasticity are treated by using tensors. Vectors, index notation, differential geometry of space, and rotation of coordinates are concisely described in the first chapters. Green's identities and other integral equations in potential theory and the useful methods of variational calculus are reviewed. Additional topics covered concisely are elasticity equations in thermodynamics, vibrations and body and surface waves, and nonlinear elasticity. The mathematical treatment is clear, fairly complete, and rigorous. — E. C. R.

- 185-569. Caputo, Michele. Deformation of a layered earth by an axially symmetric surface mass distribution: Jour. Geophys. Research, v. 66, no. 5, p. 1479-1483, 1961.

Series expressions are developed for the surface displacements of a spherical earth model, deformed by both surface tractions and body forces arising from an axially symmetric distribution of mass over its surface. The model

consists of  $m-1$  homogeneous elastic spherical shells, plus an inner core which is treated either as elastic or as a liquid.

This solution is more rapid than that which treats the problem as a special case (zero frequency) of the normal mode theory of a vibrating layered sphere; for the nonsymmetric case there is no advantage in this method over the normal mode theory. — D. B. V.

- 185-570. Usami, Tatsuo. Solutions of the equations of equilibrium of a homogeneous and isotropic elastic body referring to spheroidal coordinates: [in Japanese with English abstract]: *Zisin*, ser. 2, v. 13, no. 2, p. 97-112, 1960.

The equation of equilibrium of a homogeneous and isotropic elastic body is solved in the prolate and oblate spheroidal coordinates for the cases of  $m=0$ , 1, and 2. Equations are derived for a three part solution: the first part satisfies  $\Delta=0$  and  $\bar{\omega}=0$ ; the second part satisfies  $\Delta=0$  and  $\bar{\omega}\neq 0$ ; and the third part satisfies  $\Delta\neq 0$  and  $\bar{\omega}\neq 0$ . — V.S.N.

- 185-571. Donath, Fred A. Experimental study of shear failure in anisotropic rocks: *Geol. Soc. America Bull.*, v. 72, no. 6, p. 985-990, 1961.

Preliminary work has shown that planar anisotropy (foliation) may have a marked effect on both the breaking strength and the angle of shear fracture in rocks. For rocks experimentally deformed at room temperature and under low confining pressure, curves of breaking strength versus inclination of anisotropy are concave upward and parabolic in form. Shear fractures tend to develop parallel to well-developed planar anisotropy for inclinations up to  $45^\circ - 60^\circ$  to the direction of maximum pressure. — Author's abstract

- 185-572. Bellière, J. Déformation plastique et déformation rupturale [Plastic deformation and ruptural deformation]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 257-260, 1960.

In plastic deformation the continuity of the deformed objects is maintained; in ruptural deformation it is broken. The type that will prevail in a given instance depends on the following factors, aside from such dynamic elements as strength and direction of the forces involved: nature of the rock; depth in the crust (level of regional metamorphism); presence of anatexis or ultrametamorphic phenomena; scale of features observed; and, probably, time at which deformation occurred in the tectonic phase. Special attention is given to the conditions in which mylonitization appears. — D. B. V.

- 185-573. Brace, W. F. Analysis of large two dimensional strain in deformed rocks: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 261-269, 1960.

For a general nonhomogeneous strain of importance in structural geology the relatively simple equations of homogeneous strain can be applied over small regions. It is assumed that these regions are large enough within a geologic structure that the strain components can be measured. The immediate purpose of strain measurement and analysis is to find the magnitude and orientation of principal strains.

The most suitable strain components appear to be the quadratic elongation ( $\lambda$ ) and unit shear ( $\gamma$ ). These are easily measurable and can be used in a Mohr diagram to investigate variation of strain and to find principal strains semigraphically. The method is described and applied to a stretched pebble, a deformed brachiopod, and a group of three stretched belemnites. Principal

strains and change of area can thus be found more simply for combined measurements than by analytical methods.

The results applied here to plane strain hold also for any plane perpendicular to one of the three principal strain axes; determination of strain axes in two such planes completely determines strain in three dimensions. The method therefore can be extended to more general types of finite strain that are of interest in structural geology. — D. B. V.

- 185-574. Kieslinger, Alois. Residual stress and relaxation in rocks: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 270-276, 1960.

All rocks of the crust are in a condition of strong elastic compression. When pressure is removed by erosion, relaxation and volume increase take place very slowly and incompletely. The resulting sheeting at the surface, most prominent in granite, occurs in all types of rock. In the outer zone of relaxation, stress is oriented in definite directions, but at greater depth it is hydrostatic. Artificial splitting and economical quarrying of granite are possible only in this outer zone of relaxation, which extends at most to 40-50 m below the surface.

Because of the incomplete elasticity of rocks, even small pieces such as testing cubes retain considerable residual stress; this accounts for striking anomalies in the testing of materials. The relaxation tendencies make use of petrofabrics if possible. Knowledge of relaxation is critically important in quarrying and for the understanding of rock slips and many other geologic phenomena. — D. B. V.

- 185-575. Iida, Kumizi; Wada, Tatsuhiko; Aida, Yoko; and Shichi, Ryuichi. Measurements of creep in igneous rocks; Nagoya Univ. Jour. Earth Sci., v. 8, no. 1, p. 1-16, 1960.

Creep measurements in granitic rocks, basalt, rhyolite, andesite, and serpentine are described. An ordinary bending apparatus was used, and measurements were limited to the range of small stresses at room temperature and atmospheric pressure. At low stresses pseudoviscous flow-type creep is observed in serpentine and in some rhyolite, and elastic flow-type creep is observed in granitic rocks, in some rhyolite, and in andesite.

For serpentine and basalt the creep rate decreases with increase in load; moreover, in the case of basalt negative creep is observed. The increase in creep resistance is a result of the formation of substructures at grain boundaries. The abnormal or reverse creep in basalt is probably a result of precipitation at grain boundaries. Overall results suggest that considerable rock deformation will occur eventually even under very small strain. — V. S. N.

- 185-576. Konstantinova, A. G. Vremennoye raspredeleniye energii uprugikh impulsov pri razrushenii gornykh porod [Time distribution of energy of elastic impulses during destruction of rocks]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1580-1592, 1960.

On the basis of an analysis of the temporal distribution of the energy of elastic impulses, certain aspects of the fissure-forming process during the destruction of rock samples under uniaxial compression and in the coal layers during the time prior to sudden ejection of coal and gas are explained. — Author's abstract, A. J. S.

- 185-577. de Wit, G., and Koehler, J. S. Interaction of dislocations with an applied stress in anisotropic crystals: *Phys. Rev.*, v. 116, no. 5, p. 1113-1120, 1959.

The equilibrium shape of a dislocation segment between two pinning points in the same glide plane is calculated. The assumption is made that the dependence of the dislocation self-energy on the geometry of the dislocation line can be expressed by using an energy per unit length,  $E$ , which is a function only of the angle,  $\theta$ , between the Burgers vector and the tangent of the dislocation. Only glide of the dislocation, not climb, is considered. The results obtained are compared with those for elastically isotropic crystals. It is found that the character of the dislocation shape is altered considerably if  $E - d^2E/d\theta^2$  can be negative. It is suggested that the change in sign of this quantity is associated with diffusionless phase changes. — Authors' abstract

- 185-578. Koehler, J. S., and de Wit, G. Influence of elastic anisotropy on the dislocation contribution to the elastic constants: *Phys. Rev.*, v. 116, no. 5, p. 1121-1125, 1959.

Calculations of the dislocation contribution to the measured elastic constants of face-centered cubic crystals are made as follows. First, the displacement of a pinned dislocation segment under an externally applied stress is evaluated. Then the contribution to the resulting macroscopic distortion of the specimen resulting from the motion of all the dislocations present is calculated. The results are that the contributions for given dislocation arrangements increase with increasing anisotropy. For copper and lead the contributions can amount to a few percent in a pure well annealed crystal and can be as large as 10 percent in slightly deformed crystals. Edge dislocations are found to make about ten times larger contributions than a similar density of screw dislocations. — Authors' abstract

- 185-579. Gunter, B. D., and Parker, F. L. The physical properties of rock salt as influenced by gamma rays: Oak Ridge, U.S. National Laboratory, ORNL-3027, 71 p., 1961.

The response of dome and bedded rock salt aggregates to gamma radiation and temperature changes was studied. The compressive strength, yield strength, modulus of elasticity, and apparent elastic limit were investigated, and short-term creep tests were made. Data are presented in tabular and graphic form. Within the statistical variation of the experiment, radiation causes only minor changes in the physical properties of rock salt and, therefore, would not prohibit the disposal of radioactive wastes in salt cavities. — V. S. N.

- 185-580. Panek, Louis A. Measurement of rock pressure with a hydraulic cell: *Mining Eng.*, v. 13, no. 3, p. 282-285, 1961.

An apparatus and a technique developed by the U.S. Bureau of Mines to measure total existing rock pressure directly are described in detail. The apparatus has been used to measure pressure in diabase, limestone, graywacke, iron ore, and concrete (drift linings) in three mines over a period of three years. The results show that pressure measurements obtained from arrays in the same drift agree within the limits of experimental error and are consistent with pressures that may be predicted by theory for simple stress situations. The technique is intended primarily for use in monitoring rock pressure at locations that may be of particular interest to investigation of ground control principles, or that may be critical to production where failure

to control rock pressure could disrupt mining. The apparatus consists of 4 straingages cemented in vertical slots in the rocks and a flat hydraulic pressure cell cemented in a horizontal slot. Procedures are described in detail. — V.S.N.

- 185-581. May, A. N. The measurement of rock pressures induced by mineral extraction: Canadian Mining and Metall. Bull., v. 53, no. 582, p. 747-753, 1960; also in Canadian Inst. Mining and Metall. Trans., v. 63, p. 497-503, 1960.

A stressmeter developed to measure unidirectional stress changes in absolute units is described. The instrument is designed to measure the stress condition in the interior of rocks surrounding underground openings. The stressmeter may be installed at the end of a diamond drill hole and left in position to record any subsequent changes in stress, or three instruments can be used in conjunction with a trepanning operation to allow the existing stress condition to be determined. Initial laboratory work and field trials are described. — V.S.N.

- 185-582. Hast, Nils. The measurement of rock pressure in mines: Sveriges Geol. Undersökning, Årsb. 52, no. 3, Ser. C, no. 560, 183 p., 1958.

A method of measuring the absolute value and direction of principal stresses of rock pressure in mines is described in the first part, and the results of application of the method in three mines in Sweden are presented in some detail in the next three parts. Hitherto unsuspected horizontal stresses of a magnitude far exceeding vertical load at the same points were revealed. A fifth part deals with stress conditions in block caving.

Part 6 is devoted to a survey of the horizontal rock pressure determined at six mines in Scandinavia. There appears to be a genetic connection between the horizontal rock pressure and secular movements in this area. Earthquakes may be due to local release of cumulative stresses built up over long periods by such movements. In certain areas where earthquakes have recurred along the same fault line, the accumulation of stress can be followed by periodic measurements of rock pressure; in this way it should be possible to ascertain when there is serious risk of an earthquake. — D.B.V.

- 185-583. Zumbege, James H., Giovinetto, Mario, Kehle, Ralph, and Reid, John. Deformation of the Ross Ice Shelf near the Bay of Whales, Antarctica: Am. Geog. Soc., IGY World Data Center A, Glaciol. Rept. Ser., no. 3, 148 p., 1960.

Parallel crevasses oriented normal to the axes of firn folds in the Ross Ice Shelf between Roosevelt Island and the Bay of Whales, Antarctica, were studied during the International Geophysical Year 1957-58 and 1958-59. Seismic data in the folded area reveal that the shelf ice has a thickness of 70-133 m and floats in water more than 500 m deep. The folds and crevasses are produced by horizontal compressional stresses induced by merging of ice streams from the east and west sides of Roosevelt Island. Plastic deformation from lateral compressive stresses has produced increased densification in the folded parts of the shelf ice.

Strain rates show that the axes of the firn folds are almost always perpendicular to the principal compressive axis and the crevasses essentially perpendicular to the principal tension axis. Comparison of strain rates in crevassed and noncrevassed areas defines a rupture criteria having the mathematical form of a surface of revolution around the line  $s_1 = s_2$ . — V.S.N.

- 185-584. Gaskell, T[homas] F. Under the deep oceans: New York, W. W. Norton and Company, 240 p., 1960.

This is a popular account of the scientific results achieved from the geophysical studies of the ocean floor conducted by the 1950 Challenger Expedition. The text includes the following chapters: geographical exploration - modern style, the earth and the oceans, seismic prospecting, the Moho, deep sounding, coral atolls, layer 2, sea-bed sediments, natural history, the Mediterranean, wandering continents, and deep drilling. The findings solved a number of old problems such as the origin of coral atolls and the status of the Mediterranean, and also brought forth new evidence for the theory of continental drift. — V. S. N.

- 185-585. Oulianoff, Nicolas. Transport des matériaux meubles sur les fonds océaniques [Transport of loose materials on the ocean bottom]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 26, p. 4410-4412, 1960.

Perpetual vibration of the earth's crust due to earthquakes and microseisms is considered the most important agent of transport of marine sediments, analogous to the "vibrating conveyors" used in industry. In comparison, the sporadic effect of turbidity currents is of secondary importance. — D. B. V.

- 185-586. Heezen, Bruce C. The rift in the ocean floor: Sci. American, v. 203, no. 4, p. 99-110, 1960.

The Mid-Atlantic Ridge, originally located by the 1873 Challenger Expedition, is now believed to be part of a continuous world-wide system of submarine ranges occupied by central rift valleys. Seismic mapping in the past few years has confirmed the existence in many parts of the world of this submarine ridge and rift system and the coincidence of the rift with a belt of mid-ocean earthquake epicenters. Landward expressions of this system are found in the East African Plateau rift valley system and in the Central Icelandic graben as well as in other parts of the world. The appearance of this system in some of the places where it has been mapped is described briefly, and the continental-drift, expanding-earth, and convection-current theories are discussed as possible explanations for the features. — V. S. N.

- 185-587. Matthews, D. H. Lavas from an abyssal hill on the floor of the North Atlantic Ocean: Nature, v. 190, no. 4771, p. 158-159, 1961.

Rocks dredged from an abyssal hill that rises 200 m from the Iberia Abyssal Plain, some 300 miles northwest of Lisbon, may represent material from "seismic layer 2." Most of the samples (354 out of 362) are highly altered vesicular basalt. These altered lavas were found to be slightly less magnetic than normal basalts, although their susceptibility (median value  $5 \times 10^{-4}$  emu per oersted per  $\text{cm}^3$ ) and remanent magnetization (median value  $5 \times 10^{-3}$  emu per  $\text{cm}^3$ ) lie within the known range of variation for basalts.

Compressional wave velocities were measured at room temperature and pressure parallel to a uniaxial compressive stress of a few tens of atmospheres; results are presented graphically. Variation of velocity with hydrostatic compacting pressure was measured under differential confining pressures of 1-1,000 kg per  $\text{cm}^2$ ; the maximum increase in velocity with pressure was 30 percent. These results suggest that altered basalt flows could be common in layer 2 under the oceans. — D. B. V.

- 185-588. Fisher, Robert L. Middle America Trench: Topography and structure: Geol. Soc. America Bull., v. 72, no. 5, p. 703-720, 1961.

From 1952 to 1959 research vessels recorded 31,950 miles of echo-sounding traverses in and adjacent to the Middle America Trench, which extends from the Islas Tres Marías off western Mexico to the Cocos Ridge southwest of Costa Rica. The results are shown in a map of the submarine topography.

Seismic refraction studies of the trench structure, reported in a companion paper (see Geophys. Abs. 185-543), showed thick sediments in the Tres Marías Basin and at the shelf station off Guatemala. On a section off Guatemala normal to the trench, the depth to the M-discontinuity is about 9 km below sea level under the Pacific basin, 10 km under the outer ridge, 16 km under the trench, and 17 km under the shelf. The crust thickens from 5-7 to 10-17 km along this same section. The M-discontinuity is deeper and the crust thicker under the two southern stations than under the two central trench stations. The mantle is deeper under the Tres Marías Basin, where thick (1.5 km) sediments are found, than under the central stations.

The Gulf of Tehuantepec marks a major change in trench configuration and possibly in its age. — D. B. V.

- 185-589. Zverev, S.M. O stroynii osadochnoytolshchini nekotorykh uchastkov Tikhogo okeana po dannym seysmicheskikh otrazhennikh voln [On the structure of the sedimentary layer of some parts of the Pacific Ocean according to seismic reflection data]: Akad. Nauk SSSR Izv. Ser. Geol., no. 2, p. 80-86, 1961.

The results of deep reflection surveys in the northwest part of the Pacific Ocean in 1957-58 show that the bottom sediments in a deep-sea trench are homogeneous in comparison with the complexly layered shelf sediments, and that their thickness decreases gradually with distance from the trench. Complex relief of the basement on the slopes bordering the Kurile-Kamchatka trench is smoothed by the sedimentary fill; away from the trench the basement relief becomes more and more gentle. About 150-250 km from the axis of this trench large-amplitude fracture zones, probably the result of tectonic movement, cut all sedimentary layers and are expressed in the bottom relief.

The sediment thickness of the marginal slopes near the Aleutian trench is two or three times greater than that in the vicinity of the Kurile-Kamchatka trench, suggesting that their conditions of sedimentation are essentially different. — D. B. V.

- 185-590. Krylov, A. Ya., Lisitsyn, A. P., and Silin, Yu. I. Znachenie argon-kaliyevogo otnosheniya v okeanicheskikh ilakh [Significance of the argon-potassium ratio in ocean sediments]: Akad. Nauk SSSR Izv. Ser. Geol., no. 3, p. 87-100, 1961.

The K/Ar ratios, absolute ages, grain size, and mineralogic composition were determined for clastic materials in modern ocean sediments from various parts of the world: Antarctic ice-rafted material in the Indian and Pacific Oceans; diatomaceous and foraminiferal deposits in the Indian Ocean; red deep-sea oozes from the Indian and Pacific Oceans; and off-shore deposits in the Gulf of Bengal, near Somali, in the Tasman Sea, and in the Bering Sea. Results are tabulated.

As radiogenic argon was found to be completely or almost completely retained in even the finest particles of feldspar and mica, and as no appreciable adsorption of potassium from sea water could be detected, it is concluded that most ocean sediments can be used for argon determinations of the age of the original rock and thereby can help solve a series of problems of marine geology



and paleogeography. Many kinds of sediments, especially the more sandy or gritty, are suitable for the purpose. Those containing organic impurities, glauconite, and products of recent volcanism are of little use, however.

The results for particular areas are discussed and compared. — D. B. V.

Wilson, Gilbert M. Project Mohole demonstrates deep water drilling techniques. See *Geophys. Abs.* 185-366.

## VOLCANOLOGY

- 185-591. Ault, W[ayne] U., Eaton, J[erry] P., and Richter, D. H. Lavatemperatures in the 1959 Kilauea eruption and cooling lake: *Geol. Soc. America Bull.*, v. 72, no. 5, p. 791-794, 1961.

The 1959 summit eruption of Kilauea Volcano, Hawaii, filled the crater of Kilauea Iki with a lake of lava 365 feet deep. Temperatures of the erupting basalt ranged between 1,060°C and 1,190°C. Temperatures down a 12.7 foot-deep hole, drilled into the crust of the lake 5 months after cessation of eruptive activity, agree with calculated temperatures based on the heat equation. The cooling effect of rainfall is pronounced only in the upper 3½ feet of the crust. — Authors' abstract

- 185-592. Tilley, C. E., and Scoon, J. H. Differentiation of Hawaiian basalts: Trends of Mauna Loa and Kilauea historic magma: *Am. Jour. Sci.*, v. 259, no. 1, p. 60-68, 1961.

New analyses strengthen the conclusion that the historic lavas of Mauna Loa and Kilauea are derived from different magmatic batches. The presence or absence of hypersthene in the lavas seems to be related to the lime and silica content. Historically, Mauna Loa lavas as a batch are higher in silica and lower in lime than the Kilauea batch; lavas of the same silicity are lower in alkalis in the Mauna Loa type. The Kilauean lavas that carry hypersthene are the more silicic types and are lower in lime. — V. S. N.

- 185-593. Macdonald, Gordon A. The activity of Hawaiian volcanoes during the years 1951-1956: *Bull. Volcanol.*, v. 22, p. 3-70, 1959; reprinted as *Hawaii Univ. Inst. Geophysics, Contr. no. 14*, 1959.

This summary of volcanic activity in Hawaii during the years 1951-56 (during which only Kilauea was active) includes the history of Kilauea, earthquakes during 1951 and early 1952, the 1952 eruption, earthquakes and ground tilt in 1953 and early 1954, the 1954 eruption, earthquakes and ground tilt during the second half of 1954 and early 1955, the 1955 eruption, conditions at Kilauea and Mauna Loa from June 1955 to December 1956, and probable submarine eruptions in 1955 and 1956. — D. B. V.

- 185-594. Morais, J. Custódio de. O vulcão dos Capelinhos da Ilha do Faial [The volcano of Capelinhos of the island of Fayal]: *Univ. Coimbra Mus. Mineralog. Geol. Mem. e Notícias*, no. 47, p. 11-16, 1959.

The eruption of Capelinhos volcano at the west end of Fayal Island and its products are described briefly, and the volcanological setting of the Azores is discussed. (See also *Geophys. Abs.* 173-361, 175-409, -410, 180-402). — D. B. V.

- 185-595. Svyatlovskiy, A. Ye. K vulkanam Kamchatki [Volcanoes of Kamchatka]: Moscow, Gosudarstvennoye Izdatel'stvo Geograficheskoy Literatury, 100 p., 1960.

A popular description is given of the volcanoes of Kamchatka. The illustrations consist of several aerial views of cones and craters and a map showing the location of active volcanoes: — J. W. C.

- 185-596. Gushchenko, I. I. Deyatel'nost' vulkanov severnoy Kamchatki v 1957 g. [The activity of the volcanoes of northern Kamchatka in 1957]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta., no. 29, p. 3-6, 1960.

The activity of Klyuchevskaya during 1957 consisted mainly of gas emission from the central and eastern parts of the crater. Sheveluch, Ploskiy Tolbachik, and Kizimen were fumarolic. Activity of Bezymyanny declined; weak explosions were noted on January 30, March 1, and July 31, but otherwise activity consisted mainly of gas emission. — D. B. V.

- 185-597. Markhinin, Ye. K. Izverzheniye vulkana Zavaritskogo na ostrove Simushir osen'yu 1957 g. [Eruption of Zavaritskiy Volcano on Simushir island in the fall of 1957]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta., no. 29, p. 7-14, 1960.

Zavaritskiy Volcano in the Kurile Islands began to erupt on November 12, 1957 after 14 years of quiescence. The eruption was preceded by tremors and dull rumbling noises. Activity was explosive; ash, lapilli, and increasingly larger fragments were showered over the surrounding area. The active vent, located on the northwest shore of the crater lake, was still erupting on December 12; activity then was mainly gas emission with occasional small explosions. Fumarolic and solfataric activity elsewhere in the caldera was vigorous. The lake level has dropped about a meter since the eruption. — D. B. V.

- 185-598. Gushchenko, I. I. Aktivnost' vulkanov severnoy Kamchatki (s 1 yanvarya po 15 oktyabrya 1958 g.) [Activity of the volcanoes of northern Kamchatka (from January 1 to October 15, 1958)]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkan. Sta., no. 30, p. 3-6, 1960.

In the period in question Tolbachik, Kizimen, and Sheveluch were moderately fumarolic. Vigorous gas emission from the eastern part of the crater and weak ash-producing explosions on May 18 and July 4 and 18 were noted at Klyuchevskaya. Fumarolic activity from the earlier agglomerate flows from Bezymyanny continued intensively. Earthquakes and tremors from an epicenter in the Bezymyanny area were recorded at the seismic station at Klyuchi. — D. B. V.

Bernshteyn, V. A. On the magnetic field on Zavaritskiy volcano (Simushir Island, Kurile Islands). See Geophys. Abs. 185-481.

Tokarev, P. I. The Koz'yevsk seismic station. See Geophys. Abs. 185-147.

- 185-599. Sekiya, H. An analysis of volcanic activity of Mt. Asama (3d paper) [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 3, p. 71-81, 1960.

Several statistical properties of the volcanic activity of Mt. Asama in Japan are discussed. The secular variation and the mean properties over a 20-30 yr period of groups of volcanic activities (duration of eruption, number of earthquakes, probability of eruption, frequency of quantity of smoke, explosion energy) are shown in figures and tables. The correlation between the monthly number of microearthquakes or the quantity of smoke of class 5 (or more) with both the probability of eruption and explosion energy are calculated and illustrated. The fluctuation of observed frequency of smoke of class 5 or more is found to be more useful for the long range forecast of an eruption than correlations of energy or probability with earthquakes. — V.S.N.

185-600. Hamilton, W. M., and Baumgart, I. L. White Island: New Zealand Dept. Sci. Indus. Research Bull. 127, 84 p., 1959.

White Island is an active volcano in the Bay of Plenty and lies about 32 miles northeast of Whakatane, North Island, New Zealand, at lat 37°31' S., long 177°11' E. The island is  $1\frac{1}{2}$  by  $1\frac{1}{4}$  miles in size; the highest peak, Mt. Gisborne is 1,053 feet in elevation; and the crater, elongated east-west, is  $\frac{3}{4}$  mile long by  $\frac{1}{4}$  mile wide. Historical records indicate that the nature of the activity, consisting of fumaroles, hot springs, and intermittent minor eruptions of ash, has not altered materially in the last 125 years. The bulletin includes the following chapters by various authors: general description, history, volcanology 1927-29, physical and chemical investigations 1939-55, soils, vegetation, and birds, with a note on the mammal Rattus exulans Peale. — V.S.N.

Lotze, Franz. Actuo-geologic characteristics of the year 1958. See Geophys. Abs. 185-114.

185-601. Glangeaud, L[ouis]. Introduction aux études sur "Plutons et volcans". Les deux magmas des plutons et des volcans. Leurs rapports avec le métamorphisme [Introduction to the studies on "Plutons and volcanoes." The two magmas of plutons and of volcanoes. Their relations to metamorphism]: Rev. Géographie Phys. et Géologie Dynam., v. 3, no. 2, p. 77-85, 1960.

The fundamental problems of plutonism, which are the origin of granite and metamorphism, are discussed in terms of experimental, geologic, and geophysical evidence and thermodynamic principles. Different models of the present crust are illustrated, relating observed facts to geophysical measurements in different types of oceanic and continental areas. A bibliography of 80 entries is given. — D.B.V.

185-602. Vymorokov, B. M. Kak deystvuyut geyzery [How geysers work]: Priroda, no. 11, p. 97-99, 1960.

The geyser mechanism is reviewed on the basis of studies of boreholes drilled in volcanic regions of New Zealand and Kamchatka. The activity in these boreholes is cyclic like that of geysers. — A.J.S.



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