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

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



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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 to 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 183 that have not been listed previously.

- Acad. Sci. Poland Rev. —The Review of the Polish Academy of Sciences. Polish Academy of Sciences Press (Ossolineum). Warsaw, Poland.
- Eng. Inst. Canada Trans. —Transactions of the Engineering Institute of Canada. Montreal, Quebec, Canada.
- Geol. Landesamt Baden-Württemberg Abh. —Abhandlungen des Geologischen Landesamtes in Baden-Württemberg [Transactions of the Geological Survey of Baden-Württemberg]. Freiburg, German Federal Republic.
- Indiana Dept. Conserv. Geol. Survey Prog. Rept. —Indiana Department of Conservation, Geological Survey, Report of Progress. Bloomington, Indiana.
- Jour. Chem. Physics—Journal of Chemical Physics. American Institute of Physics. New York, New York.
- Oceanog. Works in Japan Rec. —Records of Oceanographic Works in Japan. Science Council of Japan. Tokyo, Japan.
- Precambrian—Precambrian. Winnipeg, Manitoba, Canada.
- Sci. Papers [Tokyo]—Scientific Papers of the Institute of Physical and Chemical Research. Tokyo, Japan.
- Utah Univ. Eng. Expt. Sta. Bull. —University of Utah, Engineering Experimental Station Bulletin. Salt Lake City, Utah.

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 Wanda L. Grimes, A. J. Shneiderov, and A. B. Tanner, as well as by the principal authors. Authors' abstracts are used in many instances. The initials of an abstracter following the notation "Author's abstract" indicates a translation from the original language.

AGE DETERMINATIONS

- 183-1. Folinsbee, R. E., Baadsgaard, H., and Lipson, J[oseph I.]. Potassium-argon time scale: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 3, p. 7-17, 1960.

Minerals of known biostatigraphic age have been dated by the potassium-argon method for certain key points on the paleontological time scale. Upper Cretaceous (Maestrichtian) sanidine is 66×10^6 yr old, and mica from the same horizon is $75-79 \times 10^6$ yr old. Upper Cretaceous (Campanian) biotites are $68-82 \times 10^6$ yr old. Middle Cretaceous (Lower Cenomanian) sanidine is 94×10^6 yr old, but Middle Cretaceous (Albian) biotite is $114-119 \times 10^6$ yr old, suggesting argon loss from the sanidine. Potassium-argon ages for Cretaceous and Jurassic glauconites are variable, usually younger than correlative mica and feldspar ages. Sanidine from a bentonite that marks the Devonian-Mississippian contact gives ages of 242×10^6 and 250×10^6 yr. A Lower Cambrian glauconite gives ages of only $395-413 \times 10^6$ yr, suggesting argon loss. These results do not allow any major revision of the Holmes time scale. — D. B. V.

- 183-2. Kulp, J. L[aurence]. The geological time scale: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc. pt. 3, p. 18-27, 1960.

New isotopic age determinations on rocks with reasonably well defined stratigraphic position permit a refinement of the time scale from Cambrian to Recent. Key points in the scale are tabulated and discussed in the light of potassium-argon, rubidium-strontium, and uranium (thorium)-lead measurements. The problem of the age of the Swedish colm is also discussed. Precambrian age measurements are evaluated in terms of major orogenic cycles and concepts of continental growth and worldwide synchronicity of larger scale events.

These considerations lead to a revised geologic time scale. The overall lengthening of the Holmes scale is no more than 15 percent, but there are major changes for certain periods; the Jurassic, Permian, and Carboniferous periods are roughly doubled in length and the Ordovician is somewhat shortened. Orogenic events that have been called Caledonian range from Silurian well up into the Carboniferous. Little evidence of the Taconic orogeny is left. Metamorphic events in the Black Forest (Germany) and Cornwall (England) that have been called Hercynian are separated by at least 60 million years. — D. B. V.

- 183-3. Quennell, A. M., and Haldemann, E. G. On the subdivision of the Precambrian: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 9, p. 170-178, 1960.

Extension of the classical geologic time-scale and stratigraphic column into the Precambrian is open to criticism. Neither the period nor the system can have counterparts because major marine transgressions can rarely be recognized; there is no biostratigraphic column; and orders of magnitude, with regard to time range, are very different.

It has been suggested that Precambrian stratigraphy should be based on recognition of geologic cycles, their time range, and their spatial extent of influence (see also *Geophys. Abs.* 183-326). Absolute age determinations can provide a wide range of correlation of events in different provinces. The post-Precambrian would also be amenable to this treatment. This approach is applied to the Precambrian of Africa. — D. B. V.

- 183-4. Davidson, C. F. Age of the Cambrian System: *Nature*, v. 187, no. 4742, p. 1020-1021, 1960.

It is shown that the brannerite ("absite") from South Australia that has been used to support the dating of the base of the Cambrian at $600 \pm 20 \times 10^6$ yr (see *Geophys. Abs.* 180-1) is completely lacking in stratigraphic definition and contributes no information on Cambrian chronology. For this reason it was ignored by Davidson in his own notes on the geologic time scale (see *Geophys. Abs.* 179-1, 181-406). The dating of the base of the Cambrian System at $600 \pm 20 \times 10^6$ yr on other evidence is not questioned. — D. B. V.

- 183-5. Aldrich, L. Thomas. *Geochronology*: *Am. Geophys. Union Trans.*, v. 41, no. 2, p. 287-288, 1960.

Work on absolute age determinations in 1957-60 in the United States and Canada has provided a steadily increasing amount of reliable data on North America in particular and more generally on South America, the Fennoscandian Shield, and the Red Sea area. A new laboratory has been established at the University of Arizona at Tucson. The work of the various laboratories in the United States is summarized briefly. — D. B. V.

- 183-6. Cook, Melvin A. *Geological chronometry*: *Utah Univ. Eng. Expt. Sta. Bull.*, no. 83, 59 p., 1956.

Various methods of dating the formation of the earth and the universe give apparent ages of comparable magnitude, namely 10^9 - 10^{10} yr. Despite this apparent agreement there are many reasons to believe that age determinations for the earth and universe may be far from satisfactory.

Experimental observations of neutron yield in the atmosphere and C^{14} concentration in the biosphere indicate that C^{14} may not yet have reached a steady state or equilibrium concentration in our atmosphere. On this evidence the C^{14} method, taken without modification of its basic theory except the questionable equilibrium postulate, appears to date the atmosphere at less than 15,800 yr, and if an ocean circulation lag of 400 yr is considered, at 14,000 yr. Re-examination of the helium balance in the earth and atmosphere and of the rates of accumulation of uranium in the ocean from river water also suggests ages in agreement with the C^{14} nonequilibrium theory.

Examination of the uranium-thorium decay, ocean salt deposition, and other methods shows them to be unsatisfactory for measurement of age in the earth's crust, and it is concluded that all current methods of geological chronometry are inadequate for providing any sort of quantitative or even qualitative age determinations. In Cook's opinion only superposition of strata and the nature and disposition of fossils provide a relative age determination. — V. S. N.

- 183-7. Kuroda, [Paul] K. On the nuclear stability of the uranium minerals: *Jour. Chem. Physics*, v. 25, no. 4, p. 781-782, 1956.

An attempt is made to apply the nuclear reactor theory to geochronology and to explain certain interrelations between the age and the nuclear physical stability of the uranium minerals as well as the geologic environments of the mineral formation. The infinite multiplication constant k_{∞} is an indicator of the stability of the uranium minerals; the system will be nuclear physically unstable if k_{∞} is greater than 1. According to the nuclear reactor theory, $k_{\infty} = \epsilon pf\eta$, where ϵ is the fast fission factor, p is the resonance escape probability, f is the thermal utilization factor, and η is the number of fast neutrons available per neutron absorbed by uranium. The values of p and f can be calculated from the chemical composition of the mineral, ϵ is always close to unity, and η as a function of uranium enrichment is known; hence the value of k_{∞} of a mineral at any geologic time may be calculated.

Calculated values of p , f , η , and k_{∞} of a sample of Johanngeorgenstadt pitchblende are tabulated. Similar calculations show that most uranium minerals were physically stable during the past 2,800 million years if the water content remained unchanged; a slight increase of the water/uranium ratio, however, would cause a sharp increase in p without affecting f appreciably, and make the system physically unstable. Recalculations in this light show that the Johanngeorgenstadt pitchblende and water assemblage was physically unstable when crystallization took place 2,100 million years ago; critical uranium chain reactions could have taken place if the assemblage were more than a few feet thick, elevating the temperature and destroying the critical assemblage.

The effect of ground water or magmatic water thus might explain the fact that the ages of the large uranium deposits never exceed 2,000 million years, or the marked discrepancies between the Pb^{206}/U^{238} and Pb^{206}/Pb^{207} ages of uranium minerals. — D. B. V.

- 183-8. Kuroda, [Paul] K. On the infinite multiplication constant and the age of the uranium minerals: *Jour. Chem. Physics*, v. 25, no. 6, p. 1295-1296, 1956.

The values of p , f , and k_{∞} (see *Geophys. Abs.* 183-7) of 20 samples of uraninite, pitchblende, bröggerite, nivenite, and cleveite have been calculated and are tabulated. A plot of k_{∞} against $Pb/(U+0.36\ Th)$ suggests that the greater the age of the mineral, the smaller the value of k_{∞} , although minerals with small values of k_{∞} are not necessarily old. Values of f are almost entirely dependent on the rare earth content of the minerals. The old minerals are always associated with considerable amounts of rare earths, but some younger minerals may also have a high rare earth content. — D. B. V.

- 183-9. Danilevich, S. I. Odostovernosti vozrasta monatsitov, opredelenno po uranovomu metodu [On the reliability of the age of monazites, determined by the uranium method]: *Akad. Nauk SSSR Doklady*, v. 132, no. 2, p. 443-446, 1960.

The Pb^{208}/Th^{232} , Pb^{206}/U^{238} , Pb^{207}/U^{235} , and Pb^{207}/Pb^{206} ages of 63 monazites are compiled from the literature, mainly Russian, and a coefficient A has been derived for each. A represents the ratio $(Pb^{207} \times 100)/(Pb^H \times Th/U)$, where Pb^{207} is in atomic percent and Pb^H is the nonradiogenic lead content in percent. The larger the value of A , the more reliable the "uranium" age of the monazite.

In 33 measurements $A > 1$, ranging from 1.0 to 45.7; in 14, $A < 1$, ranging from 0.13 to 0.76. In 8 measurements the A values are considered to be not fully justified; these are from 3 sources outside the U. S. S. R. and the A values range from 0.43 to 13.1. — D. B. V.

- 183-10. Tilton, G[eorge]R. Volume diffusion as a mechanism for discordant lead ages: *Jour. Geophys. Research*, v. 65, no. 9, p. 2933-2945, 1960.

The discordant uranium-lead ages of 16 minerals that have Pb^{207}/Pb^{206} ages of 2,400-2,700 million years closely fit a 2,800-600 million year chord when placed on a Pb^{207}/U^{235} - Pb^{206}/U^{238} diagram. If the data are interpreted as evidence of an episode of lead loss 600 million years ago from minerals that crystallized 2,800 million years ago, it is strange that the same time of loss is indicated for all 4 continents from which the minerals were collected; furthermore, most of the samples are from shield areas where there is no evidence for metamorphic events 600 million years ago.

As an alternative explanation, lead may be considered to diffuse continuously from crystals at a rate governed by a diffusion constant (D), the effective radius (a), and the concentration gradient. Calculations of the present-day Pb^{206}/U^{238} and Pb^{207}/U^{235} ratios as a function of the parameter D/a^2 yield ratios that lie on a 2,800-600 million year chord on a Pb^{206}/U^{238} - Pb^{207}/U^{235} diagram for losses of up to two-thirds of the lead produced in the sample. Other examples have been found in suites of minerals with discordant ages which fit this hypothesis; they include minerals with apparent ages of 1,900, 1,700, and 1,100 million years.

Volume diffusion thus explains irregularities that exist in discordant uranium-lead ages from several continents and does away with the need for episodic loss of lead in several cases where there is no evidence of metamorphic events at the time required. It also will play a prominent part in resolving problems that have arisen from comparison of uranium-lead ages of zircon with rubidium-strontium and potassium-argon ages of coexisting micas in granites and gneisses. The diffusion hypothesis is amenable to rather rigorous testing even in the absence of diffusion rate determinations. — D. B. V.

- 183-11. Starik, I. Ye., Starik, F. Ye., Yelizarova, A. N., Petryayev, Ye. P., and Lazarev, K. F. Znachenije vyshchelachivayemosti razlichnykh radioelementov pri opredelenii vozrasta svintsovym metodom [The significance of diffusion of various radioactive elements in age determination by the lead method]: *Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy*, 5th sess. *Trudy*, p. 221-232, 1958.

Complete agreement between ages of the same sample obtained by the lead method is infrequent, and an acceptance of one or another of the determined values is generally arbitrary. To establish a criterion for preferential acceptance of an age determined by the lead method, a study was made of the comparative capacities of uranium, isotopes of radium and thorium, and lead to diffuse from a crystal into a solvent without destroying the lattice of the crystal. The results of the studies indicate that uranium is located internally, that the age of monazites obtained from Pb^{206}/U^{238} may be exaggerated, that some portion of radiothorium locates itself at the nodes of the lattice to take the place of disintegrated thorium, that the ages determined from Pb^{207}/Pb^{206} may be undervalued, and the age of uranium pitchblende from Pb^{206}/U^{238} may be exaggerated. — A. J. S.

- 183-12. Evernden, J[ack] F[oord], Curtis, G[arniss] H., Kistler, R. W., and Obradovich, J. Argon diffusion in glauconite, microcline, sanidine, leucite, and phlogopite: *Am. Jour. Sci.*, v. 258, no. 8, p. 583-604, 1960.

It is concluded from data on the diffusion of argon in sanidine, microcline, phlogopite, glauconite, and leucite that: (1) Dynamic lattice changes marked-

ly influence argon loss at the time of the changes; (2) if argon diffusion takes place under conditions of no lattice changes, all argon will be lost at a single activation energy; (3) glauconite and phlogopite have essentially identical diffusion characteristics; (4) the parameters of the diffusion equations for both feldspar and mica are only explainable on an hypothesis of extreme ordering of the diffusing argon atoms; (5) glauconite and illite, due to their fine grain-size, are susceptible to high argon loss at a temperature of 100°C if that temperature is maintained for a few million years, and thus knowledge of the burial history of a sample is absolutely essential for each glauconite dated; (6) feldspar diffusion appears to be a complex of lattice and grain-boundary diffusion, with the lattice unit having dimensions of 10-30 μ ; and (7) heating a mica of 1 mm thickness to 300°C for a few million years should remove all preexisting argon, thus rendering impossible the dating of events prior to the last heating. — V. S. N.

- 183-13. Gerling, E. K., and Morozova, I. M. Izucheniye kinetiki vydeleniya argona iz mikroclin-pertita [The study of the kinetics of argon liberation from microcline perthite]: *Geokhimiya*, no. 7, p. 615-620, 1958.

The liberation of argon from microcline perthite was investigated mass spectrometrically over the temperature range 100°C-500°C. Five positions of argon in microcline were ascertained, corresponding to the following heats of diffusion: 15,000, 26,000, 42,000, 99,000, and 130,000 cal per g-atom of argon. The first three of these activation energies characterize diffusion of argon in the lattice disturbed by perthitization; as the radiogenic argon related to these heats of diffusion may easily be lost, microcline is unsuitable for use in age determinations. The last two activation energies are connected with shifts of argon in the undisturbed microcline lattice. — D. B. V.

- 183-14. Afanasiev [Afanas'yev], G. D., Kojina [Kozhina], T. K., and Starik, I. E. [Ye]. Results of age determinations for standard muscovite, biotite and microcline samples by the argon method: *Internat. Geol. Cong., 21st, Copenhagen 1960, Proc.*, pt. 3, p. 28-32, 1960.

Standard samples of muscovite, biotite, and microcline from the same pegmatite from northern Karelia were measured in six different potassium-argon dating laboratories in the U. S. S. R. The percentages of potassium and argon measured and the ages calculated in each laboratory are tabulated.

The results show that the methods used are all reliable, and that the accepted precision of ± 5 percent is correct. All deviations of more than 5 percent in values obtained can be attributed to defects in the sample. The ages calculated for microcline are 20 percent lower than those of the micas; this is attributed to the perthitic nature of the microcline. — D. B. V.

- 183-15. Nurmia, M., and Karras, M. The use of Sm-146 in age determinations: *Geophysica [Helsinki]*, v. 7, no. 2, p. 83-90, 1960.

On the basis of the recently reported discovery of Sm¹⁴⁶ in natural samarium, it is estimated that its half life must be in the vicinity of 3×10^8 yr. From nuclear abundances it is concluded that the initial isotopic abundance of Sm¹⁴⁶ was between 1 and 10 percent. Since Sm¹⁴⁶ is by far the shortest-lived natural radionuclide that is not being continuously produced in nature, it may yield important information about the age of the universe once its half life becomes accurately known. — V. S. N.

Anders, Edward, and Stevens, Charles M. Search for extinct lead 205 in meteorites. See Geophys. Abs. 183-63.

Gastil, Gordon. Continents and mobile belts in the light of mineral dating. See Geophys. Abs. 183-324.

183-16. Stern, T[homas] W., Stieff, L[orin] R., Klemic, Harry, and Delevaux, M[aryse] H. Lead-isotope age studies in Carbon County, Pennsylvania, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-45-B-48, 1960.

Lead-isotope age determinations were made on samples of uranium-bearing sandstone from the Mount Pisgah deposit, Mauch Chunk formation (Mississippian), near Jim Thorpe, Pa.; on sandstone samples with disseminated uraninite and a sample of clausthalite from the upper Catskill formation (Devonian) near Penn Haven Junction; and on specimens of galena from post-Pottsville rock (Pennsylvanian) and from Trimmers Rock sandstone (Devonian) collected at Nesquehoning and Walcksville, respectively.

The lead-uranium and lead-lead ages of the uranium-bearing samples from Mount Pisgah and Penn Haven Junction are discordant. However, a graphical analysis of the discordant Carbon County ages in terms of old radiogenic lead contamination is made with the assumptions that there was only one period of mineralization for each deposit; that the mineralizing solutions for each deposit were contaminated by a single common lead and a single generation of an older radiogenic lead; and that they have not been recently altered. Assuming an isotopic composition of the contaminating common lead similar to the Nesquehoning galena plus original radiogenic lead, concordant ages of 115 and 135 million years are obtained for Penn Haven Junction and Mount Pisgah, respectively. Maximum ages of source rock providing the old radiogenic lead range from approximately 350 to 475 million years.

An exact age solution is not justified, but it appears to be mathematically and geologically sound to conclude that both Carbon County uranium occurrences were formed near the end of the Jurassic or early in Cretaceous. — V. S. N.

183-17. Leighton, Morris M. The classification of the Wisconsin glacial stage of North Central United States: Jour. Geology, v. 68, no. 5, p. 529-552, 1960.

The Wisconsin glacial stage of the north-central United States is subdivided on the basis of stratigraphy into six glacial substages from older to younger as follows: Farmdale, Iowan, Tazewell, Cary, Mankato, and Valders. Consideration is given to other classifications including the one recently proposed by Frye and Willman (Geophys. Abs. 181-30). The radiocarbon dates available for each stage are discussed and evaluated. The questionable reliability of C^{14} dates on large pulmonate land snails, used by Frye and Willman as the keystone to their new classification, is emphasized. There is strong evidence that land pulmonate snails living in a calcareous loess environment used in part the dead carbonate of limestone particles in the loess for making their shells; thus the amount of dead carbonate used would be a factor in any date determination on the shell. — V. S. N.

183-18. Coulter, Henry W., Hussey, Keith M., and O'Sullivan, John B. Radiocarbon dates relating to the Gubik formation, northern Alaska, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-350-B-351, 1960.

Radiocarbon dating of a log from the base of the upper member of the Gubik formation near Barrow, Alaska, and of two peat-bearing beds overlying the upper Gubik are 38,000+ yr, 3,540±300 yr, and 9,100±260 yr, respectively. Deposition of the upper member of the Gubik formation was thus initiated prior to 38,000 yr B. P. and terminated prior to 9,100 yr B. P. — V. S. N.

- 183-19. Moore, G. W. Recent eustatic sea-level fluctuations recorded by Arctic beach ridges, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-335-B-337, 1960.

In areas near Point Hope and Cape Krusenstern on the northwest coast of Alaska, extensive barrier bars composed of numerous beach ridges have been formed since the last major rise of sea level throughout the world, about 3000 B. C. The age of many of the ridges can be closely estimated from C¹⁴ dating of archeological findings. Because of the tectonic stability of this area and lack of glaciation, it is an especially suitable place for finding evidence of former small eustatic changes of sea level.

Evidence from the relative elevations of the beach ridges indicates that sea level has risen about 3 m during the last 5,000 yrs, and that the rise was characterized by minor fluctuations with an amplitude of 1 to 2 m. The highest stand of sea level since the Wisconsin stage was attained in the 19th century. At Point Hope the youngest beach ridges have been related to an absolute time scale by C¹⁴ dating of the Tigara culture (A. D. 1300-1700) and the Ipiutak culture (A. D. 100-500). The oldest beach ridges now preserved were formed about 200 B. C. — V. S. N.

- 183-20. Miller, John A. Potassium-argon ages of some rocks from the South Atlantic: *Nature*, v. 187, no. 4742, p. 1019-1020, 1960.

Micas from 9 quartz-mica schists from the South Orkney Islands have been dated by the potassium-argon method. Results range from 176×10⁶ yr to 199×10⁶ yr and indicate an Early Jurassic-Late Triassic age either for the original metamorphism of the schists or for some subsequent metamorphism sufficiently intense to have released their radiogenic argon. The results are consistent with the hypothesis that radiogenic argon already present was released from the schists during the orogeny that folded the overlying Carboniferous graywackes. — D. B. V.

- 183-21. Holmes, A[rthur], and Cahen, L[ucien]. Geochronologie Africaine [African geochronology], in Asociacion de Servicios Geologicos Africanos: Internat. Geol. Cong. 20th, Mexico City 1956, p. 21-26, 1959.

The status of geochronology in Africa is reviewed. The following geologic cycles are recognized: <50 million years, 230-255 million years, 400 million years, 485 million years, 520 million years, 875-900 million years, 1,040 million years, 2,000 million years, 2,650 million years, 2,800-3,100 million years, and 3,200-3,400 million years. The various areas where these cycles are represented are listed. (See also Geophys. Abs. 161-131.) — J. W. C.

- 183-22. Besairie, H[enri]. La geochronologie à Madagascar en 1956 [Geochronology in Madagascar in 1956], in Asociacion de Servicios Geologicos Africanos: Internat. Geol. Cong., 20th, Mexico City 1956, p. 27-29, 1959.

The results of 24 age determinations using various lead methods are reported. Essential ages in Madagascan geochronology are given as: Eocam-

brian orogeny at 485 million years, limit of the Cipolins series at 1,120 million years, limit of the Vohibory system at 2,140 million years, and limit of the Graphite system at 2,600 million years. Plutonic manifestations occurred at 670, 1,385, and 1,515 million years, and a lead mineralization is dated at 1,820 million years. — J. W. C.

- 183-23. Besairie, H[enri], and Roques, M[aurice]. Determination de l'âge apparent de zircons de Madagascar par la méthode plomb-alpha [Determination of the apparent age of zircons of Madagascar by the lead-alpha method], in *Asociacion de Servicios Geologicos Africanos: Internat. Geol. Cong.*, 20th, Mexico City 1956, p. 31-33, 1959.

The ages of 7 zircons from Madagascar were determined using the method of Larsen and others (see *Geophys. Abs.* 154-14732). Data are presented in a table on the lead in parts per million, alpha activity per hour per milligram, and age in millions of years. The ages fall into three groups: 372-390, 435-455, and 1,385-1,555 million years. — J. W. C.

- 183-24. Bessoles, B., and Roques, M[aurice]. Âges apparents par la méthode plomb-alpha de zircons extraits de roches cristallines d'Afrique Equatoriale Française et du Cameroun [Apparent ages by the lead-alpha method of zircons extracted from crystalline rocks of French Equatorial Africa and the Cameroons], in *Asociacion de Servicios Geologicos Africanos: Internat. Geol. Cong.*, 20th, Mexico City 1956, p. 35-37, 1959.

Results are presented of lead-alpha age determinations on 14 specimens of zircon from granitic rocks of French Equatorial Africa and the Cameroons. The rocks in the north of this region yield apparent ages between 230 and 734 million years; those to the south give 628 to 2,500 million years. These ages may be real, or they may reflect a difference in climate. The dry climate of the north may favor the loss of radon, which would result in low apparent ages. — J. W. C.

- 183-25. Choubert, G. Les études de géochronologie au Maroc [Studies of geochronology in Morocco], in *Asociacion de Servicios Geologicos Africanos: Internat. Geol. Cong.*, 20th, Mexico City 1956, p. 39-40, 1959.

The first results of an age determination program in Morocco are reported. Three groups of minerals are being analyzed: uranium and thorium minerals, feldspars and micas from pegmatites, and galena. — J. W. C.

- 183-26. Roques, M[aurice]. Âges apparents de quelques zircons de l'Afrique Occidentale Française et du Togo [Apparent ages of several zircons of French East Africa and of Togo], in *Asociacion de Servicios Geologicos Africanos: Internat. Geol. Cong.*, 20th, Mexico City 1956, p. 41-43, 1959.

Five age determinations for French East Africa based on zircon are presented: Garbo pegmatites, 2,310 million years; Man granite, 2,680 million years; sands of the Casamance beaches, 1,045 million years; amphibole granite, 684 million years; and Kidal biotite granite porphyry, 319 million years. Zircon from the granodiorite of Anié of Togo yielded an age of 364 million years. — J. W. C.

- 183-27. Durand, Georges L. Détermination de l'âge absolu de galènes français par spectrométrie de masse [Determination of the absolute age of French galenas by mass spectrometry]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 24, p. 4018-4019, 1960.

The absolute age of 13 French galenas has been determined according to the Pb^{206}/Pb^{204} and Pb^{207}/Pb^{204} isotope ratios. Results are tabulated. The sub-Recent galena from Ambernac is of "Mississippi Valley" type (reworked), and the sample from Carnoet apparently is a mixture of two primary galenas of different age ($400 \pm 100 \times 10^6$ yr and $100 \pm 100 \times 10^6$ yr, Ordovician and Cretaceous). The other 11, ranging in age from Eocene ($50 \pm 90 \times 10^6$ yr) to Cambrian ($565 \pm 100 \times 10^6$ yr), are normal. — D. B. V.

- 183-28. Krog, Harald. Post-glacial submergence of the Great Belt dated by pollen-analysis and radiocarbon: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 4, p. 127-133, 1960.

Carbon-14 measurements date the beginning of submergence of two former freshwater basins in the Great Belt of Denmark as 6,600 B. C. Pollen analysis shows that the basins were contemporary. Submergence was due either to eustatic rise or to drainage water from the Ancylus Lake. A present 4.5-m difference in level between the two basins is explained by differences in isostatic uplift. — D. B. V.

- 183-29. Magnusson, Nils H. The stratigraphy of the pre-Cambrian of Sweden outside of the Caledonian mountains: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 9, p. 133-140, 1960.

On the basis of new field determinations and absolute age determinations, the Precambrian geochronology of Sweden outside the Caledonides is established as pre-Gothian (oldest) → Svionian or Svecofennian → Karelian → Gothian → Dalslandian → Subjotnian → Jotnian → Eocambrian. These are separated by large unconformities. The Svecofennian and Karelian were both metamorphosed $1,800 \times 10^6$ yr ago. The Gothian has been dated as $1,300 \times 10^6$ yr. Late Dalslandian granites were intruded 900-1,100 $\times 10^6$ yr ago. The Subjotnian, Jotnian, and Eocambrian together comprise the Algonkian. — D. B. V.

- 183-30. Simonen, Ahti. Pre-Cambrian stratigraphy of Finland: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 9, p. 141-153, 1960.

The pre-Karelian basement in eastern Finland is $2,600 \times 10^6$ yr old. The metamorphic supracrustal formations have been divided into Svecofennian and Karelian; the former has generally been considered to be older, as it is more highly metamorphosed, but they may actually represent different facies of the same sedimentary cycle. Both are cut by synorogenic intrusions dated as 1,750-1,850 $\times 10^6$ yr old. The youngest Precambrian in Finland is represented by the anorogenic rapakivi granites, $1,620 \times 10^6$ yr old, and unmetamorphosed Jotnian post-orogenic sediments. Correlations with eastern Karelia, the Kola Peninsula, and Sweden are discussed. — D. B. V.

- 183-31. Polkanov, A. A., and Gerling, E. K. The pre-Cambrian geochronology of the Baltic Shield: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 9, p. 183-191, 1960.

The Precambrian of the Baltic shield is subdivided on the basis of 480 potassium-argon age determinations on micas and some tens of lead and rubid-

ium-strontium determinations. There are two Katarchean (3,500 and 3,000 $\times 10^6$ yr), two Saamian (2,600-2,700 and 2,300-2,450 $\times 10^6$ yr), one Belomorian (1,950-2,000 $\times 10^6$ yr), and two Karelian (1,860 and 1,550 $\times 10^6$ yr) cycles. Intrusion of the rapakivi complex (1,640 $\times 10^6$ yr) was followed by the Gothian (1,260-1,400 $\times 10^6$ yr), Riphean (665-1,125 $\times 10^6$ yr), and Caledonian (500-620 $\times 10^6$ yr) cycles.

This geochronology shows that instead of the hypothetical enormous Precambrian hiatus there were at least 10 or 11 periods of denudation and sedimentation connected with the formation of geosynclines and their folding. The hypothetical Precambrian pangeosyncline and panplatform probably never existed.

Comparisons with the geochronologies of the Ukrainian shield and Russian platform show that absolute age determinations provide an excellent method for the study of the very obscure oldest geologic history of the earth and of many of the principal problems of theoretical geology. — D. B. V.

- 183-32. Zhiron, K. K., Zykov, S. I., Zhirona, V. V., and Stupnikova, N. I. Vliyaniye protsessov gidrotermal'nogo izmeneniya na opredeleniye vozrasta po radioaktivnym mineralam [Effect of hydrothermal alteration processes on age determination according to radioactive minerals]: *Geokhimiya*, no. 8, p. 657-665, 1957.

Results of study of the isotopic composition of 12 galenas and age determinations on 14 samples of monazite, allanite, sphene, wiikite, and carburan, all from pegmatites of northern Karelia, and the age of 2 allanites from the Taimyr Peninsula are presented. Three types of galena are distinguished on the basis of comparison of their apparent ages with the ages of the other minerals: ancient galenas, probably related to the processes of pegmatite formation; anomalously young galenas formed during subsequent hydrothermal processes; and radiogenic galenas formed from the lead removed from radioactive minerals in a late hydrothermal process. The Pb^{207}/Pb^{206} ratio gives the most reliable results; Pb^{207}/U^{235} ages are low and Pb^{208}/Th^{232} very low. Removal of uranium with simultaneous introduction of considerable amounts of lead ore is a complicating factor. — D. B. V.

- 183-33. Polevaya, N. I., Murina, G. A., and Kazakov, G. A. Absolyutnyy vozrast nizhnepaleozoyskikh i pozdnedokembriyskikh glaukonitov evropeyskoy chasti SSSR [Absolute age of Early Paleozoic and Late Precambrian glauconites of the European part of the USSR]: *Akad. Nauk SSSR Doklady*, v. 133, no. 6, p. 1425-1427, 1960.

The potassium-argon ages of 26 glauconites—12 from the Russian platform, 8 from the west flank of the southern Urals, and 6 from the Murmansk-Kola arctic hyperboreal regions—are tabulated. In all cases the absolute ages confirm previous biostratigraphic dating. The results indicate that the sedimentary cover of the Russian platform, the Riphean sediments of the Bashkir anticlinorium, and the hyperboreal sedimentary series were deposited over a long period of time and are synchronous in part.

The decay constants used in the calculations were $\lambda_K = 0.55 \times 10^{-10} \text{yr}^{-1}$ and $\lambda_\beta = 4.72 \times 10^{-10} \text{yr}^{-1}$. — D. B. V.

- 183-34. Semenenko, N. P., Rodionov, S. P., Danilevich, S. I., Savonenko, V. G., Tugarinov, A. I., and Filippov, M. S. Absolute geochronology of the Ukrainian pre-Cambrian: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 9, p. 108-115, 1960.

The stratigraphic subdivision of the Precambrian of the Ukrainian shield, recognized largely with the aid of absolute age determinations, is outlined and discussed. The Precambrian I (Katarchean) is represented only by isolated determinations of $2,900 \times 10^6$ yr. Precambrian II (Archean) includes the Dnieper, Podolian, and Bug groups. Precambrian III (Proterozoic) includes the Krivoy Rog and Ovruch groups. Precambrian IV includes the Pri-Azov alkaline complex; further investigations may show that these rocks are actually the same age as the Korosten intrusive complex, youngest of the Ovruch group. The Riphean sediments and effusives of the west slope of the shield are the youngest Precambrian; the horizon underlying the Lower Cambrian blue clays is $530-570 \times 10^6$ yr old. Correlations with the Baltic shield and Sweden are mentioned. (See also Geophys. Abs. 183-35.)—D. B. V.

- 183-35. Vinogradov, A. P., Komlev, L. V., Danilevich, S. I., Savonenko, V. G., Tugarinov, A. I., and Filippov, M. S. Absolute geochronology of the Ukrainian pre-Cambrian: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 9, p. 116-132, 1960.

This is a summary of results of 103 age determinations by the lead-uranium-thorium method and 160 by the potassium-argon method made in the past 5 years on formations of the Ukrainian shield. These results show that the greater part of the granites of the Ukrainian shield were formed in a relatively narrow time interval ($1,500-2,100 \times 10^6$ yr ago), and that a pronounced culmination of magmatism occurred at $1,900-2,100 \times 10^6$ yr.

The following igneous complexes are distinguished: Riphean, $550-600 \times 10^6$ yr; Volyn, $1,400-1,500 \times 10^6$ yr; Uman, $1,500-1,600 \times 10^6$ yr; Korosten, $1,770-1,800 \times 10^6$ yr; Tokov, $1,800-1,900 \times 10^6$ yr; Kirovograd-Zhitomir, $1,900-2,000 \times 10^6$ yr; Chudново-Berdichev, $2,000-2,100 \times 10^6$ yr; Saxagan, Ingulets, and Basavluk migmatites, $2,300-2,700 \times 10^6$ yr; and the Dnieper complex, $3,000 \times 10^6$ yr and more.

Metamorphism of the Krivoy Rog slates occurred $1,800-2,100 \times 10^6$ yr ago; therefore, this series was deposited more than $2,000 \times 10^6$ yr ago.—D. B. V.

- 183-36. Komlev, L. V. Geokhronologicheskaya skhema raschleneniya dokembriya Ukrainy [Geochronological subdivision of the Precambrian of the Ukraine]: Geokhimiya, no. 7, p. 621-631, 1958.

Five major magmatic complexes are recognized on the basis of absolute age determinations on Precambrian rocks from the Ukrainian shield: the Dnieper ($2,300-2,900$ million years old), the Podolian-Krivoy Rog ($2,000-2,100$ million years), the Kirovograd-Zhitomir ($1,900-2,000$ million years), the Korosten-Bokovyan-Tokov ($1,700-1,800$ million years), and the Uman-Azov ($1,550-1,750$ million years).

A progressive geochemical differentiation of magmas with enrichment in radioactive elements—potassium, uranium, and thorium—has been established within the younger cycles. A change of accessory minerals from allanite to monazite and thorite is typical.—D. B. V.

- 183-37. Vinogradov, A. P., Tugarinov, A. I., Zykov, S. I., Gavrilova, L. K., Kropotova, O. I., Knoppe, K. G., and Stenko, V. A. Vozrast dokembriyskikh porod Ukrainy [The age of Precambrian rocks of the Ukraine]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy, 5th sess. Trudy, p. 111-133, 1958.

This paper is a continuation of one by Vinogradov and others (see Geophys. Abs. 181-47) reporting on determinations of the age of Precambrian rocks of

the Ukrainian S.S.R. using the uranium-thorium-lead and the potassium-argon methods and checked by mineralogic-petrographic investigations. The age determinations were made on granite and biotite by the potassium-argon method and on monazite, zircon, allanite, sphene, and humite by the uranium-thorium-lead method. A technique of oscillographic polarography was used in analyzing the isotopic composition of the argon. The ages of the Precambrian rocks investigated were found to range from 1,140 to 920 million years, reaching in isolated cases the age of $2,400 \pm 200$ and $2,600 \pm 200$ million years. Nine photomicrographs, five tables, and a map of the Precambrian outcrops investigated are given. — A. J. S.

- 183-38. Komlev, L. V., Danilevich, S. I., and Kuchina, G. N. Vozrast dneprovsko-tokovskikh, korosten'skikh i umanskikh granitov Ukrainy (opredeleniye argonovym metodom po biotitu) [The age of the Dnieper-Tokovo, Korosten', and Uman' granites of the Ukraine (determination by the argon method on biotite)]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy, 5th sess., Trudy, p. 186-193, 1958.

The ages of a large number of mica samples (mostly biotites) taken from the Dnieper-Tokovo, Korosten', and Uman' granites of the Ukraine were determined. The procedure of the argon method as applied is reported in detail, and the accuracy is ± 5 percent. The constant (λ_K/λ_β) = 0.124 (the ratio of K-decay and β -decay of potassium) was used. The ages of biotite samples were found to range from 1,420 to 2,070 million years. If a value of 0.06 to 0.085 is taken for (λ_K/λ_β), the ages are accordingly reduced by about 30 percent. — A. J. S.

- 183-39. Ovchinnikov, L. N., and Harris, M. A. Absolute age of geological formations of the Urals and the Pre-Urals: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 3, p. 33-45, 1960.

Intrusive cycles in the Urals, corresponding to definite orogenic phases, are distinguished on the basis of absolute age determinations as follows: Archean ($1,900-2,100 \times 10^6$ yr), Proterozoic ($1,000-1,150 \times 10^6$ yr), Early Paleozoic ($440-500 \times 10^6$ yr), Middle Paleozoic ($320-360 \times 10^6$ yr), and Late Paleozoic ($240-270 \times 10^6$ yr); independent Mesozoic volcanism (165×10^6 yr) is also established. Microclinization in crystalline rocks of the Tatar arch of the Russian platform occurred during the Karelian epoch ($1,500-1,700 \times 10^6$ yr); gabbro-diorite intrusions into the Lower Bavly series in the Bashkir A.S.S.R. were emplaced during the Proterozoic cycle. Arkosic material from the Asha series in the southern Urals is post-Riphean, and similar material from the Zilmerdacksky series is correlated with the boundary between Upper and Lower Bavly in the eastern Russian platform. Metamorphism in the Urals occurred at several different times, synchronous with the magmatic cycles. Contact-metamorphic, hydrothermal (sulfide), and some other mineralizations have also been correlated with definite magmatic and orogenic phases. — D. B. V.

- 183-40. Atrashenok, L. Ya., Avdzeyko, G. V., Krylov, A. Ya., and Silin, Yu. I. Absolyutniy vozrast "monastyr'skikh" granitov Kalby [The absolute age of the "Monastirian" granites of the Kalba]: Geokhimiya, no. 3, p. 278-279, 1960.

The age of the Monastirian granites in the Kalba as previously determined by the helium method ($190-210 \times 10^6$ yr, Permian) was incompatible with results obtained by the argon and lead methods on Hercynian granites of the

Kazakh S. S. R., the Tien Shan, and the Altay. New determinations have been made on the basis of the lead isotopes in accessory monazite and by the argon method on total rock samples of the granites. The lead isotope age is 320×10^6 yr and the argon age is 260×10^6 yr. The former is considered to be the more reliable. It corresponds well with the ages of the other Hercynian granites ($250-330 \times 10^6$ yr). The age corresponds to Early Devonian on Holmes' time scale, but according to the geologic evidence the granites of the Kalba cannot be older than Late Carboniferous. — D. B. V.

- 183-41. Krishnan, M. S. Pre-Cambrian stratigraphy of India: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 9, p. 95-107, 1960.

Only a few absolute age determinations have been made on Indian rocks. Pegmatites cutting the Middle Dharwar have been dated as $2,450 \times 10^6$ yr old; others cutting the Upper Dharwar are $2,300 \times 10^6$ yr old; post-Eastern Ghats pegmatites are $1,600 \times 10^6$ yr old; pegmatites from Bihar are 930×10^6 yr old; post-Delhi pegmatites from Rajasthan are 750×10^6 yr old; and a monazite from Late Precambrian gneiss in South India is 500×10^6 yr old. Correlations are attempted on the basis of the available data. — D. B. V.

- 183-42. Fisher, N. H. Age determinations of Northern Australian granites: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 9, p. 179-182, 1960.

Granites from the Katherine-Darwin region of Northern Territory, Australia, have been dated by the potassium-argon method as $1,600-1,700 \times 10^6$ yr old; these intrude what have been called Lower Proterozoic sediments and are overlain with erosional unconformity by the Upper Proterozoic sequence. The implied age for the Lower Proterozoic necessitates a revision of the assumption that the base of the Proterozoic in Australia is at $1,200 \times 10^6$ yr.

Uranium deposits in the area have been dated as $500-700 \times 10^6$ yr old, showing that emplacement of the uranium in its present position is not directly connected with the granitic intrusions.

Granites from central Australia are mostly $1,400-1,500 \times 10^6$ yr old. — D. B. V.

- 183-43. Lundelius, Ernest L. Post Pleistocene faunal succession in Western Australia and its climatic interpretation: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 4, p. 142-153, 1960.

The succession of vertebrate faunas from caves along the south half of the west coast of Australia is used as an indicator of climatic change on the basis of their present day ranges and ecology. Charcoal associated with the bones made it possible to obtain C^{14} dates for a number of assemblages; these range from 12,000 to 3,700 yr. There has been no essential change in climate in the southwest corner of Australia for the last 37,000 yr; somewhat drier conditions began more than 7,800 yr ago and have continued with no detectable reverse to the present. There is no evidence for a more arid period 4,000-7,000 yr ago. — D. B. V.

- 183-44. McKellar, I. C. Pleistocene deposits of the upper Clutha Valley, Otago, New Zealand: New Zealand Jour. Geology and Geophysics, v. 3, no. 3, p. 432-460, 1960.

Five glacial advances are recognized in the Wanaka-Hawea basin and upper Clutha Valley of New Zealand. The base of a peat section in a river channel that was abandoned after the youngest glacial maximum has been dated by the radiocarbon method as $15,000 \pm 200$ yr. — D. B. V.

- 183-45. Schofield, J. C. Sea level fluctuations during the last 4,000 years as recorded by a chenier plain, Firth of Thames, New Zealand: *New Zealand Jour. Geology and Geophysics*, v. 3, no. 3, p. 467-485, 1960.

Sealevel fluctuations in New Zealand are reconstructed on the basis of geomorphic evidence and radiocarbon dating of seven shell samples from old beach ridges and intertidal flats along the Firth of Thames. The shells range in age from 980 ± 60 to $3,900 \pm 90$ yr. The curve obtained correlates well with periods of transgression recorded on the coast of Holland and Belgium. — D. B. V.

- 183-46. Starik, I. Ye., Ravich, M. G., Krylov, A. Ya., Silin, Yu. I., At-rashenok, L. Ya., and Lovtsyus, A. V. Novyye dannye ob absolyutnom vozraste porod Vostochnoy Antarktity [New data on the absolute age of rocks of eastern Antarctica]: *Akad. Nauk SSSR Doklady*, v. 134, no. 6, p. 1421-1423, 1960.

Thirty-five new potassium-argon age determinations made on igneous and metamorphic rocks from different parts of eastern Antarctica are tabulated. The results fit in with the cycles established by previous work and supplement the earlier data. The results from new localities (Mawson and Queen Maud Land Stations) emphasize again the broad distribution of igneous and metamorphic rocks related to the Early Paleozoic tectonic cycle in eastern Antarctica. — D. B. V.

- 183-47. Péwé, Troy L. Glacial history of the McMurdo Sound region, Antarctica: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 4, p. 71-80, 1960.

At least four major Quaternary glaciations are recognized in the McMurdo Sound region of Antarctica. Radiocarbon dating of dried algae in drained and buried ponds indicates a minimum age of 6,000 yr for the last advance. The chronology of the four stages forms the main substance of this paper. — D. B. V.

- 183-48. Péwé, Troy L. Multiple glaciation in the McMurdo Sound region, Antarctica—A progress report: *Jour. Geology*, v. 68, no. 5, p. 498-514, 1960.

This is virtually the same as the paper published in *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 4, p. 71-80, 1960 (see *Geophys. Abs.* 183-47). — V. S. N.

Goebel, K., and Schmidlin, P. Tritium measurements on stone meteorites. See *Geophys. Abs.* 183-64.

Reynolds, J[ohn] H. Determination of the age of the elements. See *Geophys. Abs.* 183-66.

Reynolds, J[ohn] H. Isotopic composition of primordial xenon. See *Geophys. Abs.* 183-67.

Reynolds, J[ohn] H. I-Xe dating of meteorites. See *Geophys. Abs.* 183-68.

Wasserburg, G. J., Fowler, William A., and Hoyle, F. Duration of nucleosynthesis. See *Geophys. Abs.* 183-69.

Eberhardt, P[eter], and Geiss, J[ohannes]. Comment on the age of the elements. See *Geophys. Abs.* 183-71.

Paneth, F. A. The Breitscheid meteorite - I. See *Geophys. Abs.* 183-74.

COSMOGONY

- 183-49. Woolfson, M. M. Origin of the solar system: *Nature*, v. 187, no. 4731, p. 47-48, 1960.

A new model for the origin of the solar system is proposed that is believed to be more successful in explaining the many regularities. This model envisages a star having a mass 100 times that of the Sun and moving with a velocity of 100 kmps that approached the Sun to within a distance of 10 solar radii. The Sun is imagined as initially spinning about an axis not in the plane of orbit of the star. A tidal bulge was raised on the Sun and broke away; moving under the combined gravitational attractions of the star and the Sun it formed the planet Pluto. This loss of material at the solar surface set up waves which traveled around the Sun from the obverse tidal bulge. As this wave crest approached the oncoming star, another portion of material was drawn off to form Neptune.

This process was repeated. As the star approached closer to the Sun, the size of the planets increased. Possibly a large planet formed at this stage and was captured by the star. The residue of ejected material formed the belt of asteroids. The four smaller planets were formed as the star receded. A similar process on a different scale, with the planet itself acting as the parent body, could explain satellites. The total time for the whole process of removal of material for the formation of the planets from the sun is calculated as 12 hr.

It is hoped that computer calculations will show the basic ideas of this theory to be feasible and if so, find values of the constants that would give an approximation of the existing system. — D. B. V.

- 183-50. Briggs, M. H. Origin of the solar system: *Nature*, v. 187, no. 4743, p. 1102-1103, 1960.

Although Woolfson's model to account for the origin of the solar system explains many of the observed regularities (see *Geophys. Abs.* 183-49), there are certain features that cannot be explained by any catastrophic hypothesis. First, the known properties of meteorites indicate that the early history of the solar system was most complex and that the present planets are second or possibly third generation structures that were preceded by objects of approximately planetary dimensions that have broken up. Second, the densities of the planets indicate considerable fractionation of the chemical materials from which they arose. Third, the comets are part of the solar system and must also be accounted for.

If catastrophic in origin, solar systems would be rare in the universe; yet there is a growing body of evidence for the existence of extra-solar planetary systems. — D. B. V.

- 183-51. Bülow, K[ur]d von. Planetarische Fundamentaltektonik dargelegt an Mond, Erde, und Mars [Fundamental planetary structures displayed on the Moon, Earth, and Mars]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 21, p. 7-14, 1960.

Parallels are pointed out between the Earth and Moon with regard to the general structure of the crust (concentric), tangential movements, subcrustal currents, morphologic elements, major lineaments (fracture zones) and their governing principles, and genuine volcanic forms. A volcanic origin for the lunar craters is accepted.

The tectonic picture of Mars is not clear enough for detailed interpretation. "Deserts," "seas," and "canals," are visible. In the southern hemisphere

there is less "solid land"; it appears to be broken into blocks similar to the terrestrial Gondwanaland. The canals have been likened to geosutures, and it has been suggested that they are cracks resulting from meteor impact analogous to cracks in a bullet-pierced pane of glass. In that case Mars would be a special case from a tectonic point of view. — D. B. V.

- 183-52. Mason, Brian. The origin of meteorites: *Jour. Geophys. Research*, v. 65, no. 9, p. 2965-2970, 1960.

It is suggested that chondritic meteorites are not fragments of a disrupted planet but have always been independent and individual objects, produced by recrystallization of material now represented by the carbonaceous chondrites. Heated above 600°C, carbonaceous chondrites would give a mixture of olivine, orthopyroxene, and nickel-iron similar to that of chondritic meteorites. The texture and structure of chondrites and the intimate admixture of nickel-iron and silicate suggest recrystallization in the solid state. The other types of meteorites can be explained as fragments of a differentiated planetoid or planetoids formed by the aggregation of chondrites. — D. B. V.

- 183-53. Pokshivnitskiy, Ye. (Pokrzywnicki, Jerzy). Ob udel'nom vese meteoritov [On specific gravity of meteorites]: *Akad. Nauk SSSR Meteoritika*, no. 18, p. 41-47, 1960.

From data on the specific gravity of 352 achondrites and chondrites and 34 siderolites and siderites, a graph in which specific gravity is plotted against the number of meteorites was constructed. Sharp maximums occur at 3-4 g per cm³ and 7-8 g per cm³. Referring to the hypothesis of the origin of meteorites from the explosion of the hypothetical planet Phaëthon, Pokrzywnicki interprets the maximums on the graph as an indication that the internal structure and the size of Phaëthon were similar to those of the earth. — A. J. S.

- 183-54. Ringwood, A. E. The Novo Urei meteorite: *Geochim. et Cosmochim. Acta*, v. 20, no. 1, p. 1-4, 1960.

The occurrence of diamond in meteorites is of considerable genetic importance as an indicator of the pressure under which meteorites formed, and therefore of the minimum size of the parent bodies from which they were derived. The presence of diamond in the Novo Urei ureilite has been confirmed by X-ray diffraction. The meteorite is regarded as an intensely metamorphosed chondrite in which the original texture is obscured by recrystallization. Differences in composition between Novo Urei and average chondrites might be explained if metamorphism were sufficiently intense to cause the formation of a small amount of liquid which subsequently migrated or was squeezed elsewhere. The relationships previously inferred between ureilites and chondrites imply that the parent body was at least as large as the moon. — D. B. V.

- 183-55. Fesenkov, V. G. Osnovnyye dostizheniya meteoritiki za posledneye vremya [Principal achievements in meteoritics in recent time]: *Akad. Nauk SSSR Meteoritika*, no. 18, p. 5-15, 1960.

This is a review of studies on meteorites including age determinations mostly for the last few years with a few references to earlier studies. The outstanding difference in age of meteorites determined by the lead-uranium, rubidium-strontium, and argon methods (4.5 billion years) as against that determined from the content of gaseous helium (250-300 million years) is explained by the fact that the first method gives the age of meteorites since the time they were solidified, whereas the second method yields the time since meteorites began to exist as individual celestial bodies subject to cosmic irradiation. — A. J. S.

- 183-56. Radice, Maria Magdalena. Noticias sobre la colleccion de meteoritos del Museo de la Plata [Notes on the collection of meteorites of the Museo de la Plata]: La Plata, Argentina, Revista del Museo de la Plata, Universidad Nacional de la Plata, 154 p., 1959.

This publication serves to bring up to date the guide published by Kantor in 1921 on the meteorites in the Museo de la Plata. A brief history of the development of the collection is given followed by the description of 39 individual meteorites. The data on each include the time and place of fall, classification, chemical analysis, collections where other specimens are housed, general observations, and references in the literature. — J. W. C.

- 183-57. Crozier, W. D. Black, magnetic spherules in sediments: Jour. Geophys. Research, v. 65, no. 9, p. 2971-2977, 1960.

Among the magnetic particles recovered from sediments from Ordovician to Recent in age were black spherules, ranging from 28 to 240 per gram of sediment. These are apparently the same as the magnetic spherules currently being collected from the atmosphere and found in deep sea sediments; they are presumably of meteoritic origin.

Large discrepancies exist between the apparent rates of deposition of the spherules in the deep sea and in the San Agustin (N. Mex.) playa deposits and for the present atmospheric deposit; further work on the quantities and on the physical and chemical nature of the spherules is needed to throw light on these discrepancies. Ultimately, the spherule content may be a useful tool in study of rates of sedimentation. — D. B. V.

- 183-58. D'yakonova, M. I., and Kharitonova, V. Ya. Rezul'taty khimicheskogo analiza nekotorykh kamennykh i zheleznykh meteoritov kolleksii AN SSSR [Results of chemical analysis of certain stony and iron meteorites from the collection of the Academy of Sciences, USSR]: Akad. Nauk SSSR Meteoritika, no. 18, p. 48-67, 1960.

The chemical analyses of 9 chondrites, 2 achondrites, and 8 iron meteorites from the collection of the Academy of Sciences, U. S. S. R., are discussed. These analyses were preceded by magnetic separation of magnetic from nonmagnetic fractions of the meteorites; analysis was then carried out for each fraction separately. A mineralogical description, the time and place of the fall, and the chemical composition is given for each meteorite of the chondrite and achondrite type. — A. J. S.

- 183-59. Vdovikin, G. P. Predvaritel'nyye resul'taty lyuminescentnogo-bituminologicheskogo issledovaniya chetyrekh uglistykh khondritov [Preliminary data on luminescence-bituminological study of four carbonaceous chondrites]: Akad. Nauk SSSR Meteoritika, no. 18, p. 78-81, 1960.

Chemical analyses of four carbonaceous chondrites are compared with luminescence-bituminological analyses of the same meteorites. It was found that the bitumens present in the meteorites differ from one another both qualitatively and quantitatively, suggesting somewhat different conditions of their formations. A new term "velerite" is proposed for the organic matter found in carbonaceous chondrites to distinguish it from organic matter of biogenic origin. — A. J. S.

- 183-60. Signer, P., and Nier, A[lfred] O. The distribution of cosmic-ray produced rare gases in iron meteorites: Jour. Geophys. Research, v. 65, no. 9, p. 2947-2964, 1960.

The cosmogenic Ar^{38} , Ar^{36} , Ne^{22} , Ne^{20} , He^4 , and He^3 distribution in part of a cross section of the iron meteorite Grant has been measured and found to vary systematically with depth. The depth effect is analyzed in terms of production mechanism.

The study demonstrates that functional relationships exist that correlate the relative amounts of cosmogenic nuclides (stable or radioactive) with position in and size of a meteoritic body. In principle, the determination of a sufficient number of cosmogenic nuclides in a single sample may make it possible to determine the size and radiation history of the meteoroid as well as the position of the sample within the body. To exploit these possibilities fully, however, more quantitative data will be required than those presented here. — D. B. V.

- 183-61. Schaeffer, O[liver] A., and Zähringer, J. Helium, neon, and argon isotopes in some iron meteorites: *Geochim. et Cosmochim. Acta*, v. 19, no. 2, p. 94-99, 1960.

The cosmic ray produced He^3 , He^4 , Ne^{20} , Ne^{21} , Ne^{22} , Ar^{36} , and Ar^{38} have been measured in seven iron meteorites with varying helium contents. The results on isotope abundance agree well with previous results. The depth of a given sample in the original meteoroid may be determined from the He^3/He^4 , $\text{He}^3/\text{Ne}^{21}$, and $\text{He}^3/\text{Ar}^{38}$ ratios rather than from the absolute amount of any particular isotope. — D. B. V.

- 183-62. Fireman, E. L., and DeFelice, J. Argon 37, argon 39, and tritium in meteorites and the spatial constancy of cosmic rays: *Jour. Geophys. Research*, v. 65, no. 10, p. 3035-3047, 1960.

The radioactive isotopes Ar^{37} , Ar^{39} , and tritium are measured in the Hamlet chondritic meteorite and in the Aroos iron meteorite. The ratio of the radioactivity of Ar^{37} to that of Ar^{39} at the time of fall is 2.3 ± 0.2 for the Hamlet meteorite and 1.4 ± 0.3 for the Aroos meteorite. The ratio of the production rate of Ar^{37} to that of Ar^{39} in a sample of the Hamlet meteorite irradiated with 2-Bev protons is 1.2 ± 0.3 . These measurements indicate a higher flux of cosmic rays at a distance of 1 astronomical unit from the sun than at several astronomical units. The ratio of the radioactivity of tritium to that of Ar^{39} is 29 ± 6 for the Hamlet meteorite and 2.0 ± 0.5 for the Aroos meteorite. The ratio of the production rates in the Hamlet target sample is 24 ± 6 . The ratio of tritium to Ar^{39} in the Benton chondritic meteorite is 29 ± 4 . The data indicate that the cosmic-ray flux integrated over the same region of space for different times is constant. The tritium is anomalously low in the Aroos iron meteorite. Similar tritium anomalies have been observed previously in iron meteorites. — Authors' abstract

- 183-63. Anders, Edward, and Stevens, Charles M. Search for extinct lead 205 in meteorites: *Jour. Geophys. Research*, v. 65, no. 10, p. 3043-3047, 1960.

The isotopic composition of thallium from six meteorites was measured in order to determine whether any radiogenic Tl^{205} from the decay of 24-million-year Pb^{205} was present. Although the Pb/Tl ratios of these meteorites differed by factors of 50, isotopic compositions of meteoritic and terrestrial thallium were equal to within 1 percent. For Canyon Diablo, this implies a solidification time of $\geq 3.0 \times 10^8$ yr after nucleogenesis by the "sudden synthesis" model, and $\geq 1.0 \times 10^8$ yr after the isolation of the solar system by the "continuous synthesis" model. The bearing of these results on the $^{129}\text{Xe}^{129}$ ages of Reynolds is discussed. — Authors' abstract

- 183-64. Goebel, K., and Schmidlin, P. Tritium-Messungen an Steinmeteoriten [Tritium measurements on stone meteorites]: *Zeitschr. Naturforschung*, v. 15a, no. 1, p. 79-82, 1960.

The tritium content was measured on 5 chondrites and 2 achondrites. In most, the number of tritium disintegrations per minute per gram lies between 0.5 and 0.7, in contrast to 0.2-0.3 found by others (see *Geophys. Abs.* 169-2, 170-19, 179-292, 181-61).

Helium-3 contents are known for two of the meteorites measured, Breitscheid and Ramsdorf. Using a value of 1-1.5 for the effective cross section for He^3/T , the cosmic ray ages are calculated as $14.5-18 \times 10^6$ yr for Breitscheid and $4.8-6 \times 10^6$ yr for Ramsdorf (see *Geophys. Abs.* 181-65). The potassium-argon ages of most meteorites are in the range of $3-4 \times 10^9$ yr. This discrepancy suggests that meteorites have originated from larger objects whose material was formed long before the breakup. — D. B. V.

- 183-65. Fisher, D[avid] E., and Schaeffer, O[liver] A. Cosmogenic nuclear reactions in iron meteorites: *Geochim. et Cosmochim. Acta*, v. 20, no. 1, p. 5-14, 1960.

The cosmogenic He^3 , He^4 , Ne^{21} , Ar^{36} , and Ar^{38} isotopes have been measured mass spectrometrically in 8 iron meteorites (7 ataxites and 1 octahedrite). An attempt at analysis of these and previous data is made, based on nuclear reactions induced by high energy protons. A combination of He^3/He^4 , $\text{He}^3/\text{Ar}^{38}$, and $\text{Ne}^{21}/\text{Ar}^{38}$ ratios is used as a measure of the energy and intensity of the incident radiation.

Exposure ages are deduced on the basis of these ratios, total isotopic abundances, and previously measured Cl^{36} values. The spread in the ages indicates that there was no one cataclysmic event that produced all the meteorites. Their formation began at least 1,700 million years ago and was still taking place 19 million years ago. The possibility of the breakup of a body or bodies of planetary or lunar dimensions is not precluded, but if this has happened the original breakup must have formed fragments larger than the meteorites, which then broke up by a continuous process of collision among themselves.—D. B. V.

- 183-66. Reynolds, J[ohn] H. Determination of the age of the elements: *Phys. Rev. Letters*, v. 4, no. 1, p. 8-10, 1960.

Xenon from the Richardton chondrite is found to be heavily enriched in Xe^{129} . This isotope almost certainly was formed from the radioactive decay of I^{129} , now extinct as a natural radioactive element. The time elapsed between formation of the elements and of the meteorite can be calculated from the formula

$$\Delta t = \frac{1.72 \times 10^7}{0.693} \left[\ln \left(\frac{\text{I}^{127}}{\text{Xe}^{129}} \right)_{\text{met}} + \ln \left(\frac{\text{I}^{129}}{\text{I}^{127}} \right)_0 \right] \text{ yr};$$

assuming that $(\text{I}^{129}/\text{I}^{127})_0 = 1$ and that the amount of iodine in chondrites is 1 ppm, $\Delta t = 0.35 \times 10^9$ yr. The I-Xe method has the unique advantage that it dates meteorites from the beginning of the solar system rather than from the present.

Xe^{128} , Xe^{130} , and Xe^{131} also occur to significant excess, but Xe^{129} is dominant by an order of magnitude. The presence of isotopes other than Xe^{129} in the anomalous spectrum probably means that other nuclear processes, induced by cosmic-ray bombardment, have contributed to the xenon in Richardton. — D. B. V.

- 183-67. Reynolds, J[ohn] H. Isotopic composition of primordial xenon: *Phys. Rev. Letters*, v. 4, no. 7, p. 351-354, 1960.

Secondary anomalies similar to those found in the Richardton chondrite (see *Geophys. Abs.* 183-66) have been found in the xenon from the carbonaceous chondrite Murray. As the ratio of xenon to the cosmic-ray-produced nuclides Ne^{21} and He^3 is very different for the two meteorites, it is concluded that the anomalies are not due to cosmic ray reactions, but that there is an isotopic difference between primordial xenon—or at least xenon incorporated in stone meteorites—and xenon in the atmosphere. Xenon appears to be unique among the elements in exhibiting an effect of this kind and magnitude.

All the rare gases in the two meteorites have been analyzed by isotopic dilution; results are tabulated. Data for argon, helium, and neon show clearly that there is primordial gas in Murray. There is one other stone meteorite known to contain primordial gas, the Pesyanoye.

The isotopic compositions of the anomalous components of the xenon in Richardton and Murray are compared. Within experimental error the isotopic composition of the secondary anomalous component—that is, excluding Xe^{129} —is the same for both meteorites. The anomalous Xe^{129} , on the other hand, is definitely an independent component, in agreement with an origin mainly by decay of extinct I^{129} . The secondary anomalous component is more abundant in Murray than in Richardton by a factor of 43; Murray is poorer by a factor of 5 in cosmic-ray-produced nuclides and richer by a factor of at least 42 in a primordial nuclide. These ratios are strong evidence that the secondary anomalous xenon component in the meteorites is primordial in origin.

The xenon in meteorites may have been augmented by nuclear processes between the time it was separated from the xenon now on earth and the time the meteorites were formed, or a strong mass-dependent fractionation may be responsible for most of the anomalies. — D. B. V.

- 183-68. Reynolds, J[ohn] H. I-Xe dating of meteorites: *Jour. Geophys. Research*, v. 65, no. 11, p. 3843-3846, 1960.

Other carbonaceous chondrites examined recently are, like Murray (see *Geophys. Abs.* 183-67), xenon-rich and exhibit the secondary anomalies in xenon isotopic composition. A table gives the isotopic composition of the anomalous component of xenon from Murray, Mighel, and Orgeuil.

In the formula for Δt (see *Geophys. Abs.* 183-66), the experimental quantity to be evaluated is $(\text{I}^{127}/\text{Xe}^{129})_{\text{met}}$; previous estimates have been based on a guess of the abundance of iodine in meteorites. A convenient and precise method of measuring $(\text{I}^{127}/\text{Xe}^{129})_{\text{met}}$ is described, by means of which the required ratio can be determined almost directly and from a single sample. Using this method, the $(\text{I}^{127}/\text{Xe}^{129})$ ratios in two 1-gram fragments of Richardton are found to be $(2.5 \pm 0.4) \times 10^5$ and $(1.02 \pm 0.11) \times 10^5$, respectively.

These values are about an order of magnitude less than previous estimates. The discrepancy between the samples is not understood at present. It could arise from contamination of the first sample by terrestrial iodine, or it may be that there are iodine-bearing minerals in the stone having different values of Δt and that these minerals are sampled differently in the two specimens. Experimental error is also possible. — D. B. V.

- 183-69. Wasserburg, G. J., Fowler, William A., and Hoyle, F. Duration of nucleosynthesis: *Phys. Rev. Letters*, v. 4, no. 3, p. 112-114, 1960.

It does not appear possible to explain the isotopic anomalies in the xenon from the Richardton chondrite reported by Reynolds (see *Geophys. Abs.* 183-

66) by any single mechanism. Because of the existence of anomalies in four isotopes, it is difficult to conclude that the Xe^{129} excess is simply the product of I^{129} decay. If, however, it is assumed that most of the Xe^{129} can be attributed to the decay of I^{129} remaining after some element-building processes, some deductions can be made regarding these processes. It is concluded that Reynolds' value $\Delta t = 3.5 \times 10^8$ yr is the maximum time interval which could exist between termination of nucleogenic processes and the formation of Richardton; it does not directly date the time of formation of the elements.

There is also a question regarding the assumption that Richardton formed a closed system with respect to xenon and iodine. If the argon age of $(4.15 \pm 0.10) \times 10^9$ yr found by Geiss and Hess (see Geophys. Abs. 173-8) represents the time that Richardton became a closed system, then the maximum time since termination of nucleosynthesis is 4.50×10^9 yr; if the true time of formation of Richardton is 4.6×10^9 yr and the xenon has been retained since then, then the maximum time is 4.95×10^9 yr as reported by Reynolds. If the true time of formation is 4.6×10^9 yr and the last major outgassing is given by the argon age, then it is possible that relatively short-lived ($\sim 10^6$ yr) radioactivities could contribute significantly to heat production in the early history of the solar system. The most critical parameter is the time interval between the formation of meteorites and the termination of nucleosynthesis; if it is within an order of magnitude of the maximum of 3.5×10^8 yr there will be no significant heat contribution. — D. B. V.

183-70. Kuroda, P[aul] K. Nuclear fission in the early history of the earth: *Nature*, v. 187, no. 4731, p. 36-38, 1960.

The difference between the abundance ratio of the stable xenon isotopes ($\text{Xe}^{136}/\text{Xe}^{130}$) in the Richardton meteorite and that in the earth's atmosphere reported by Reynolds (see Geophys. Abs. 183-66) indicates that at least 10 percent of the atmospheric xenon is fissiogenic. The observed value is much greater than the calculated maximum contribution from spontaneous fission of U^{238} . The contribution from Pu^{244} spontaneous fission is calculated to have been several hundred times greater than that from U^{238} . Another important contribution to the atmospheric inventory of xenon is from neutron-induced fission of U^{235} . The total inventory of Xe^{136} in the atmosphere is calculated to be of the order of 10^6 tons, or at least one million times greater than the contribution from nuclear bomb tests. — D. B. V.

183-71. Eberhardt, P[eter], and Geiss, J[ohannes]. Comment on the age of the elements: *Zeitschr. Naturforschung*, v. 15a, no. 5/6, p. 547, 1960.

Assuming that the excess Xe^{129} found in the Richardton chondrite was formed in the meteorite, Reynolds (see Geophys. Abs. 183-66) has calculated the maximum time that has elapsed between the synthesis of the elements and the formation of the meteorite to be 3.5×10^8 yr. This paper suggests that all the xenon, including the excess Xe^{129} , could be trapped primordial gas from an atmosphere in which the decay of I^{129} contributed relatively more Xe^{129} than in our atmosphere, and that the time between nucleogenesis and meteorite formation may have been longer than that deduced by Reynolds. — D. B. V.

183-72. Signer, P. Bestätigung des abnormal hohen Gehaltes an Xe^{129} in Richardton [Confirmation of the abnormally high Xe^{129} content in Richardton]: *Zeitschr. Naturforschung*, v. 15a, no. 8, p. 748-749, 1960.

Five independent measurements on samples of the Richardton chondrite show that Xe^{129} is enriched by at least 40 percent with respect to atmospheric xe-

non. This confirms Reynolds' findings of a large excess of Xe^{129} in that meteorite (see Geophys. Abs. 183-66). — D. B. V.

- 183-73. Goles, G. G., Fish, R. A., and Anders, E[dward]. The record in meteorites—1. The former environment of stone meteorites as deduced from K^{40} - Ar^{40} ages: *Geochim. et Cosmochim. Acta*, v. 19, no. 3, p. 177-195, 1960.

The potassium-argon ages of meteorites are systematically lower than their rubidium-strontium and lead-lead ages, owing to diffusion losses of argon. An equation is derived that gives the apparent potassium-argon age as a function of the "true" age and the parameter D/a^2 (D = diffusion constant of Ar^{40} , a = radius of potassium-bearing grains). As the dependence of D/a^2 on temperature in stone meteorites may be obtained from the work of Geiss and Hess (see Geophys. Abs. 173-8) it is possible, given a "true" and an apparent age, to deduce an upper limit to the mean temperature at which a meteorite was held since the cessation of strong heating in its parent body. The activation energy for diffusion of radiogenic argon from meteorites is unexpectedly small (14 kcal per mole), so that for a group of 8 dated chondrites the upper limit of mean environmental temperature is found to be $\leq 196^\circ\text{K}$. This implies that their parent body was at least 1.44 astronomical units from the sun and at most 250 km in radius. Using cosmic ray ages reported by Eberhardt and Hess (see Geophys. Abs. 182-71), it is shown that they probably came from the asteroid belt.

Further diffusion losses will occur after the release of the meteorites from their parent bodies. Consideration of the radiation temperature of a meteorite in space shows that even for perihelia barely within the earth's orbit, some 10-20 percent of the radiogenic and cosmic ray induced argon will be lost in times of the order of typical exposure ages of chondrites. — D. B. V.

- 183-74. Paneth, F. A. Der Meteorit von Breitscheid - I. Einleitung [The Breitscheid meteorite - I. Introduction]: *Geochim. et Cosmochim. Acta*. v. 17, no. 3/4, p. 315-319, 1959.

Der Meteorit von Breitscheid - IV. Radiochemische Untersuchungen [The Breitscheid meteorite - IV. Radiochemical investigations]: *ibid*, p. 339-351.

König, H., Wänke, H., and Mayne, K. I. Pt. A. Helium und Neon [Helium and neon]: *ibid*, p. 339-342.

Goebel, K., and Schmidlin, P. Pt. B. Tritium: *ibid*, p. 342-349.

Ebert, K. H., Hernegger, F., König, H., and Wänke H. Pt. C. Uran [Uranium]: *ibid*, p. 349-350.

König, H., and Wänke, H. Pt. D. Kalium-Argon [Potassium-argon]: *ibid*, p. 350-351.

A stone meteorite weighing about 1.5 kg fell at Breitscheid in the Dellkreis, Germany, on August 11, 1956. It is a bronzite-olivine chondrite; both primary and secondary troilite are found, and ilmenite is proved to be a meteoritic mineral. Helium, neon, argon, tritium, potassium, and uranium were measured by methods specially developed during the work. The helium and neon contents differ widely in different parts of the meteorite, and the isotopic composition of the helium and neon differs greatly from that of terrestrial helium and neon. The uranium content was determined by two different methods, both involving neutron activation analyses; values of 1.5×10^{-8} and 1.23×10^{-8} g U per g meteorite were obtained. Using a value of 1.3×10^{-8} , the helium age is calculated as 2.5×10^9 yr. The potassium-argon age is 3.3×10^9 yr. The He^3/H^3 ratio in one part of the meteorite yields an irradiation age of 20×10^6 yr. — D. B. V.

- 183-75. Alekseyeva, K. N. Novyye dannyye o fizicheskikh svoystvakh kamennykh meteoritov [New data on the physical properties of stony meteorites]: Akad. Nauk SSSR Meteoritika, no. 18, p. 68-76, 1960.

Experimental determinations of thermal conductivity, electrical resistivity, coefficient of elasticity, and hardness of 9 chondrites are described and discussed. It was found that the stony meteorites differ substantially in these physical properties from mineralogically and chemically similar rocks of terrestrial origin; they have lower elasticity, thermal conductivity, electrical resistivity, and hardness. — A. J. S.

- 183-76. Shoemaker, Eugene M. Penetration mechanics of high velocity meteorites, illustrated by Meteor Crater, Arizona: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 418-434, 1960.

Studies of craters formed by detonation of nuclear devices at shallow depth in alluvium show that structures of the crater rims are related to the depth of explosion and the yield of the device. The penetration mechanics for Meteor Crater, Ariz., are derived by scaling relationships from the nuclear explosion craters, based on detailed geologic mapping of both types of craters. A meteorite that strikes the ground at a speed exceeding the acoustic velocity of the rocks propagates a shock wave in the rocks. If the speed of the meteorite also exceeds the acoustic velocity of the meteorite, a shock wave also travels back through the impacting body. At hypersonic velocity an impacting meteorite penetrates the ground by a complex mechanism that includes compression of the target rocks and the meteorite by shock as well as hydrodynamic flow of the compressed material under high pressure and temperature. The depth of penetration of the meteorite, before it loses its integrity as a single body, is a function primarily of the velocity and shape of the meteorite and the densities and equations of state of the meteorite and target. The intensely compressed material then becomes dispersed in a large volume of breccia formed in the expanding shock wave. — Author's abstract

- 183-77. Lovering, J. F. High-temperature fusion of possible parent materials for tektites: Nature, v. 186, no. 4730, p. 1028-1030, 1960.

In comparing the composition of possible parent materials for tektites, it has been assumed tacitly that tektite formation involved only simple melting. However, if tektites were formed at sites of large meteorite impacts considerable areas would have been heated to temperatures far in excess of simple melting temperatures, and volatilization of major constituents might be expected approximately in the order $MgO, CaO < Al_2O_3 < SiO_2, FeO < Na_2O, K_2O$; the tektite glass would be enriched in MgO, CaO , and possibly in Al_2O_3 with respect to the parent rock. If the concentrations have changed in this way during formation of tektites, then average shale is not a suitable parent material.

To establish whether high-temperature fusion of granitic rocks would form such glasses, a powdered granite was subjected to a series of fusions in a solar furnace at temperatures ranging from 1,800°C to 3,000°C. The results indicate that rocks of granitic composition, particularly the felsic granophyre differentiates from mafic magmas (which resemble most closely the probable rocks of the moon's surface), are suitable parent materials if tektites have been formed at relatively high temperatures at the site of meteorite impacts. This conclusion is not at all inconsistent with a lunar origin. — D. B. V.

- 183-78. Cherry, R. D., Taylor, S. R., and Sachs, Maureen. Major element relationships in tektites: *Nature*, v. 187, no. 4738, p. 680-681, 1960.

Analysis of published data for australites shows that silica concentration is negatively correlated with the concentrations of alumina, ferrous oxide, magnesium oxide, potassium monoxide, and calcium oxide. The regression lines (silica on alumina and vice versa) have been drawn on the silica versus alumina graph; both pass through 100 percent silica to within 3 percent. This fact, plus the presence of lechatellierite particles in tektites, suggests that tektite composition might be explained on the basis of a mixing process between silica and some other material. A quartz:shale ratio of 1:3 agrees excellently with average major element compositions of tektites.

Both quartz and shale are readily available on the earth; the question of the mechanism of the mixing process remains. The Urey comet hypothesis is regarded as promising. — D. B. V.

- 183-79. Urey, H[arold] C. Origin of tektites: *Nature*, v. 187, no. 4740, p. 855-857, 1960.

This is an answer to Baker's criticism (see *Geophys. Abs.* 181-71) of Urey's theory of tektite origin (see *Geophys. Abs.* 175-391). It is true that tektites are not spaced some 50 million years apart in age, but it has been pointed out that cometary collisions are ten or more times more frequent than originally assumed. Baker's explanations of a large loss of mass are shown to be improbable. If a massive swarm existed, it might have accumulated into a more compact object and arrived at the earth as such, in which case it approximates the cometary model.

New evidence shows that tektites lack Al^{26} and probably have not been exposed to cosmic rays; if they came from space, their time in space was very brief. The potassium-argon age of the australites is the same as that of the tektites from southeast Asia ($610,000 \pm 50,000$ yr); if Baker's age of 5,000 yr for the australites is correct, degassing occurred 610,000 yr ago but delivery to Australia was much later. Simultaneous arrival is much simpler to explain.

Cometary collisions should occur occasionally, should be very energetic, and their volatile constituents should supply a mechanism for propelling materials out of the atmosphere and to great distances; the agreement in potassium-argon ages is also understandable in the light of a cometary collision origin. — D. B. V.

- 183-80. Whitten, E. H. Timothy. Average composition of granites, the genesis of tektites, and petrogenesis: *Nature*, v. 187, no. 4740, p. 867-868, 1960.

Lovering's recent comparison of the composition of tektites with that of various terrestrial rocks (see *Geophys. Abs.* 183-77) involves an important question that is too frequently ignored. Critical analysis of several granite bodies makes it clear that for any one granitic mass the arithmetic mean computed for a few "typical specimens" yields a meaningless value in terms of the average composition of the entire volume. Thus, even a very strong positive correlation with the 72 calcalkaline granites or the 35 granophyres does not indicate that the tektites are related to the average composition of either. Similar arguments apply with equal force when a few "typical specimens" are used in relation to petrogenic theories. — D. B. V.

- 183-81. Friedman, Irving, Thorpe, Arthur, and Senftle, Frank E. Comparison of the chemical composition and magnetic properties of

tektites and glasses formed by fusion of terrestrial rocks: *Nature*, v. 187, no. 4743, p. 1089-1092, 1960.

Chemical and magnetic measurements were made on several types of silicate rocks before and after fusing at 2,500°C in air at atmospheric pressure. Results are tabulated and compared with the composition and magnetic properties of tektites. The changes in composition indicate that tektites were either melted at temperatures higher than 2,500°C or heated at this temperature for longer than 20 minutes. Thus, the small change noted in composition suggests that the observed composition of tektites probably reflects the composition of the material from which they came. The larger ferric/ferrous ratio of the fused rocks compared to that of tektites suggests that the tektites were melted in an oxygen atmosphere the pressure of which was less than that on the earth's surface.

The changes in magnetic properties indicate that a heating period of 15-20 min at 2,500°C is sufficient to produce magnetic properties similar to those of tektites, but does not preclude the possibility of longer heating. Comparison of the magnetic susceptibility of tektites and the melted rock from the same location shows that tektites could not be formed from the rocks in which they are found. It is concluded that tektites were not formed by heating of surface material in place or by lightning. — D. B. V.

183-82. Ehmann, W. D. Nickel in tektites by activation analysis: *Geochim. et Cosmochim. Acta*, v. 19, no. 3, p. 149-155, 1960.

The nickel and iron abundances and Ni/Fe ratios of most of the major occurrences of tektites and of several meteorite impact glasses and obsidians have been determined. In the Libyan Desert glass, Ivory Coast tektites, and bediasites the Ni/Fe ratios fall within the range for the other tektite occurrences. Major differences in Ni/Fe ratio are observed among specimens of indochinite, but no significant differences are observed among specimens from three philippinite sites. The differences in Ni/Fe ratios for tektites and known meteorite impact glasses suggest different modes of formation. — D. B. V.

183-83. Baker, George. Comments on the recent letter on "Moldavites and similar tektites from Georgia, U. S. A.": *Geochim. et Cosmochim. Acta*, v. 19, no. 3, p. 232-233, 1960.

Statements made in the paper by Cohen (see *Geophys. Abs.* 179-43) regarding australites are corrected. Primary surfaces are preserved in only a few australites, and those are from the more temperate regions within the strewn-field rather than from the desert. The distribution of australites is very sporadic and on the whole sparse. In only 3 or 4 of the centers of concentration is the concentration probably due to a primary (that is, extraterrestrial) cause; usually it is due to stream action. — D. B. V.

183-84. Cohen, Alvin J. Germanium content of tektites and other natural glasses. Implications concerning the origin of tektites: *Internat. Geol. Cong. 21st, Copenhagen 1960, Proc.*, pt. 1, p. 30-39, 1960.

The trace germanium contents were determined for 5 obsidians, 14 impactite glasses and their surrounding rocks, 6 stony meteorites, 13 tektites, and 2 silicate minerals. The results indicate that the Libyan Desert glass is undoubtedly terrestrial and the Darwin glass from Australia is probably terrestrial. The germanium contents are of the same order of magnitude in 9 of the tektites as in the meteorites, suggesting that they have in common a high temperature origin. It is concluded that tektites are the result of heating by impact, but whether this impact took place on the earth or on the moon is not yet clear. — D. B. V.

- 183-85. Vorob'yev, G. G. Zagadka tektitov [The riddle of tektites]: Priroda, no. 6, p. 75-77, 1960.

A historical review of tektite discoveries is given followed by data on their chemical composition and geological position. The age of tektites determined by the potassium-argon method is 0.2-8.5 million years, whereas that found by the lead method is 4-5 million years. The excess of Al^{26} and Be^{10} in tektites, as compared with terrestrial rocks, indicates a nonterrestrial origin. The theories of the origin of tektites are: meteoritic, lunar, impact, and terrestrial. The riddle of tektites still remains unsolved. — A. J. S.

- 183-86. Vorob'yev, G. G. Issledovaniye sostava tektitov. II. Moldavitye [Investigation of the composition of tektites. II. Moldavites]: Akad. Nauk SSSR Meteoritika, no. 18, p. 35-40, 1960.

This is a continuation of a previous report on spectrographic analysis of tektites (see Geophys. Abs. 181-74). Results of spectrographic analysis of moldavites were found to agree well with those obtained by the method of chemical silicate analysis. It was found that in comparison with terrestrial rocks, tektites represent a hybrid material of an anomalous microelement composition; this indicates superposition of a basic or meteoritic phase on a silicic phase. The data obtained from the analyses, however, do not contradict the cosmic theory of tektite origin which considers a nonterrestrial differentiation of meteoritic substance possible. — A. J. S.

- 183-87. Priroda. Tret'ya Sovetskaya kosmicheskaya raketa [The third Soviet cosmic rocket]: Priroda, no. 11, p. 3-15, 1959.

A popular descriptive account is given of the third Soviet cosmic rocket fired October 4, 1959 for photographing the back side of the moon. The general design of the automatic interplanetary station is described, and its trajectory around the moon discussed. The nearest approach of the station to the moon is estimated to be 7,900 km. Photographing of the moon was continued for 40 min, and the images were later telecast to the earth. Reproductions of two telecast photographs of the back part of the moon with the names of new features distinguishable on the photographs are given; these features are described and discussed. — A. J. S.

- 183-88. Press, Frank, Buwalda, Phyllis, and Neugebauer, Marcia. A lunar seismic experiment: Jour. Geophys. Research, v. 65, no. 10, p. 3097-3105, 1960.

A feasibility study shows that a lunar seismic experiment can provide significant data on the structure and composition of the moon. The presence or absence of lunar seismicity is an important clue to current tectonic processes that affect the lunar surface. In the first generation of experiments, single detectors are envisaged with the capability of recording body and surface waves. Investigation of proposed methods of lunar-seismogram interpretations indicates that these detectors should be sufficient to give a rough outline of lunar seismic geography and to indicate crudely the composition of the moon as well as its main structural features. In the absence of lunar seismicity, the best statistics on the frequency of meteorite impacts indicate that meteorites may provide useful auxiliary seismic sources. In reaching this conclusion, reasonable estimates were made of the efficiency of impact as well as of seismic-wave attenuation. Critical factors in the experiment are instrument lifetime and sensitivity and the nature of lunar microseismic noise. — Authors' abstract

- 183-89. Green, Jack, and Poldevaart, Arie. Lunar defluidization and its implications: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 21, p. 15-33, 1960.

A theory of lunar defluidization is suggested to account for the moon's surface features. The distribution of lunar craters, large fracture zones, and the morphology of lunar craters compared with terrestrial calderas do not support an impact origin for the craters, but agree with a special, explosive volcanic origin. Defluidization occurred early in lunar history in response to compaction, phase transformation, and decay of radioactive elements. A similar early phase of even more vigorous defluidization probably characterized the first 1-2 billion years of earth history and produced the primitive terrestrial crust, atmosphere, and hydrosphere. Because of the smaller mass of the moon, defluidization was probably less complete, while many of the lighter elements escaped. A special type of volcanism for the origin of lunar surface features has many implications. Thick dust and welded tuffs probably cover the nonmaria areas; predominantly volcanic flows occur in the maria. Likely surface rocks are rhyolites and basalts. Water-soluble elements are probably concentrated in lunar surface rocks. Potassium, uranium, and thorium are also probably enriched in the moon's crust. Sublimates of certain volatile elements may be abundant in the nonmaria areas. Many of these elements have high neutron-capture cross sections. — Authors' abstract

- 183-90. Öpik, E. J., and Singer, S. F. Escape of gases from the moon: Jour. Geophys. Research, v. 65, no. 10, p. 3065-3070, 1960.

Calculations of the escape time of krypton and xenon ions from different lunar atmospheric models lead to the conclusion that an independent lunar atmosphere (one evolved from the moon) cannot exist. The lifetime of an atmosphere containing all the krypton and xenon believed to have evolved since the origin of the moon is of the order of 800 yr for a thick atmosphere and 50 yr for a thin atmosphere.

After the atmosphere has thinned to an exosphere, another mechanism of escape of heavy gases exists. Because of intense solar ultraviolet radiation the moon is positively charged to a potential of about +20 v; krypton or xenon atoms ionized while in flight within the screening length near the moon would be expelled by this electrostatic field. It is concluded that any gas in the vicinity of the moon must come from interplanetary space. — D. B. V.

- 183-91. Havemann, Hans. Der Pazifik keine Mond-Narbe [The Pacific is no moon-scar (with English and French summaries)]: Geofisica Pura e Appl., v. 45, p. 22-26, 1960.

The pictures of the back side of the moon show that while the northern part of the visible side contains a complex of maria, most of the rest of the surface seems to be "continent." This anisotropy, similar to that of the earth's sialic cover, contradicts the theory that the moon was formed from the earth, and demands some other explanation for the origin of the Pacific basin as well as one for the distribution of the lunar maria. The theory proposed by Jeffreys (1952) and Vening Meinesz (see Geophys. Abs. 153-14573) of a primary convection current which produced the original distribution of the earth's sialic cover is worth increased attention. — D. B. V.

- 183-92. Niblett, E. R., and Sayn-Wittgenstein, C. Variation of electrical conductivity with depth by the magneto-telluric method: *Geophysics*, v. 25, no. 5, p. 998-1008, 1960.

Apparatus has been installed at the Dominion Observatory Research Station at Meanook, Alberta, for continuous recording of earth potentials. The theory of the magnetotelluric prospecting method, in which the relative amplitudes of the horizontal components of the electrical and magnetic fields are used to interpret the subsurface structure (Cagniard, see *Geophys. Abs.* 154-14645), is applied in a modified form to data from Meanook records. Electrical conductivity values between depths of 10 and 100 km are estimated; they vary roughly between 10^{-13} and 10^{-14} emu. — D. B. V.

- 183-93. Hessler, V. P., and Wescott, E. M. Earth current activity at College, Alaska, 1956-1958: *Alaska Univ. Geophys. Inst. Sci. Rept.*, no. 2, 16 p., 1960.

Monthly tables of 3-hourly earth current activity are presented for the entire period from January 1956 through December 1958. The data are analyzed for diurnal, seasonal, and yearly averages of activity. The principal direction of earth current disturbance at College, Alaska, is about N. 33° W., and the records for the 3 years show a pronounced maximum of disturbance activity at local midnight with a tendency toward a second maximum from 0500 to 0800.

There is a high correlation between geomagnetic and earth current activity and a great similarity in the form of disturbance. The high correlation between earth current activity and other ionospheric disturbances makes it a useful tool as an indicator of ionospheric activity. — V. S. N.

- 183-94. Wescott, E. M., and Hessler, V. P. The effect of topography and geology on telluric currents: *Alaska Univ. Geophys. Inst. Sci. Rept.*, no. 3, 60 p., 1960.

As the electric field vectors, *E*, associated with telluric currents, vary in comparative magnitude and principal direction at different locations, a study was undertaken to determine the effect of topography and geology on the telluric field and in particular the variations to be found in the vicinity of the University of Alaska Geophysical Institute. Recordings made at 17 field sites were compared with those of the Institute. Results show that the comparative magnitude of the vectors may change by a factor of 5 and the principal direction may range over 33°.

Surface resistivity measurements were made at each recording location, and some of the results are explained on the basis of model studies using a resistor network to determine the effects of simple topographic and conductivity configurations upon the telluric field. The principal direction at the Institute site agrees within 10° of the regional principal direction, but the magnitude is abnormally high.

Experience gained in this study shows that before a permanent telluric current observatory is set up a number of temporary sites should be occupied in the area to determine a regional level. Where the geology and topography are known well, an estimate could be made of the significance of telluric disturbance from the site.

Because of the effects of topography the telluric current method in geophysical prospecting would seem to be most useful in flat sedimentary basins. The magnetotelluric method must be used with caution, although this method is intended to give information to great depths, the near surface conditions greatly effect the results. Interpretation in an area as complex geologically as the College area would seem to strain the limits of the method. — V. S. N.

- 183-95. Izergin, A. M. Konvektivnyy elektricheskiy tok atmosferazemlya [Convective electric current of the atmosphere-earth]; Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 919-923, 1959.

The air-earth current results from the motion of charges acted upon by electrical force (conductive current) and by mechanical force (convective current). The results are presented of test measurements of convective currents in which a method proposed by Izergin is used. The measuring plate is shielded by a grounded screen placed horizontally above it. This excludes the conductive and induced current without appreciably disturbing the dynamic regimen of the atmosphere and thus interfering with the convective current itself.

The mean convective current amounts to 7-32 percent of the conductive current. In some instances the convective current becomes as large as the conductive current or even exceeds it. The measurements can be classified according to weather conditions. — J. W. C.

- 183-96. Nikitenko, K. I. Iz opyta primeneniya metoda TT v SSSR [From an experiment in the application of the telluric current method in the USSR]; Razvedochnaya i Promyslovaya Geofizika, no. 33, p. 29-42, 1959.

Defining the method of telluric currents as a variation of the method of natural electric field applied to broad regional structures of tens of thousands of square kilometers in area for determination of the regional components of the earth's electric field, Nikitenko gives a brief historical review of the telluric current method in the U. S. S. R., the characteristic of the telluric currents, and the processes of reduction and interpretation of field data. Regional stratigraphic surveys by combined magnetometric, gravimetric and telluric current methods are complemented with seismic and electric sounding when quantitative data are required. — A. J. S.

EARTHQUAKES AND EARTHQUAKE WAVES

- 183-97. Brazee, Rutlage J., and Cloud, William K. United States earthquakes 1958: U. S. Coast and Geod. Survey, 76 p., 1960.

This is a summary of earthquake activity for the calendar year 1958 in the United States and regions under its jurisdiction. Noninstrumental results are listed for all recorded earthquakes, and fluctuations in well-water levels and seismological observatory and strong-motion seismograph results are summarized in tables. — V. S. N.

- 183-98. Stewart, S[amuel] W., Hofmann, R[enner] B., and Diment, W[illiam] H. Some aftershocks of the Hebgen Lake, Montana, earthquake of August 1959, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-219-B-221, 1960.

Two portable seismographs were operated intermittently at three stations from August 21 to August 24, 1959, to record aftershocks of the Hebgen Lake, Mont., earthquake of August 18, 1959, for the purpose of determining possible differences between ground motion caused by earthquakes and that caused by underground nuclear explosions. The observations are summarized, but no general comparisons are made between the effects of nuclear explosions and those of earthquakes.

At the Keg Spring station, 604 aftershocks were recorded with sufficient amplitude to permit calculation of approximate magnitudes. The weighted

values of the numbers of shocks indicate increasing numbers of aftershocks for decreasing magnitudes from 3.7 to 1.2. Thirty aftershocks were sufficiently well recorded at two stations to determine the approximate locations of their epicenters. A group of epicenters in the eastern part suggests a zone of activity trending slightly east of north. This alinement does not correlate with any known surface effects of the earthquake or with any known geologic trends. The area is underlain by Cenozoic volcanic rocks and alluvium. Most of the remaining epicenters were in the area where the surface was deformed by the earthquake. — V. S. N.

- 183-99. Jackson, W[ayne] H. Depth soundings in Hebgen Lake, Montana, after the earthquake of August 17, 1959, *in* Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-221-B-223, 1960.

Soundings were made throughout Hebgen Lake to determine the extent of any changes produced by the Montana earthquake of August 17, 1959. The present gradient, determined by the channel depth at the dam and at traverses slightly further upstream, is 2 feet per mile upstream. This reversal in gradient suggests warping of the lake floor and an estimated 10-foot relative vertical movement of the dam. Evidence of tilting was observed in other parts of the lake, but the soundings gave no indications of major faulting of the lake bottom. — V. S. N.

- 183-100. Nuttli, Otto [W.]. A note concerning the sense of the first P motion for the Montana earthquake of August 18, 1959: *Seismol. Soc. America Bull.*, v. 50, no. 2, p. 211-215, 1960.

The short- and long-period seismograms at both St. Louis and Florissant appear to indicate an opposite sense of the first P-motion for the Montana earthquake of August 18, 1959. The P-motions are impulsive and seem to arrive simultaneously on both short- and long-period seismograms.

In order to avoid any doubt about the relation between trace and ground displacements, the seismograms are compared with those of the earthquake of August 26, 1959. In the latter the first P-motion is impulsive and shows the same sense in both short- and long-period seismograms. No attempt is made to explain the differences in sign observed in the case of the Montana earthquake. It would be interesting to learn if the same phenomenon occurred at different distances and (or) azimuths. — D. B. V.

- 183-101. Richter, C[harles] F., and Gardner, John K. The Walnut, California, earthquakes of July-August, 1959: *Seismol. Soc. America Bull.*, v. 50, no. 2, p. 181-185, 1960.

A swarm of minor earthquakes began on July 29, 1959, near lat 34°00' N., long 117°48' W. Records at Pasadena show P- and S-waves reflected from the M-discontinuity. A portable instrument recorded some of these at a point about 6 km from the epicenter. The characteristic false S-P of about 1 sec at short distances was recorded.

Shocks with magnitudes ranging between 2.2 and 3.5 occurred on July 29 (10 shocks), July 30 (5), August 1 (2), August 3 (6), August 5 (1), and August 6 (1). The times and magnitudes of these are tabulated. The P and S travel-time data for several stations are given for 7 of the larger shocks in another table, and details are given for the shock of August 3 at 15^h26^m42.5^s (magnitude=3.5) and for a smaller shock on August 24 with slightly different epicenter.

The sequence of shocks is unusual for the Los Angeles area, being rather of the swarm type than of the usual aftershock pattern. The possibility existed (at the time this paper was written) that these were foreshocks of a more considerable event; those culminating in the Whittier earthquake of July 8, 1929, began in May. — D. B. V.

183-102. Richter, C[harles] F. Earthquakes in Owens Valley, California, January-February, 1959: *Seismol. Soc. America Bull.*, v. 50, no. 2, p. 187-196, 1960.

In January 1959, two series of small earthquakes originated in southern Owens Valley. The first and largest of these, of magnitude 4.7, originated on January 5, 12:36:02.9 G. c. t., near 36°09' N., 118°03' W., near Haiwee. This and other shocks of the series were well recorded by standard and strong-motion instruments at Haiwee, showing the characteristic false S-P of about one second. The timing is good and demonstrates that no change of supposed epicenter, depth, or velocities can reasonably account for the second phase as S. Other shocks were located at 36°07' N., 118°03' W., which probably represents the terminus of faulting in the first shocks. A shock of magnitude 3.2 occurred on January 7, at 00:20:40.2 G. c. t. near 35°46' N., 117°35' W., near China Lake. This was followed by numerous others from the same source, mostly showing a false S, and recorded by the Benioff instrument at China Lake down to very small magnitudes. However, shocks of this group of magnitude 0.7-0.8 were more numerous than those of magnitudes of 0.0-0.6. Initial compressions and dilatations in both groups of shocks were consistent, especially at the nearer stations, but lead to no simple fault-plane solutions. — Author's abstract

183-103. Tocher, Don. The Alaska earthquake of July 10, 1958, Introduction: *Seismol. Soc. America Bull.*, v. 50, no. 2, p. 217-220, 1960.

This is a general introduction to the four succeeding articles on the major earthquake (Richter magnitude 8) that was felt throughout southeast Alaska and vicinity shortly after 0615 (G. c. t.) on July 10, 1958. The shock was initiated by movement on the Fairweather fault along the Fairweather Range of the St. Elias mountains. The felt area exceeded 250,000 sq mi. Because the area is sparsely settled, only 5 were killed.

The available record of foreshocks and aftershocks is quite incomplete. The nearest seismograph stations were at Sitka and College; therefore, epicenters could be determined for only a few of the larger aftershocks. — D. B. V.

183-104. Davis, T. Neil, and Sanders, Norman K. Alaska earthquake of July 10, 1958: Intensity distribution and field investigation of northern epicentral region: *Seismol. Soc. America Bull.*, v. 50, no. 2, p. 221-252, 1960.

The earthquake of July 10, 1958, centered near Lituya Bay, Alaska, caused moderate property damage at Yakutat, 100 miles to the northeast, and was readily felt within 400 miles of the epicenter. Five persons died, 2 in Lituya Bay where a cataclysmic wave sank two fishing vessels, and 3 near Yakutat, when a beach on which they were standing sank 100 feet beneath the sea.

Effects of the earthquake were examined a few days later in the area extending from the north shore of Yakutat Bay southward to Lituya Bay. These included slides in mountain areas and numerous sandblows and fissures in the coastal plain. Reports by local and distant observers are given. The paper is illustrated by many photographs, both aerial and ground, of earthquake effects. — D. B. V.

- 183-105. Miller, Don J. The Alaska earthquake of July 10, 1958: Giant wave in Lituya Bay: *Seismol. Soc. America Bull.*, v. 50, no. 2, p. 253-266, 1960.

Lituya Bay, a T-shaped tidal inlet on the northwest shore of the Gulf of Alaska, heads in the trench along the Fairweather fault. Displacement along this fault at the time of the earthquake of July 9, 1958 (local time), triggered a rockslide into deep water in Gilbert Inlet, one of the two arms at the head of Lituya Bay. The rockslide, with a volume of 40 million cu yd, caused water to surge to an altitude of 1,740 feet on a spur opposite the point of impact, and generated a gravity wave that swept 7 miles to the mouth of the bay at a speed probably between 97 and 130 mph. The surge and wave of water destroyed the forest on the shores over an area of 4 sq mi, sank two of three fishing boats in the outer part of the bay, and took two lives. — Author's abstract

- 183-106. Tocher, Don. The Alaska earthquake of July 10, 1958; Movement on the Fairweather fault and field investigations of southern epicentral region: *Seismol. Soc. America Bull.*, v. 50, no. 2, p. 267-292, 1960.

The earthquake of July 10, 1958, was caused by movement on much or all of a 200-km segment of the Fairweather fault. A right-lateral offset of 10 feet or more occurred at Palma Bay, and fresh scarps were formed on the south shore of Nunatak Fiord. A displacement in which the southwest side moved 21.5 feet northwest and 3.5 feet up, relative to the northeast side, was measured just east of the north end of Crillon Lake.

Extensive minor faulting in bedrock east of the center of Crillon Lake was observed on flat areas on both sides of the Fairweather fault. These systems of minor faults were similar in general appearance to those formed on the Nunatak Fiord both in this earthquake and in the Yakutat Bay earthquakes of 1899.

Among the wide variety of other geologic effects observed along the coast from Cape Spencer to Mount St. Elias were earth and rock avalanches, snow and ice avalanches, earth slumps, earth lurches, and sandblows from craterlets and fissures. — D. B. V.

- 183-107. Stauder, William. The Alaska earthquake of July 10, 1958: Seismic studies: *Seismol. Soc. America Bull.*, v. 50, no. 2, p. 293-322, 1960.

The instrumental epicenter of the Alaska earthquake of July 10, 1958, has been located on the hanging-wall side of the Fairweather fault near the surface expression of the fault and at the southeast end of the greatly disturbed area. The fault-plane solution from P-waves gives a fault plane which differs by 15° from the strike of the observed surface faulting. The theoretical relative amplitudes computed from the fault-plane solution are interpreted as partly explaining the residuals of P arrivals and inconsistent directions of the first motion of P. The directions of polarization of the S-waves are found to conform to the pattern expected for a single couple as the point-source model of the focal mechanism. A method is suggested for using S-waves to check fault-plane solutions from P and to select the fault plane from the two nodal planes of P. Observations of S at near stations do not correspond to the pattern expected for a couple. Large transverse motion is observed along the azimuth of the fault. In the western United States, at stations along the same azimuth, the SH motion changes progressively to SV with distance. Large SV

components at distances of 25°-27° indicate that the critical angle for SV may be reached at these distances and that even long S-waves are refracted by structure within the crust. — Author's abstract

- 183-108. Davis, T. Neil. A field report on the Alaska earthquakes of April 7, 1958: *Seismol. Soc. America Bull.*, v. 50, no. 4, p. 489-510, 1960.

The Alaska earthquake at 0530 on April 7, 1958, (150° WMT) was the largest (Richter scale 7-7½) of a series of shocks centered in an area near Huslia, Alaska. The field epicenter located at 65°45' N., 155°45' W. lies in the Koyukuk Basin where arrested sand dune deposits cover a part of the near-level alluvium deposited by the Koyuk River. Extensive fracturing occurred in the lake and river ice in the epicentral area and the sand dune deposits were heavily fissured. The most severe damage occurred in a zone approximately 10 miles wide by 40 miles long trending northeast from Huslia. Associated with the sand dunes in this zone were large deposits of silt and sand which flowed to the surface from the alluvium beneath the dunes. Because of the distinctive characteristics of these flows they have been termed sand flows to distinguish them from mud flows and sand blows. Associated with the sand flows were surface collapses resulting in near-conical pits as much as 30 feet deep and up to 120 feet in diameter. The earthquakes caused little monetary damage, although the main shock registered a Modified Mercalli intensity V or more over an area in excess of 100,000 sq mi. [See also *Geophys. Abs.* 175-33.] — Author's abstract

- 183-109. Boletín Sismológico del Servicio Geológico Nacional de El Salvador. Informe detallado sobre el fuerte temblor del día 17 de septiembre de 1959 [Detailed report on the strong shock on the 17th day of September, 1959]: *El Salvador Servicio Geol. Nac. Bol. Sismol.*, v. 5, p. 19, 1960.

The strongest earthquake in 4 years shook the southern part of El Salvador at 15^h24^m (local time) on September 17, 1959. In the previous weeks normal seismic activity of the coastal zone had been replaced by an unusual calm, during which excessive strain apparently accumulated. The focus was located at lat 13°10' N., long 80°11' W., at a depth of 95 km. An isoseismic map based on macroseismic evidence is given. Maximum intensity was 6 on the Mercalli-Sieberg scale. The areas most affected by the earthquake were around the chain of volcanoes, where the ground is composed of relatively unconsolidated recent volcanic material and is traversed by faults. — D. B. V.

- 183-110. Robson, G. R., and Barr, K. G. Unidentified earth tremors in Dominica, West Indies: *Nature*, v. 188, no. 4747, p. 306, 1960.

Tremors of unidentified origin were recorded at the Roseau seismic station on the volcanic island of Dominica during September, 1959, and have been recorded at irregular intervals ever since. Each tremor consists of an approximately sinusoidal ground motion of 0.3-sec period. The first swing is always down, the first and eighth swings are maximums, and there are about 12 swings in all. They are quite unlike the tremors produced by near earthquakes or by explosions on land or at sea. There is no evidence that these tremors are related in any way to the active thermal area or ancient eruptive centers of the island, but no alternative explanation can be put forward. — D. B. V.

- 183-111. Gorung, M. B. Zemletryaseniye v Agadir [The earthquake in Agadir]: *Priroda*, no. 6, p. 113-114, 1960.

The Agadir earthquake in Morocco is described. The first shock occurred February 29, 1960, at 23^h41^m; its intensity was evaluated by the Strasbourg seismic station as being 6 points on the Richter scale. At 01^h03^m a high sea wave deluged the city. The shock was so strong that heavy trucks were thrown into the air, 90 percent of the buildings were destroyed, 10,000 lives were lost, and 15,000-20,000 persons lost their property. The earthquake is attributed to a possible submarine volcanic eruption near the shoreline. — A. J. S.

- 183-112. Sukhov, I. M. Zemletryaseniye 10 noyabrya 1940 g. v Moldavii i sopredel'nykh oblastyakh i voprosy seysmorayonirovaniya yugo-zapadnoy chasti SSSR [The earthquake of November 10, 1940, in Moldavia and adjacent regions and problems of seismic regionalization of the southwest part of the USSR]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 93-98, 1960.

The epicenter of the earthquake of November 10, 1940, was in the Vrancea area in the eastern Carpathians north of Bucharest, Rumania; its intensity there reached 9 points. On the basis of a new study of the effects of this earthquake in the adjacent parts of the U. S. S. R., a change in the seismicity map of the Moldavian S. S. R. is proposed. It is suggested that the comparatively extensive damage to peasant houses in the vicinity of Kishinev and Vishinevka was due to the type of construction rather than to greater earthquake intensity, and that the 8-point isoseismal line should be drawn north of the area. A sketch map shows the present and proposed delineation of the seismic zones in the area in question. — D. B. V.

- 183-113. Solonenko, V. P., and Florensov, N. A. Po sledam zemletryaseniya v Gobi [On the track of the Gobi earthquakes]: Priroda, no. 2, p. 61-66, 1960.

This is a supplementary descriptive paper on the Gobi earthquake of December 4, 1957 (see Geophys. Abs. 177-52, 178-43). This earthquake was of 11-12 points intensity and was felt throughout an area of more than 5 million sq km. Its epicentral area was 7,000-8,000 sq km, and the area included within the isoseism of intensity 5 was 1.4 million sq km. Mountains were displaced, and a series of crevices extended for more than 700 km. — A. J. S.

- 183-114. Medvedev, S. V. Voprosy seysmicheskogo rayonirovaniya [Problems of seismic regionalization]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 5-27, 1960.

The seismicity map of the U. S. S. R., published in 1957 on a scale of 1:5,000,000, is reproduced and discussed from the point of view of earthquake distribution and sources of data. Maps from other countries—Western United States, Japan, Germany, Rumania, India, Hungary, Turkey, and China—are also described briefly and reproduced.

Inadequacies in the present methods of seismic regionalization are pointed out. The time factor is neglected, and no estimate is given of the probability of earthquakes of a given intensity for each point. Zones are not differentiated according to the spectral composition of surface wave oscillations, nor according to focal depth or focal mechanism of the earthquakes. Movements of the foundations of constructions in the different zones are not completely characterized quantitatively. The differential effect of ground conditions on the intensity of oscillations is not taken into account. Finally, the boundaries of the different seismic zones are not drawn with sufficient accuracy.

It is proposed that seismic regionalization be established on a "two-stage" principle. The first stage would be compilation of a map of "prediction of

seismicity, " showing zones where earthquakes of a given magnitude (energy) at the focus originate, and indicating focal depth and the probability of such earthquakes. The second stage would be compilation of a map of "prediction of seismic effects." This map would give the magnitude, spectral composition, ground oscillations at the earth's surface, and probability of earthquakes. The former would be based on seismic data; the latter would also take into account the geologic conditions. Possible lines of investigation to be pursued toward these ends in the next few years are outlined. — D. B. V.

- 183-115. Penttilä, Esko. On the local earthquakes in Finland: *Geophysica* [Helsinki], v. 7, no. 2, p. 91-96, 1960.

The seismicity of northern Finland is investigated on the basis of the records of the Sodankylä station where over 800 shocks at epicentral distances smaller than 5° have been recorded during 3½ yr. Only a fraction of these can be localized, but it is evident that weak shocks occur in the northern Kainuu region of Finland at a rate of 10-20 per yr; this region is thus the most seismic in Finland. Data from two stronger shocks in the area are also given. — V. S. N.

- 183-116. Safaryan, A. N. Voprosy metodiki seysmicheskogo rayonirovaniya na primere territorii Dariali-GES (Gruzinskaya SSR) [Problems of seismic regionalization exemplified by the Darial hydroelectric project area (Georgian SSR)]: *Akad. Nauk SSSR Sovet po Seysmologii Byull.*, no. 8, p. 88-92, 1960.

Hydrotechnical projects generally extend over a considerable area compared to cities and populated places, and are built to last longer than houses and industrial buildings. For seismic regionalization of such regions, therefore, it is necessary to have earthquake data for long periods of time and to study the seismicity of a large area. The Darial hydroelectric project on the Terek River in the Georgian S. S. R. is discussed as an example of microregionalization of a large territory.

Seismic regionalization there was based on inspection of the consequences of the Gudamakhar earthquake of 1947 in 22 populated places, on macroseismic data compiled for the past 90 years, and on detailed geologic investigations made over a period of several years. Similar investigations of seismicity have been made at other hydroelectric projects in the Caucasus and to a lesser extent in central Asia. — D. B. V.

- 183-117. Byus, Ye. I., and Tskhakaya, A. D. Seysmologicheskiye osnovy seysmorayonirovaniya Kavkaza [Seismologic bases of seismic regionalization of the Caucasus]: *Akad. Nauk SSSR Sovet po Seysmologii Byull.*, no. 8, p. 99-104, 1960.

Available information on Caucasus earthquakes is discussed. A map is given that shows the distribution of epicenters of earthquakes of intensity 7 and 8 for the years 1912-57. Not all the facts pertinent to the seismicity of the Caucasus are known. Instrumental observations have been made only for the past 45 years, although macroseismic observations of strong earthquakes date back several centuries. There seems to be sufficient information to establish seismic zones for the Caucasus; however, places that are now shown to be free of earthquakes may actually be potentially active zones. For an efficient scheme of seismic regionalization of the Caucasus, data from several sources—seismology, geology, engineering seismology, and specialized investigations in microgeology and seismic microregionalization—should be compiled. — D. B. V.

- 183-118. Nikitin, P. N. Makroseysmicheskoye dannyye o zemletryasenyakh Severnogo Kavkaza [Macroseismic data on earthquakes of the North Caucasus]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 105-109, 1960.

A catalog of local earthquakes in the North Caucasus is in preparation; it will list 2,178 earthquakes of intensity 4 or more from the earliest on record (417 B. C.) through 1955. Their distribution in space and time throughout the North Caucasus is reviewed briefly. It is concluded that this compilation of macroseismic data can contribute to the precise seismic regionalization of the area in question. — D. B. V.

- 183-119. Rastvorova, V. A., and Rustanovich, D. N. Seysmichnost' i novyshaya tektonika zony krasnopolyanskikh zemletryaseny [Seismicity and recent tectonics of the zone of the Krasnaya Polyana earthquakes]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 110-115, 1960.

The area around Krasnaya Polyana in the southwest Caucasus suffered an earthquake of intensity 6 on December 21, 1955, at 19^h54^m. The epicenter has been located at lat 43°47' N., long 40°09' E.; depth of focus was 5-8 km and magnitude was 4½. This shock was followed by a long series of aftershocks. Instrumental study was initiated in September 1956 with the establishment of 7 stations in the general vicinity; 3 more stations were added to the network later.

Between September 1956 and August 1957, 123 earthquakes were recorded; epicenters were located for 55 of these. Their distribution and intensities are shown on a sketch map. The focuses are evidently migrating, but the observation period has not been long enough to allow definite conclusions regarding trends and periodicity.

The complex geology of the area is discussed briefly. Recent tectonic movements appear to be inherited from a Mesozoic stage of orogeny. Analysis of the distribution of earthquakes in the light of recent movements shows that Krasnaya Polyana, Adler, Sochi, and Golovin are the most dangerous places, from the point of view of earthquake risk, within the zone of 7-point seismicity which embraces the whole area under consideration. — D. B. V.

- 183-120. Rubinshteyn, M. M. Geologicheskkiye kriterii seysmicheskogo rayonirovaniya Gruzii [Geologic criteria for the seismic regionalization of the Georgian SSR]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 116-120, 1960.

The deep structures in the Caucasus that are seismically active at the present time are relatively older than genetically related overlying structures. Seismicity maps of the Georgian S. S. R., based on seismostatistical data, should be corrected to take these deep structures into account. In view of the abundance of macroseismic and microseismic data and the high degree of geologic knowledge of the region, a scale of 1:500,000 is recommended. — D. B. V.

- 183-121. Kirillova, I. V., and Sorskiy, A. A. O metodike sostavleniya karty seysmicheskogo rayonirovaniya masshtaba 1:1,000,000 na primere Kavkaza [On methods of constructing a map of seismic regionalization on a scale of 1:1,000,000 exemplified by the Caucasus]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 121-124, 1960.

The general seismicity map of the U. S. S. R. is on a scale of 1:5,000,000. In this paper a seismicity map of the Caucasus on a scale of 1:1,000,000 is

presented, which was constructed on somewhat different principles: analysis of seismostatistical data, analysis and inferences from geologic data, and inferences from data on the nature of the ground and topography. In addition to the seismicity map, a sketch map shows the location and density of epicenters and focal mechanism of Caucasus earthquakes, and another shows the distribution of deep structures and deep fractures in the region.

The seismicity map distinguishes zones of three degrees of seismicity. In the regions of high seismicity earthquakes of 8-point intensity have occurred repeatedly and may occur in the future; in the zones of medium seismicity weak local earthquakes are frequent and stronger earthquakes are known; and in the zones of weak seismicity only weak local earthquakes (less than 7-point intensity) have occurred, and these rarely. In addition the map shows the nature of the ground within each zone, classified from the engineering-geologic standpoint (according to underlying rock type and topography) into seven categories of different degrees of resistance or susceptibility to earthquake damage. — D. B. V.

- 183-122. Kirillova, I. V. O seymicheskikh usloviyakh Zakavkaz'ya, Turtsii i Irana [On the seismic conditions of Transcaucasia, Turkey, and Iran]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 125-130, 1960.

A seismicity map has been compiled on the basis of published maps and data for the area south of the Black Sea, the Caucasus, and the Caspian Sea. Three zones are distinguished, characterized by high, intermediate, and unknown seismic activity, respectively. A sketch map shows the distribution of epicenters of earthquakes that occurred in the region from 1938 to 1953. The data bear out Kirillova's concept that fractures visible at the surface play a predominant role in determining the seismicity. — D. B. V.

- 183-123. Puchkov, S. V. Seymicheskoye mikrorayonirovaniye zony Ashkhabadskogo zemletryaseniya 1948 g. na osnove instrumental'nykh nablyudeniye [Seismic microregionalization of the zone of the Ashkhabad earthquake of 1948 on the basis of instrumental observations]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 142-149, 1960.

The Ashkhabad earthquake of 1948 occurred during the night of October 5-6, 1948. According to macroseismic evidence its intensity was 9-10 points. The focus lay in the Turkmen S. S. R., at lat 37.8° N., long 58.6° E., at a depth of 26 km. The strain involved a volume of 12,000 km³, and maximum motion was felt over an area of 460 km². The energy release has been calculated as 2×10^{25} ergs.

A detailed seismic regionalization map (scale 1:200,000) of the area involved in the Ashkhabad earthquake is presented. It was constructed on the basis of engineering-geologic considerations and investigations of ground motion on various types of ground with a special network of highly sensitive seismic stations with galvanometric recording. The data obtained in this study and the degree of damage in other strong earthquakes show that variations in intensity depend on very local geologic conditions in both weak and strong shocks. — D. B. V.

- 183-124. Kostenko, N. P. Izmeneniye naklonov zemnoy poverkhnosti i seymichnost' (na primere gornyykh stran yuga Sredney Azii) [Changes in inclination of the earth's surface and seismicity (exemplified by the mountainous area of southern central Asia)]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 150-156, 1960.

Oligocene-Anthropogene deformation in the Pamir and southwestern Tien Shan in the form of uplifts and depressions can be traced from changes in the drainage system. Comparison of these movements with seismic and geologic data shows that the areas that are most active seismically are located at sites of strong differential movements. — D. B. V.

- 183-125. Bune, V. I., and Nersesov, I. L. Nekotoryye rezultaty izucheniya seysmichnosti Stalinabadskogo rayona [Some results of study of the seismicity of the Stalinabad Region]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 157-165, 1960.

The distribution of earthquakes in space and time in the Stalinabad Region of the Turkmen S. S. R. has been investigated, using data obtained by the Tadzhik Joint Seismological Expedition of 1955-57. Study of weak earthquakes over this short period showed that there are two deep active zones, bounding the Hissar valley on the north and south; these pose a threat to Stalinabad.

With regard to frequency of occurrence, a graph of weak earthquakes in the period of observation is generally similar to that for strong earthquakes over an extended period; the great number of weak earthquakes makes it possible to obtain more reliable results. Earthquakes are more frequent in the southern than in the northern seismic zone. The question of the maximum intensity that can be expected in the southern zone cannot be answered on the basis of the instrumental data. — D. B. V.

- 183-126. Kon'kov, A. T. K voprosu seysmichnosti Ferganskoy vpadiny [On the problem of the seismicity of the Fergana basin]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 166-169, 1960.

The seismicity of the Fergana basin in western Central Asia is analyzed, using data from the seismicity atlas of the U. S. S. R. and from the catalog of strong earthquakes in the Fergana basin ($M \geq 3$) compiled by Kon'kov for 1883-1954. The results are shown in a map of epicenters of all earthquakes of magnitude $M \geq 3$ and a graph showing distribution of destructive earthquakes in time 1880-1957. The southern part of the basin, at the foot of the Alay range, is more active seismically than elsewhere. The Kara-Dar' River basin runs the greatest risk of earthquake damage, particularly in its central part where ground conditions are unfavorable. — D. B. V.

- 183-127. Fesenko, Yu. V. Makroseysmicheskiye dannyye o zemletryaseni-yakh tsentral'nogo Tyan'-Shanya [Macro seismic data on earthquakes of the central Tien Shan]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 170-174, 1960.

Against the background of generally high seismicity in the Tien Shan, earthquakes are clustered in three groups corresponding to basic structural elements of Central Asia: the northern Tien Shan, the eastern Fergana basin, and the south flank of the Kok-Shaal range. The Chatkal earthquake of November 1946 alone is a basis for a fourth group. Individual earthquakes are discussed briefly. Two sketch maps show the location and magnitude of strong earthquakes ($M \geq 5\frac{1}{4}$) in the Tien Shan and of all earthquakes known to have occurred in the period 1948-57.

The felt area of central Tien Shan earthquakes is not large. This explains why, prior to the establishment of several seismic stations in the area, its seismicity was thought to be low. — D. B. V.

- 183-128. Florensov, N. A., Treskov, A. A., and Solonenko, V. P. O seysmichskom rayonirovaniy Vostochnoy Sibiri [On the seismic re-

gionalization of East Siberia]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 175-178, 1960.

Earthquake records in eastern Siberia do not go back very far (200-250 yr), but on the basis of available data four zones of different degrees of seismicity are recognized. The central zone of the Baikal arch, where abrupt differential movements have been going on, can expect earthquakes of class b intensity (in Gutenberg and Richter's classification), or 10 points on the Russian scale. The zone comprising the eastern Sayan, Khamar-Daban, Daur or Khentey-Chikoy, and Stanovoi ranges is characterized by weaker differential uplift and active deep fractures; earthquakes there may reach class c strength. The west Transbaikal area, with weak differential movements, may expect class d earthquakes, and the central part of the Siberian platform is subject to weak and shallow local earthquakes. — D. B. V.

- 183-129. Denisov, Ye. P., and Smirnov, A. M. O noveyshikh tektonicheskikh dvizheniyakh yuzhnogo Primor'ya i privileyushchikh territoriy [On recent tectonic movements of the southern Primor'ye and adjacent areas]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 179-183, 1960.

The southern part of the Maritime Territory (Primor'ye) of the U. S. S. R. appears to be seismic. According to Gorshkov it lies in a zone of 6-7-point seismicity. Earthquake activity is related to young movements on deep fractures bounding broad depressions. The trend of these fractures is close to north-south and east-west. — D. B. V.

- 183-130. Organova, N. M. Seysmicheskoye mikrorayonirovaniye poluostrova Trudnogo (Yuzhnoye Primor'ye) [Seismic microregionalization of the Trudny Peninsula (southern Primor'ye)]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 184-188, 1960.

The Trudny Peninsula in southern Maritime Territory (Primor'ye) of the U. S. S. R., on which the port of Nakhodka is located, is structurally part of the Sikhote-Alin anticlinorium, folded in the Late Paleozoic and Mesozoic. The general seismicity, due to reactivation of Mesozoic faults, is 7 points.

Taking into account the geology and topography, ground conditions, thickness of unconsolidated sediments, and depth of ground water table, the peninsula is divided into zones of 6-, 7-, and 8-point seismicity. The geology, relief, and distribution of seismic zones are shown in sketch maps. — D. B. V.

- 183-131. Ferchev, M. D. K voprosu o seysmichnosti ostrova Sakhalina [On the problem of the seismicity of the island of Sakhalin]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 189-195, 1960.

The present zoning of the island of Sakhalin into two seismic regions is not accurate. Three different zones are recognized, two characterized by intensity 7 and the other by intensity 6. A 7-point zone extends down the west coast from Alexandrovsk to the south tip of the island. The east boundary of this zone follows the contact between Tertiary and Cretaceous formations except in the north part of the zone, where part of the Cretaceous terrane also lies in the 7-point zone. The other 7-point area is the peninsula that forms the north tip of the island. All the rest of the island comprises a 6-point zone. — D. B. V.

- 183-132. Rudich, Ye. M. O geologicheskoye obosnovanii seysmichnosti ostrova Sakhalina [On the geologic basis of the seismicity of the is-

land of Sakhalin]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 196-199, 1960.

The island of Sakhalin is divided into four seismic zones. In general, the seismicity decreases toward the north and east, with the strongest earthquakes (8 points) expected in a narrow coastal strip extending south from Ulegorsk. A 6-7 point zone corresponds to the West Sakhalin anticlinorium. The Susunay and Tym'-Poponay depressions are characterized by 5-point intensity. In the zone comprising the Susunay and East Sakhalin ranges and part of north Sakhalin, earthquakes are rare and seldom stronger than 4 points. An area of somewhat higher activity (6 points) is found in the vicinity of Okha in north Sakhalin.

The zones established in this paper differ somewhat from those outlined by Ferchev (see Geophys. Abs. 183-131). — D. B. V.

183-133. Safaryan, A. N. K seysmicheskomu rayonirovaniyu territorii Armyskoy SSR [Seismic regionalization of the territory of the Armenian SSR]: Akad. Nauk Armyan. SSR Izv., v. 11, no. 5, p. 51-53, 1958.

The need for a coordinated approach to the problem of seismic regionalization is emphasized. Data should be drawn from tectonics, geophysics, seismogeology, engineering geology, engineering seismology history, and archaeology. Various studies of the seismic regionalization of Armenia are reviewed. — J. W. C.

183-134. Flinn, E. A. Local earthquake location with an electronic computer: Seismol. Soc. America Bull., v. 50, no. 3, p. 467-470, 1960.

A straightforward least-squares iterative procedure for locating local earthquakes now in use at the Australian National University is described. An IBM 650 electronic computer is used for all calculations, including estimates of the probable error of epicentral coordinates, depth of focus, and origin time.

Local earthquakes registered by the 9-station network of southeastern New South Wales which meet the following conditions can be treated by this procedure: (1) epicenters are close to at least 3 of the stations, to the degree that first arrivals in the P and S groups are the direct waves P_g and S_g ; and (2) at least 6 first arrival times are observed. — D. B. V.

183-135. Golenetskiy, S. I. Ob opredelenii nachalnoy ordinaty i sposobe postroyeniya epitsentraly pri lineynom godografe [On the determination of the initial ordinate and the method of plotting epicenters with a linear traveltime curve]: Akad. Nauk Tadzhik. SSR Inst. Seysmologii Trudy, v. 71, no. 2, p. 29-37, 1957.

On the assumption of a linear traveltime curve of diffracted waves, a method of determination of the initial ordinate is proposed that does not depend on the epicenter. A nomogram is described that is efficient for use in analyzing observations by the method of epicenters. — Author's abstract, J. W. C.

183-136. Shlanger, Ari B. M. [Ben-Menahem, Ari]. Some consequences of earthquake statistics for the years 1918-1955: Gerlands Beitr. Geophysik, v. 69, no. 2, p. 68-72, 1960.

The temporal distribution of more than 650 earthquakes with magnitudes 7 and more has been studied in a search of trends. The observed distribution fits the theoretical Poisson distribution so well as to exclude the possibility

that the occurrence of major earthquakes is influenced by any dominant external force. The probability of an earthquake of a given magnitude occurring within a given time interval can be calculated from these results. — D. B. V.

- 183-137. Chinnery, M. A. Some physical aspects of earthquake mechanism: *Jour. Geophys. Research*, v. 65, no. 11, p. 3852-3854, 1960.

Two possible earthquake focal mechanisms have been proposed, a single couple with moment (nucleus I) and a double couple without moment (nucleus II). The importance of distinguishing between the two has arisen in connection with fault plane solutions. If only P-wave arrivals are considered, the fault plane solution defines two possible planes corresponding to the two kinds of nuclei. Investigations of S-wave arrivals have confused rather than clarified the issue.

The physical implications of the two nuclei are considered, and it is shown that there is a relationship between the mechanism and the properties of the material around the focus. It is suggested that if a fracture occurs in a reasonably rigid solid the observed first motions should correspond to the distribution of a nucleus II. If a nucleus I is observed, this must indicate a nonequilibrium situation that is explainable only if some plasticity in the material around the focus is assumed. If equilibrium is attained shortly after fracture ceases, indicating a small degree of plasticity, it may be possible that observations of seismic waves of period comparable to the time of fracture will indicate an unbalanced nucleus and that similar observations of long-period waves will indicate an equilibrium nucleus.

As the crust of the earth is rigid for small time intervals, surface faults should emit the distribution of a nucleus II; and evidence of the equilibrium process, which involves a rotation of material at the focus, should be observed in the immediate area of the fault. An example of such evidence is cited in the case of the Tango earthquake.

For deep earthquakes the nature of the mechanism reflects the properties of the mantle at the focus. If the distribution of a nucleus I is observed at all, it should be only for waves below some critical wavelength. If nuclei I are really present to any extent, theories that treat the mantle as an elastic solid may have to be revised. — D. B. V.

- 183-138. Stauder, William. S waves and focal mechanisms: The state of the question: *Seismol. Soc. America Bull.*, v. 50, no. 3, p. 333-346, 1960.

The problem of using S-waves in the determination of the focal mechanism of earthquakes is shown to be closely related to questions regarding the adequacy of present focal models. A review of the theory and uses of the S phase by previous investigators suggests methods by which the sign of the initial motion of SH and SV or, preferably, the plane of polarization of \vec{u}_0 may be used to study the source mechanism by means of S-wave data. There is need of systematic application of these and other techniques in the interpretation of S-waves observed in individual earthquakes.

A choice of earthquakes the mechanism of which can be explored by methods of S-wave analysis is limited to certain epicentral distances. At distances shorter than 35° - 40° the angle of incidence at the surface is greater than the critical angle for SV, and SV is out of phase with SH. Optimum distances are in the range $40^\circ < \Delta < 82^\circ$. In order that S may record well in that range, magnitude should be of the order of $7 < M < 7\frac{3}{4}$. The earthquake should also be so chosen that they are well observed at all azimuths about the epicenter. — D. B. V.

- 183-139. Stauder, William. Three Kamchatka earthquakes: *Seismol. Soc. America Bull.*, v. 50, no. 3, p. 347-388, 1960.

The relation between S-waves and source mechanism is studied for three Kamchatka earthquakes, two with previously determined fault-plane solutions. These shocks were chosen according to the principles outlined in the preceding paper (see Geophys. Abs. 183-138). The direction of first motion and the plane of polarization of S are determined by the construction of particle-motion diagrams.

In the case of the two earthquakes with previously determined fault plane solutions, no correspondence is found between the observed S-wave data and the character of the S-motion expected on the basis of the given nodal planes of P, whether the source be considered as a single couple or as a double couple. For the third earthquake it is found that the first motion of P is compressional all along rays leaving the focus downward and that the S-waves are strongly SV polarized.

No faulting mechanism can explain this distribution of motion of the initial P- and S-phases. The motion corresponds to that generated by a simple force acting almost vertically downward. By means of graphical and analytical techniques the trend of the force at the source is determined to be N. 12° W., with a plunge of 85°. A reconsideration of the other two shocks shows that these too are better explained by a simple force source than by a faulting mechanism. — D. B. V.

183-140. Stauder, William. S-waves: Alaska and other earthquakes: Seismol. Soc. America Bull., v. 50, no. 4, p. 581-597, 1960.

Techniques of S-wave analysis are used to investigate the focal mechanism of four earthquakes (Alaska, July 10, 1958, and October 4, 1927; Kern County, Calif., July 21, 1952; and off northern California coast, July 6, 1934). In all cases the results of S-wave analysis agree with previously determined P-wave solutions and conform to a dipole with moment or single couple as the point model of the focus. Further, the data from S-waves select one of the two nodal planes of P as the fault plane. Small errors in the determination of the angle of polarization of S are shown to result in scatter in the data of a peculiar character which might lead to misinterpretation. The same methods of analysis which in the present instances show excellent agreement with a dipole with moment source are the methods which in a previous paper (see Geophys. Abs. 183-139) required a single force type mechanism for a different group of earthquakes. — D. B. V.

183-141. Jobert, G[eorges]. Étude du mouvement du sol au voisinage d'une faille. II: [Study of the ground movement in the vicinity of a fault, Pt. 2 (with English and Esperanto summaries)]: Geofisica Pura e Appl., v. 45, p. 13-21, 1960.

The previous study (see Geophys. Abs. 179-74) is extended to take into account the possibility of plastic flow in the ground. A simple model of pre-seismic strain permits study of the distribution of the elementary shear planes. The extent of faulting in depth can be deduced from the combined pre-seismic and seismic strains. Applied to the San Francisco earthquake, the model gives a depth of only 7 km. — D. B. V.

183-142. Vvedenskaya, A. V. Ob opredelenii napryazheniy, deystvuyushchikh v ochagakh zemletryaseniy, po nablyudeniym seismicheskikh stantsiy [On determination of stresses acting at the focuses of earthquakes according to observations at seismic stations]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 513-519, 1960.

On the assumption that a part of the crust or the upper mantle is acted upon by forces in addition to those of hydrostatic pressure, a situation is visualized

where two mutually perpendicular double forces may cause a rupture and shear along a plane in a strained medium. The locus of such a rupture is considered to be the focus of an earthquake. An analysis of such a system of forces allows them to be interpreted as a tensor represented by two double, mutually perpendicular forces without moment, applied to the elements of the plane yz of the future rupture at an angle of 45° , referred to the coordinate system of the focus of the earthquake (\bar{x} —north, \bar{y} —east, \bar{z} —zenith). A system of differential equations is derived for the case when directions y and z are orthogonal. This system solved on the basis of first displacement data obtained at seismic stations provides for a mathematical expression with the aid of which the axis of the main stress at the focus of the earthquake can be determined. — A. J. S.

- 183-143. Petruskevskiy, B. A. Geologicheskkiye usloviya vozniknoveniya zemletryaseniya [Geologic conditions of origin of earthquakes]: Sovetskaya Geologiya, no. 2, p. 74-82, 1960.

Earthquakes that have their focuses in the earth's crust are believed to be the result of movement along faults. These faults, however, generally do not extend to the surface. The diversity of geologic conditions under which faulting can occur, however, should be reflected in the seismicity of a region.

Seismic studies in the U. S. S. R. indicate that differences in geologic history leave their imprint on the seismic characteristics of a region. In zones of Alpine folding the tectonic processes causing earthquakes are confined largely to the sedimentary strata of the crust and to the granitic layer, whereas in zones of platform rejuvenation these processes occur in the basaltic layer. This is possibly the explanation of the more frequent occurrence of strong earthquakes in rejuvenated platform areas than in zones of Alpine folding. — J. W. C.

- 183-144. Whitten, C. A. Horizontal movement in the earth's crust: Jour. Geophys. Research, v. 65, no. 9, p. 2839-2844, 1960.

The conventional method for determining horizontal movement in the earth's crust has been to reobserve networks of triangulation and compare the coordinates of the adjusted results. A new method of analysis of reobservations is presented. The changes in the angles in a network indicate the presence of strain or deformation within the crust. This type of analysis will also indicate small displacements which may occur along fault lines in an area of seismic activity. Results of the application of this technique to resurveys along the San Andreas Fault in California are given in graphical form. — Author's abstract

- 183-145. Karmaleyeva, R. M. Popytka prognoza blizkikh zemletryaseniya vo vremeni [An attempt at prognosis of local earthquakes according to time]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 467-474, 1960.

Slow motions of the ground that precede seismic disturbances are studied. Of the 30 local earthquakes ($\Delta \leq 100$ km) investigated, 28 were preceded by changes in the rate and direction of tilting of the ground. Disturbance in the tilting 3-4 days before the earthquake was observed in 70 percent of the cases studied, 5-7 days in 23 percent, and 2 days in 7 percent. Changes in tilting rate of destructive earthquakes (for example, the strong Stalinabad earthquake) were observed 13 days in advance of the earthquake. An analysis of observations of tilt variation at the Stalinabad seismic station on quiet days, when no earthquakes were recorded by the station, reveals a rather smooth

curve with two reversals in the direction of the tilt at 800 and 1800 hours local time. This variation is attributed to the diurnal change in temperature. The curves change their form by a well defined S-turn 2-3 hours before an earthquake is recorded by the station. Such turns were found to occur for the earthquakes with a $\Delta \leq 800$ km and $M \geq 4$; $800 < \Delta < 4,000$ km and $M \geq 5$; and $\Delta \geq 4,000$ km and $M = 5.5$. It was also noticed that during the periods which preceded earthquakes of $\Delta \leq 100$ km, the tilt assumed a preferential direction toward the epicenter. Tilting in an opposite direction occurred after these earthquakes. The direction of the tilt in the final phase of the S-turn coincides with the direction of the epicenter when the first phase of the earthquake is registered as a compressional wave and is opposite to the epicentral direction when a dilatational wave is recorded first. — A. J. S.

- 183-146. Bycroft, G. N. Yield displacements in multistory aseismic design: Seismol. Soc. America Bull., v. 50, no. 3, p. 441-453, 1960.

Plastic displacements occur when certain types of elastoplastic multistory shear structures are subjected to large earthquakes. This study is directed toward finding a variation of the horizontal stiffness and strength up the structure in order to minimize yield displacements and distribute them over the structure. The analysis has been made on an analog computer using a white noise source to simulate the earthquake disturbance. — D. B. V.

- 183-147. Bycroft, G. N. Effect of stiffness taper in aseismic design: Seismol. Soc. America Bull., v. 50, no. 4, p. 537-552, 1960.

An investigation is made of the effect of changing the stiffness distribution up the height of a linear shear framed structure when subjected to idealized earthquake motions. The mean value of the largest strains arising in successive earthquakes is determined together with the associated probability distribution. It appears that the chances of finding a strain value greater than twice the mean are very small. — Author's abstract

- 183-148. Sinitsin, A. P. K voprosu ob opredelenii seysmicheskoy nagruzki na massivnyye sooruzheniya [On the problem of determining the seismic stress on heavy constructions]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 212-216, 1960.

The results of model experiments of the effect of shock waves and earthquake waves on heavy constructions such as dams are reported. It is shown that when the dimensions of the structures are commensurate with the wavelength of the earthquake waves, it is necessary in calculating their stability to take into account the precise manner of transmission of the seismic effect. The analysis undertaken here is a first approximation of the solution of this difficult problem and is of great practical significance. The purpose of this paper is to draw attention of specialists in engineering seismology to the problem. — D. B. V.

- 183-149. Gutenberg, Beno. Low-velocity layers in the earth, ocean, and atmosphere: Science, v. 131, no. 3405, p. 959-965, 1960.

Combination of layers with increasing and decreasing velocities leads to complicated wave paths which may produce shadow zones. If the source of vibrations is in a layer with relatively low velocity, the waves leaving the source nearly horizontally may be channeled within the layer and never reach the surface, whereas waves arriving just beyond the shadow zone at the surface may concentrate and form a caustic.

The outer core of the earth and the asthenosphere in the upper mantle are such low-velocity layers, and numerous channels exist in the lithosphere. The presence of a low-velocity layer in the ocean, with all the expected phenomena, has been verified; similar channels in the atmosphere can explain zones of silence within zones of audibility around explosions, and sonic booms may be caustics resulting from airplanes breaking the sound barrier as much as 50 or 100 miles away.

The outer core is a low-velocity layer either because it is fluid or because there is a sudden density increase at the core boundary. The other channels can all be explained in terms of temperature (or pressure and temperature) effects; in the case of the atmosphere, wind also is a factor. — D. B. V.

- 183-150. Gilbert, Freeman, and Knopoff, Leon. Seismic scattering from topographic irregularities: *Jour. Geophys. Research*, v. 65, no. 10, p. 3437-3444, 1960.

An approximation, similar to the Born approximation, is developed for scattering of seismic waves by an irregular surface. It is assumed that the magnitude and slope of the irregularity are small. The irregularity is replaced by an equivalent stress distribution so that the problem is reduced to Lamb's problem for distributed surface sources; the latter problem can be solved by convolution methods. As examples, the problems of the scattering of plane P-waves, plane S-waves, and surface Rayleigh waves are treated. Solutions are obtained in terms of integrals of functions that arise in the theory of Lamb's problem for isolated surface line sources. The example of the scattering from a mountain with plane sides is worked out in detail. The result is valid for pulses whose durations are long compared with the vertical travelt ime across the irregularity and short compared with the horizontal travelt ime across the irregularity. — Authors' abstract

- 183-151. Wadati, K[iyoo]. On the T-phases observed at Torishima: *Geophys. Mag. [Tokyo]*, v. 30, no. 1, p. 1-18, 1960.

This is a continuation of earlier work by Wadati and Inouye on T-phases observed in Japan (see *Geophys. Abs.* 158-142). Conspicuous T waves are often observed on islands and coasts facing the deep sea, especially at Torishima Island. Data are compiled on 42 shocks during 1954-57 for which T phases were recorded there. Earthquakes with focal depths of 110-200 km were most favorable for the production of T waves. Of special interest is the shock of May 14, 1955, which was produced by an underwater atomic explosion off California.

It is concluded that (1) T waves may be erroneously interpreted as local shocks; (2) the mechanism of their formation needs further investigation; (3) strong reflections can occur, but these may arrive so late as to be mistaken for another shock; and (4) data from hydrophone observations and reports of sea shocks felt by ships at sea would be valuable in the study of T waves. — D. B. V.

- 183-152. Vaněk, J[iří], and Stelzner, J[ohannes]. Oscillatory character of amplitude curves for seismic body waves: *Nature*, v. 187, no. 4736, p. 491-492, 1960.

Observations at four central European seismic stations — Prague, Jena, Collnberg, and Potsdam — have been combined to yield a set of homogeneous data from which the fine structure of the amplitude curves for P, PP, and S waves could be derived. Two partial sections of amplitude curves are reproduced. Their oscillatory character is clear. A similar oscillatory charac-

ter has also been observed in amplitude curves of P-waves from underground nuclear explosions.

These results suggest regional influences, probably due to regional structures in the mantle. The oscillations observed in the distance range studied are evidently connected with the surface field of waves diffracted at the low-velocity layer in the asthenosphere. — D. B. V.

- 183-153. Bulin, N. K. Opredeleeniye glubiny skladchatogo fundamenta pri pomoshchi obmennykh prokhodyashchikh voln tipa PS, registriruyemykh pri zemletryasenyakh [Determination of the depth of the folded basement with the aid of exchange transmitted waves of PS type recorded in earthquakes]: Akad. Nauk SSSR Izv. Ser. Geofiz. no. 6, p. 781-786, 1960.

A possibility of identifying exchange waves of type PS on seismograms obtained with Kirnos seismographs is investigated. The seismograms of 1956-58 of the Bayram-Ali seismic station in southeastern Turkmenia were analyzed (see Andreyev, Geophys. Abs. 169-68, Vasil'yev, 170-281), and a formula for the depth (h) of the basement, $h = V_P[\Delta t(PS)]/(k-1)$, is derived. In this formula $k = V_P/V_S$, where V_P and V_S are average velocities of longitudinal and transverse waves respectively, in the rock above the basement. The mean velocity of the longitudinal wave to the basement was found to be 3.25 km/s, and h proved to be 7.6 ± 0.5 km. Arrivals of clearly recorded exchange waves should provide data on the deep structure of the earth's crust in the regions of these stations. — A. J. S.

- 183-154. Oliver, Jack [E.], and Major, Maurice. Leaking modes and the PL phase: Seismol. Soc. America Bull., v. 50, no. 2, p. 165-180, 1960.

The PL phase is a normally dispersed train of waves of periods greater than about 10 sec beginning at or near the time of the initial P-wave and sometimes continuing at least to the time of the beginning of the Rayleigh-wave train. With adequate instrumentation the PL phase is commonly observed at distances less than about 25° from shallow shocks. In general, surface particle motion is elliptical and progressive, and amplitudes are not greater than about one-quarter those of Rayleigh waves of the same period. Comparison of PL- and Rayleigh-wave dispersion shows that both waves propagate in roughly the same near-surface wave guide. Whereas Rayleigh waves correspond to normal- (nonleaking-) mode propagation, PL waves appear to correspond to leaking-mode propagation within this wave guide. — Authors' abstract

- 183-155. Herrin, Eugene, and Richmond, Jean. On the propagation of the Lg phase: Seismol. Soc. America Bull., v. 50, no. 2, p. 197-210, 1960.

Empirical determinations of the mean surface velocity of Lg indicate a range from 3.47 to 3.54 km/s, with one set of velocities off the east coast of Mexico as low as 3.20 km/s. Computations based on ray theory show that Lg with these velocities may be shear waves guided in the upper crust by an alternation of refractions and surface reflections. The slower velocities would result from shear waves traveling almost entirely in the sedimentary layer. Polarization of Lg is related to the angle at which the guided shear waves are incident at the surface. Calculations show that Lg would travel in a continental crust covered by a considerable thickness of water, thus supporting the hypothesis that the absence of Lg indicates that an oceanic crust underlies such bodies of water as the Gulf of Mexico. All computations were run on the Univac 1103 at Southern Methodist University. — Authors' abstract

- 183-156. Nafe, John E., and Brune, James N. Observations of phase velocity for Rayleigh waves in the period range 100 to 400 seconds: *Seismol. Soc. America Bull.*, v. 50, no. 3, p. 427-439, 1960.

Phase velocity as a function of period has been determined for Rayleigh waves in the period range 100-400 sec. The results were derived from a study of seismograms from the southeastern Alaska earthquake of July 10, 1958, and from published data on the Assam earthquake of August 15, 1950. The method depends on measurement of the traveltime of wave crests along an arc of known length, with proper correction for change of period with distance. For observations of a single Rayleigh wave train at a single pair of observing stations, crest identification is uncertain, and so too is the resulting curve of phase velocity versus period. A set of phase velocity curves may be computed, each one corresponding to a different choice of crest identification. Only one of these is consistent with the data from several earthquakes and several pairs of observing stations. In the present work, high precision in phase velocity measurement is achieved by using the observations of the Rayleigh waves R_3 and R_5 at Pasadena of the Assam earthquake. Data from the southeastern Alaska earthquake are used to resolve the ambiguity resulting from uncertainty in crest identification. The final phase velocity curve is estimated to be accurate to better than one percent in the range of periods 100-400 sec. — Authors' abstract

- 183-157. Jobert, Nelly. 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]: *Acad. Sci. [Paris] Comptes Rendus*, v. 250, no. 22, p. 3693-3695, 1960.

This is a continuation of the study of Love-wave dispersion at the earth's surface (see *Geophys. Abs.* 179-126, 182-130). The phase velocities and group velocities for the fundamental mode according to the Lehmann and Gutenberg earth models are compared in a graph. The group velocities are very similar for wavelengths less than 300 km (period less than 70 sec) and would be in better agreement with observations if a value of 3.55 km/s were taken for crustal velocity rather than 3.6 km/s. For longer wavelengths the Lehmann model gives higher velocities; the group velocity is closer to that observed for continental Love waves of long wavelength.

Gutenberg's oceanic model is then compared with his continental model for the fundamental mode and first harmonic. For the fundamental mode of waves some hundred kilometers long, the phase and group velocities are larger for the oceanic model than for the continental model; this difference decreases as wavelength increases. These waves are less dispersed in the oceanic model. The variation of group velocity has its maximum toward a period of 30 sec (group velocity 4.5 km/s) and minimum toward a period of 3 min (group velocity 4.4 km/s). The variation in the first harmonic is more regular.

For wavelengths of the order of 100 km the amplitude function Y in the oceanic model shows a secondary maximum at a depth close to that of the low velocity layer; the maximum group velocity is also in this region. The wave guide therefore can be excited from the surface under certain conditions. — D. B. V.

- 183-158. Öcal, Nevzat. Die Dispersion von Oberflächenwellen im asiatischen Kontinent [The dispersion of surface waves in the Asiatic continent (with English summary)]: *Gerlands Beitr. Geophysik*, v. 69, no. 1, p. 35-56, 1960.

The dispersion of Love and Rayleigh waves across Asiatic paths is analyzed, using seismograms obtained in 1936-51 at the Kandilli-Istanbul station

in Turkey. Using Sato's formulas and nomograms, 146 Love wave dispersion curves were computed; a comparable number were computed for Rayleigh waves.

Values obtained for crustal thickness, transverse wave velocity, ratio of transverse wave velocity in the upper layer to that in the underlying half space, and ratio of rigidity modulus in the upper layer to that in the underlying half space differ for the two waves used. The Rayleigh wave results agree well with those of Akima (see *Geophys. Abs.* 162-113). — D. B. V.

183-159. Kizawa, Takashi, and Yamaguchi, Rinzo. Some new phases observed in a study of earthquake swarms relating to volcanic activity, (2): *Geophys. Mag.* [Tokyo], v. 30, no. 1, p. 93-129, 1960.

Two new phases (called the "third" and "fourth") with markedly slower group velocities were detected in a study of earthquakes due to activity at Usu Volcano in Japan (see *Geophys. Abs.* 182-134). The nature of these phases is investigated by means of computer calculations of Rayleigh wave dispersion curves corresponding to different models. It was assumed that the path of propagation consists either of liquid-liquid-solid or of liquid-solid-solid layers, and the calculations were made for different thicknesses, density, and elastic constants for each layer. The results are presented in 20 pages of tables.

The model that best fits the observed data is a water-sediment-solid model in which the sedimentary layer is fairly thick and has a velocity lower than that of the water layer. — D. B. V.

Dorman, James, and Prentiss, David. Particle amplitude profiles for Rayleigh waves on a heterogeneous earth. See *Geophys. Abs.* 183-189.

183-160. Ingram, R. E. An integral solution of the electromagnetic seismograph equation: *Seismol. Soc. America Bull.*, v. 50, no. 3, p. 461-465, 1960.

In investigating the response of an electromagnetic seismograph to various ground movements it is advantageous to have the solution of the differential equation as an integral. This is done by finding the Green's function, $f(s)$, for the particular instrument. The angular movement of the galvanometer is then

$$\theta(t) = q \int_0^t f(s) x''(t-s) ds$$

where $x(t)$ is the ground movement and prime stands for the operator d/dt . It is sufficient to find one function, $F(s)$, with $dF/ds = f(s)$, to give the response to a displacement test, a tapping test, or a ground movement. — Author's abstract

183-161. Walter, Edward J. The interpretation of vibration records: *Earthquake Notes*, v. 30, no. 4, p. 37-41, 1959.

One phase of interpretation of vibration records, the equivalent use of acceleration and displacement, is discussed. The computation of displacement from acceleration, and vice versa, in vibration analysis should be done with great care so as not to overlook significant low amplitude events of a critical frequency on the records. It is suggested that if a displacement index is to be used as a criterion for damage, then displacement meters should be used as measuring instruments. Conversely, if acceleration is to be used as the index of damage, then accelerometers should be used. Other solutions would be the use of integrating and differentiating devices, or the use of instruments that have a flat response curve so that magnification is independent of frequency. — V. S. N.

- 183-162. Panasenko, G. D. Ob opredelenii elementov seysmicheskogo lucha po dannym odnoy stantsii [On determination of elements of a seismic ray from the data of a single station]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 548-556, 1960.

An evaluation is given of errors in determining the azimuth angle and the modulus of the horizontal component of the displacement vector in a three-component arrangement of seismographs, depending on the magnitude of the azimuthal angle. It is shown that the probability of those errors with respect to the smallest error at an angle of 45° increases rapidly as the azimuthal angle decreases. The conditions under which the required accuracy in determining the azimuthal angle and the modulus of the horizontal component can be achieved are defined. A four-component system of seismograph arrangement is proposed. Its advantages in comparison with the three-component system are shown. Examples of determination of the azimuthal angle and the apparent emergence angle of a seismic ray according to the records of a four-component unit of general type seismographs (Kirnos) of the Apatity seismic station are discussed. — Author's abstract, A. J. S.

- 183-163. Peterson, P. Checking the performance of electrodynamic seismometers: Seismol. Soc. America Bull., v. 50, no. 4, p. 561-562, 1960.

The performance of electrodynamic seismometers slowly deteriorates as the magnets age and the hinges become strained. This deterioration can be determined by the extremely simple measurement of the d-c sensitivities of the seismometer and galvanometer, and the change in the theoretical synchronous magnification can be calculated. — Author's abstract

- 183-164. Melton, Ben S. An explanation of Benioff calibration procedures and associated concepts: Earthquake Notes, v. 30, no. 4, p. 41-47, 1959.

Instructions are given that will enable an operator to calibrate a Benioff seismograph under field conditions. Empirical constants used refer to the combination of a Geotechnical Model 1051 seismometer and a Geotechnical Model 1305-1 (5 cycles per sec) galvanometer, under normal adjustment where the seismometer magnets are charged to produce a normal air-gap flux of 750 gauss, and the galvanometer magnets are charged to produce a nominal 4,400 gauss threading the coil. Shaking-table measurements provide empirical relations of accuracy sufficient for practical calibration of the system in terms of earth motion.

The calibration instructions are followed by a few notes on theoretical relations for those who wish to consider some of the fundamental factors affecting the characteristics of the Benioff seismograph. Some of the relations between amplitude, velocity, and acceleration functions and the reasons for their use are clarified, and, finally, a brief discussion of terminology of units is given. — V. S. N.

- 183-165. Karras, M., and Nurmia, M. A method for the calibration of seismographs: Geophysica [Helsinki], v. 7, no. 2, p. 73-76, 1960.

A seismograph calibrating method involving the use of a known sinusoidal force produced with a coil system and a permanent magnet is described. The system is suitable for the calibration of both mechanical and electrical seismographs over a very wide frequency range. The magnification curves of the seismograph types now employed in Finland are given. — Authors' abstract

- 183-166. Bereza, G. V. O proverke identichnosti kanalov seismicheskoy stantsii [On the checking of the identity of channels of a seismic station]: *Razvedochnaya i Promyslovaya Geofizika*, no. 18, p. 41-43, 1957.

The method of checking multichannel seismic stations for channel identity proposed by Khokhlov (see *Geophys. Abs.* 181-463) is criticized, and measures are suggested for improving the method used at present. — A. J. S.

- 183-167. Gilman, Ralph. Report on some experimental long-period seismographs: *Seismol. Soc. America Bull.*, v. 50, no. 4, p. 553-559, 1960.

The unexpected usefulness in research of the Press-Ewing seismograph system (see *Geophys. Abs.* 172-46) has stimulated further efforts to obtain even higher seismograph sensitivity in the period range beyond 100 sec. A major difficulty has been in maintaining pendulum stability at long periods. This paper describes a stable long-period seismometer and gives results from several seismograph systems incorporating long-period pendulums and galvanometers.

The results suggest that long-period seismographs may provide as much or more information about the focal mechanism of earthquakes as short period instruments. The instrument here described may be able to record free vibrations of the earth if they are sufficiently large. Ultra-long period waves recorded following the earthquake of January 13, 1960, are now being studied to see if they are free vibrations of the earth; a report on this work will appear shortly. — D. B. V.

- 183-168. Hudson, Donald E[llis]. The Wilmot survey type strong-motion earthquake recorder: *California Inst. Tech. Earthquake Eng. Research Lab. Rept.*, 20 p., 1958.

The Wilmot survey type strong-motion earthquake recorder, an instrument for the direct measurement of one point on the response spectrum of the ground motion caused by strong-motion earthquakes, is described and its theory of operation discussed. Results of tests on two instruments for tilt sensitivity, damping, and period, and of direct comparisons between the instrument results and the spectrum analysis of base accelerations lead to the conclusion that the instrument is suitable for application to strong-motion earthquake measurement. — V. S. N.

- 183-169. Nurmia, M. Some inexpensive seismometer designs: *Geophysica [Helsinki]*, v. 7, no. 2, p. 77-82, 1960.

Some seismometer types developed in Finland from 1956 to 1959 are described, and data on their performance are given. The vertical seismometers designed employ the variable-reluctance principle, and the system may be considered a double Benioff transducer with coils common to both systems. The new short-period horizontal seismometer employs a two-pole magnet which moves laterally with respect to a coil system that is similar to those used in the vertical instruments. A very simple moving-magnet electrodynamic long-period seismometer was also designed. — V. S. N.

- 183-170. Siivola, A. A new seismograph recorder with transistor amplifiers: *Geophysica [Helsinki]*, v. 7, no. 2, p. 107-116, 1960.

A seismograph recording system consisting of a transistor amplifier, a moving-coil pen unit, and a smoked-paper recorder is described. The ampli-

fier has four directly coupled differential stages, and its power gain is 64 db with a generator resistance of 10 k Ω and a load resistance of 1 k Ω . — V. S. N.

- 183-171. Watt, P. A. The application of a D. C. amplifier to seismic recording: *Seismol. Soc. America Bull.*, v. 50, no. 3, p. 471-476, 1960.

The paper describes a d-c chopper stabilized amplifier which is being used to amplify seismic signals from a Willmore S. P. geophone to a level suitable for direct recording on a 0-1 ma pen recorder. The overall magnification of the system is approximately 10,000 while the amplification of the d-c amplifier is 60v per μ a. The frequency response of the amplifier is direct current to 75 cycles per second (3 db down). — Author's abstract

- 183-172. Korostin, G. N. Optikomekhanicheskiy akselerograf s polutenevoy registratsiyey [Optico-mechanical accelerograph with semi-shaded recording]: *Akad. Nauk SSSR Sovet po Seysmologii Byull.*, no. 8, p. 206-211, 1960.

Three special devices designed to furnish a record of ground acceleration at the time of registration of an earthquake are described. The first is a system which switches the accelerograph on and off automatically, the second is the accelerograph itself (based on optical principles), and the third is a punch-tape recording device. The last can be used with other types of apparatus also. The paper is illustrated with photographs and schematic diagrams. — D. B. V.

- 183-173. Fremd, V. M. Datchik s fotosoprotivleniyem dlya seysmicheskikh stantsiy [A pickup with photo-resistance for seismic stations]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 3, p. 482-483, 1960.

To satisfy the requirement that the pendulum of the SVK seismograph should not deviate from its equilibrium position by more than two divisions of the scale, a pickup consisting of an FSK-1 photoresistance and a special illuminator were constructed to maintain the pendulum in its equilibrium position automatically. The inertia of the device is determined to be 0.03-0.04 sec. The device has been tested at the Alma-Ata Central Seismic Station where it has been in operation since 1958. — A. J. S.

Lyamzina, G. A. Determination of velocity of propagation of elastic waves on small bases in the study of the seismic properties of foundations. See *Geophys. Abs.* 183-212.

- 183-174. Robson, G. R. Seismic stations in Jamaica: *Geonotes*, v. 2, no. 4, *Geol. Survey Jamaica Pub.*, no. 59, p. 134, 1960.

By mid-1960, the Seismic Research Unit of the Imperial College of Tropical Agriculture (soon to become part of the University College of the West Indies) will have established 3 seismograph stations in Jamaica at Hope, Black River, and Beverly Land Settlement. Each station will be equipped with a 1-sec-period seismometer and a $\frac{1}{4}$ -period galvanometer. — V. S. N.

EARTH TIDES AND RELATED PHENOMENA

- 183-175. Longman, I. M. The interpolation of earth-tide records: *Jour. Geophys. Research*, v. 65, no. 11, p. 3801-3803, 1960.

A method is presented whereby earth-tide gravity records can conveniently be interpolated. It is based on the theoretical rigid-earth gravity tide $g_0(t)$

and its time derivative. The possibility is envisaged that earth-tide gravity records may be generated in their entirety by this method if a pair of constants has been determined. — V. S. N.

183-176. Zotov, P. P., Lyustikh, Ye. N., and Magnitskiy, V. A. Razogrevayut li Zemlyu sily tyagoteniya? [Is the earth heated by gravity force?]: Priroda, no. 3, p. 122-124, 1960.

A hypothesis is proposed that a part of the earth's heat originated from tidal friction due to the earth's rotation in the gravitational fields of the sun and moon. Tides in the solid earth reach 50-60 cm in the region of Moscow, and such a displacement of the earth's mass leads to friction between particles and to generation of heat. Zotov has computed that during the 5 billion years of its existence, the earth has made 10 trillion revolutions on its axis, each revolution generating a certain quantity of heat. Considering that in its past the moon was several times closer to the earth than it is now, the earth tides were tens and hundreds of meters high, traveling in the earth's body with much greater (10,000 km per hr) velocity than now. Assuming that the earth has increased its period of rotation from 4 to 24 hr and that its mass and moment of inertia have remained the same, the amount of heat generated up to the present time should be 1.07×10^{30} ergs, less a potential energy of about 15 percent stored in the removed moon. This would produce 2.17×10^{30} cal of heat, which is 11 billion times the heat (2.0×10^{20} cal per yr) released by the earth per yr. Taking the specific heat of the earth's matter to be 0.2 cal per g X degree, the above calculated quantity of energy could heat the entire earth from 0°C to 1,800°C. This tidal heat is found to equal two-thirds of the radiogenic heat generated in the earth in 5 billion years. The tidal heat so formed and accumulated during the cosmic history of the earth is considered to participate in the tectonic processes in the earth. Since the tidal heat generation under the continents and the oceans is practically the same, this would explain why the heat flux at the bottom of the oceans and on the continents is the same, contrary to the radiogenic heat theory. — A. J. S.

183-177. Witkowski, Jozef. Earth tides and their observation at the latitude station of the Polish Academy of Sciences: Acad. Sci. Poland Rev., v. 5, no. 1, p. 53-62, 1960.

A brief historical review is given of the development of the idea that the earth is an elastic body and as such should undergo deformation from the action of solar and lunar tide-generating forces, and should show tides somewhat similar to ocean tides. The forces responsible for earth tides (lunar, solar, and terrestrial gravitational action, the centrifugal force of the rotation of the earth, and the corresponding force in the movement of the earth around the center of mass of the Earth-Moon or Earth-Sun system) and the groups of terms that may be distinguished in developing the function of the potential of the disturbing forces are discussed. An analysis is made of the better known and observed manifestations of earth tides: deflection of the vertical in relation to the Earth's crust, deflection of the vertical in relation to the celestial axis, changes in the force of gravity, and diminution of the ocean tide amplitude. Mention is also made of two less explored phenomena: elastic stress in the earth's crust and tides in subterranean water bodies.

The permanent gravimetric and pendulum stations of the Polish Academy of Sciences at Borowiec, part of the International Geodetic Union's world-wide chain of 33 stations, are described. Results obtained for the previous 8 months at this station were presented at the earth tide symposium in Trieste in 1959 and confirmed, in general, the results by other gravimetric and pendulum stations.

The present elastic properties of the earth in terms of Love's numbers as obtained from existing observations of the entire earth tide phenomena are given. — V. S. N.

ELASTICITY

- 183-178. Deresiewicz, H. The effect of boundaries on wave propagation in a liquid-filled porous solid: 1. Reflection of plane waves at a free plane boundary (non-dissipative case): *Seismol. Soc. America Bull.*, v. 50, no. 4, p. 599-607, 1960.

A general solution is deduced of the differential equations which describe the propagation of elastic waves in a nondissipative liquid-filled porous solid. The solution is then used to examine some of the phenomena which arise when each of the three body waves predicted by the field equations is, in turn, incident on a plane traction-free boundary. It is found, for example, that an obliquely incident wave of each type in general gives rise to reflected waves of all three types. — Author's abstract

- 183-179. Bortfeld, Reinhard. Seismic waves in transition layers: *Geophys. Prosp.*, v. 8, no. 2, p. 178-217, 1960.

A transition layer is a layer lying between two layers of constant velocity v_a and v_e , respectively, in which velocity changes linearly with depth from v_a to v_e . Seismic events within and without the transition layer that result when a plane displacement wave leaves the upper layer (v_a) and is vertically incident on the transition layer are calculated, using elementary calculus methods.

The transition layer is regarded as the limit of a sequence of constant-velocity-layer divisions, so that after computing the first few multiples of the incident wave for these divisions the respective multiples of the transition layer are obtained as the limit of these multiples. Then the multiples of the transition layer of any order can be computed by means of recurrence formulas. The sum of all multiples defines the complete response of the transition layer and satisfies the differential equations of the problem.

The solution has the form of a superposition integral, and the transition layer is seen to have the properties of a linear filter. The superposition integral is built up out of the incident wave and a conglomerate of Bessel functions which are the response corresponding mathematically to an incident spike impulse. The reflected and transmitted responses to the spike impulse are shown for two values of the velocity ratio. For large values of this ratio, both responses have a wave-like shape and the transition layer may seriously affect the shape of the incident waves. — D. B. V.

- 183-180. Black, M. C., Carpenter, E. W., and Spencer, A. J. M. On the solution of one dimensional elastic propagation problems in stratified media by the method of characteristics: *Geophys. Prosp.*, v. 8, no. 2, p. 218-230, 1960.

A numerical method of solution for wave propagation in a medium in which the elastic parameters and density vary with depth in any specified way is described. Results for a simple two-layer problem are given to illustrate the method and indicate its potential value. Computations become more laborious as the number of layers and complexity of boundary conditions increase, but high-speed digital computers can be used for the more complicated problems. — D. B. V.

- 183-181. Duda, S. J. Elastische Wellen im anisotropen Medium nach einer makroseismischen Untertage-Messung [Elastic waves in the anisotropic medium according to a macroseismic measurement underground (with English summary)]: *Geophys. Prosp.*, v. 8, no. 3, p. 429-444, 1960.

A third direct wave that has a velocity somewhat lower than the shear wave has sometimes been observed in seismic surveys in some of the Siegerland mines in Germany. In order to determine the nature and origin of this wave, investigations were made to establish the direction of oscillation and velocity of all three direct waves.

The third wave is identified as a second shear wave. Evidently the shear wave is doubly refracted, the wave of higher velocity being a pure transverse wave and the one of lower velocity a quasi-transverse wave. The transverse anisotropy of the medium is due to the stratification. It is not possible to decide whether the schistosity also causes anisotropy.

Further calculations rule out the possibility that the third wave is a surface wave propagated on the walls of the mine gallery. — D. B. V.

- 183-182. Mitra, Manindra. On the application of Cagniard's method to dynamical problems of elasticity: *Gerlands Beitr. Geophysik*, v. 69, no. 2, p. 73-86, 1960.

A method is given for calculating the surface displacement produced by time-dependent body forces acting within an isotropic, homogeneous, fully elastic half space, by applying Cagniard's method of inverting Laplace transforms. The advantage of the method is that displacement due to certain types of body forces can be calculated numerically to any desired degree of accuracy, which is not possible with methods using Fourier integrals. — D. B. V.

- 183-183. Bagdoyev, A. G. Opredeleeniye davleniya v okresnosti fronta [Determination of pressure in the neighborhood of a front]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 5, p. 653-657, 1960.

The distribution of wave pressure according to the depth in a liquid half space in the neighborhood of a wave front is discussed and treated mathematically in the first part of the paper. The second part deals with the same problem for an elastic half space. The stress tensor and pressure at the front of the wave in the half space are calculated, and an asymptotic formula derived for the case of an inhomogeneous half space. The solution is given in the form of a power series of τ , which is the moment following the passage of the front through the point. — A. J. S.

- 183-184. Pariyskaya, G. N., and Kun, V. V. Ob otноситel'noy intensivnosti golovnykh voln, rasprostranyayushchikhsya v sredakh s vertikal'nymi granitsami razdela [On the relative intensity of head waves propagating in media having vertical discontinuities]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 5, p. 725-732, 1960.

This is a continuation of Kun's paper (see *Geophys. Abs.* 182-156) devoted to the problem of the intensity of head waves generated in a medium having a vertical discontinuity. The ratio of the intensity of waves that approach the discontinuity to that of waves that pass it is studied, and approximate formulas are derived for the case when the discontinuity has a covering stratum. The effects of divergent fronts and the correlation of parameters of elasticity of the medium with the relative intensity of the waves that cross the boundary are discussed and analyzed. — A. J. S.

- 183-185. Khaykovich, I. M., and Khalfin, L. A. Ob effektivnykh dinamicheskikh parametrakh uprugikh sred pri rasprostranении ploskoy poperechnoy polarizovannoy volny [Effective dynamic parameters of elastic mediums for propagation of plane transverse polarized waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 815-826, 1959.

A solution is found to the problem of the passage of a plane transverse polarized wave through a two-component medium with one component dispersed regularly through the other. The case for plane longitudinal waves was treated in a previous paper (see Geophys. Abs. 180-85). Expressions are obtained for the effective velocity of the transverse waves and for the effective density. These expressions are functions of frequency. This explains the fact that dispersion and absorption can occur in a two component medium made up of constituents, neither of which alone exhibits either dispersion or absorption. The effective velocity can be purely imaginary for certain frequencies; therefore, an inhomogeneous two-component elastic medium can become an exponentially absorbent medium. — J. W. C.

- 183-186. Mitra, M[anindra]. Solution of the buried source problem for an extended two-dimensional source in an elastic medium: India Natl. Inst. Sci. Proc., v. 25, pt. A, no. 5, p. 236-242, 1959.

The surface displacement due to an extended two-dimensional source inside a homogeneous, semi-infinite, isotropic, elastic medium is calculated in terms of definite integrals. It is found that the displacement changes continuously. Expressions are also obtained for the body forces that produce the disturbance. — V. S. N.

- 183-187. Nagumo, Shozaburo. On the propagation of transient elastic waves: Japan Geol. Survey Rept., no. 184, 50 p., 1960.

The propagation of transient elastic waves in two dimensions is investigated by the method of dual integral transformation. A Laplace transformation is applied to the time coordinate, and a Fourier transformation is applied to one space coordinate. A simple mathematical expression for solving the problem is presented.

In chapters 1 and 2, the rewritten forms of the surface force problem and the buried line source problem in a solid are presented to illustrate the method of application of the dual integral transformation. In chapter 3, the problem of reflection and refraction of an acoustic pressure pulse at a liquid-liquid interface is analyzed in order to clear up the basic picture of reflection and refraction of a pulse that has a curved wave front. In chapter 4, diffraction of an acoustic pressure pulse by a finite fixed plane placed in a liquid is investigated. Application of a convolution formula to the inverse transformation leads to an exact solution of a form of the integral of elementary functions. An interpretation of the mechanism of a diffraction phenomenon is presented. — V. S. N.

- 183-188. Usami, T[atsumo]. Elastic waves generated from an elliptic cylindrical origin under the ground: Geophys. Mag. [Tokyo], v. 30, no. 1, p. 19-91, 1960.

In continuation of a study of the effect of the shape of the source on the initial motion of the P-wave (see Geophys. Abs. 172-40), the problem of an elliptic cylindrical source of a depth d is investigated. Numerical calculations are made for 25 cases, 11 for dilational and 14 for distortional sources, with different values of ellipticity and axial inclination of the ellipse.

It is concluded that (1) the elliptic cylindrical wave functions can be expanded into the series of cylindrical wave functions; (2) the direct P-, Rayleigh-, and surface S-waves appear for the dilational source and the direct S-, surface P-, and Rayleigh-waves appear for the distortional source; (3) in the case of dilatation the push region of initial motion becomes more distinct in the direction of the long axis of the elliptic source as the ellipticity increases, regardless of inclination; (4) there are slight differences between cases in the displacements due to Rayleigh and surface P- and S-waves; and (5) in the distortional case, the direction of displacements due to the direct S-wave changes at a point near the epicentral distance where total reflection occurs.—D. B. V.

- 183-189. Dorman, James, and Prentiss, David. Particle amplitude profiles for Rayleigh waves on a heterogeneous earth: *Jour. Geophys. Research*, v. 65, no. 11, p. 3805-3816, 1960.

The relationship between vertical and horizontal particle amplitude and depth for Rayleigh waves was obtained for several models of a heterogeneous, solid half-space using a new computing program for the IBM 650. The data show how the well-known characteristics of Rayleigh wave motion on a homogeneous half-space are modified in the common case in which compressional and shear velocities increase downward in the earth and also in the case in which a low-velocity region such as the mantle or asthenospheric low-velocity channel exists. Theoretical particle amplitude profiles and dispersion curves, computed on the basis of bore hole measurements of compressional and shear velocities made by Dobrin, Simon, and Lawrence, are compared with data on explosion-generated Rayleigh waves of 4 to 8 cycles per second recorded by them in the bore hole. Observed particle trajectories and computed amplitude profiles are in good agreement except in the upper 10 feet, where the very large horizontal amplitudes predicted by theory, particularly for short periods, are not shown in the field observations. Particle amplitude profiles based on Gutenberg's model of the mantle are given for a broad spectrum of mantle Rayleigh wave and long-period crustal Rayleigh wave frequencies. These data show that the heterogeneous character of the mantle cannot be neglected in the problem of crustal Rayleigh wave dispersion. They also show that no "captured waves" or "channelled waves" of unusual character exist in the Rayleigh mode. Instead, particle motion profiles for the heterogeneous earth differ only slightly from the profile for Rayleigh waves on a homogeneous half-space throughout the spectrum of this mode. — Authors' abstract

- 183-190. Sato, Yasuo. Synthesis of dispersed surface waves by means of Fourier transform: *Seismol. Soc. America Bull.*, v. 50, no. 3, p. 417-426, 1960.

Flexural disturbances propagated upon a thin aluminum plate were studied experimentally. The thickness of the plate is 1.0 mm, and the distances between the source and the observation points are $r=0, 3.0, 5.0, 7.0, 15.0,$ and 20.0 cm. Using the method of Fourier transform, the dispersion curve was obtained. It agrees well with the theory, and the thickness of the plate was estimated with good accuracy (0.981 mm). Disturbances at the distances 7.0, 3.0, and 0 cm were numerically reproduced by means of Fourier synthesis from the data obtained at $r=15$ cm and 20 cm, and were compared with the observed disturbances. The agreement of the two kinds of curves is fairly good, with a little larger discrepancy for the case of $r=0$ than for the others. — Author's abstract

- 183-191. Healy, John H., and Press, Frank. Two-dimensional velocity depth and density functions: *Geophysics*, v. 25, no. 5, p. 987-997, 1960.

This paper describes a method of modeling a medium with variable velocity depth and density functions, based on the two-dimensional model techniques described by Oliver and others (see Geophys. Abs. 157-90). Waves propagating in thin sheets obey the two-dimensional equation; a variable velocity is obtained by the use of a laminated sheet (made of aluminum sheets and epoxy resin) in which the relative proportions of the laminae are varied so as to change the average elastic constants, and hence the average velocities, of the sheet. The density can be modeled by changing the total thickness of the sheet.

The method is justified theoretically. It is tested by comparing the experimental and theoretical dispersion of Rayleigh waves in a model of a two-layered crust. — D. B. V.

- 183-192. Baule, H. Anomale Ultraschall-Geschwindigkeiten in Gesteinsbohrkernen [Anomalous ultrasonic velocities in rock drill cores (with English abstract)]: Geophys. Prosp., v. 8, no. 2, p. 148-153, 1960.

The velocity of supersonic pulses in cylindrical drill cores and rock samples is measured as a function of the frequency or wave length λ of the pulses. If λ is very much lower than the diameter D of the drill core — $\lambda \ll D$ — the higher velocity of the longitudinal waves v_l appears; on the other side we get the lower velocity of the rod waves v_d (Stabdehnungswellen) if $\lambda \gg D$.

Some drill cores from the Carboniferous were found, the velocities of which for sonic and supersonic pulses do not follow the above rule. It is shown that these cores have a constant velocity both for short and for long wave lengths in a frequency range between 5 kilocycles and 2 megacycles. — Author's abstract

- 183-193. Rizničenko, J. V. [Riznichenko, Yu. V.]. Einige Ergebnisse in der Anwendung seismoakustischer Methoden bei der Untersuchung des Spannungszustandes von Gesteinen [Some results of the application of seismoacoustic methods to the investigation of the state of strain in rocks]: Freiburger Forschungshefte C 81 Geophysik, p. 187-197, 1960.

This is a summary of the results of Soviet investigations of strain conditions in mines, using seismoacoustic methods. The work has proceeded in three directions: (1) ultrasonic study of the elastic properties of rocks under pressure (see Geophys. Abs. 172-67, 177-97); (2) ultrasonic study of strain conditions in place in mines (see Geophys. Abs. 164-300); and (3) investigation of the deformation process in rocks by the natural impulse method (see Geophys. Abs. 171-341, 180-90). Examples are given of each type of research. The results are useful not only in practical mining problems but also from the point of view of geophysics in general. — D. B. V.

- 183-194. Mjačkin [Myachkin], V. I. Untersuchung der Stützdruckdynamik im Kohlenflöz mit Hilfe seismischer Impulsmethoden [Investigation of the dynamics of pressure in coal seam supports with the aid of seismic impulse methods]: Freiburger Forschungshefte C 81 Geophysik, p. 198-208, 1960.

Results of ultrasonic impulse investigations of underground pressure in coal mines are reported. The method and apparatus are described briefly. The relation of elastic wave velocities to pressure was measured for artificial pressures up to 160 kg per cm^2 , and extrapolated to 500 kg per cm^2 . Fundamental laws were established concerning the distribution of dynamic pressure values in mine pillars. (See also Geophys. Abs. 169-315.) — D. B. V.

- 183-195. Volarovich, M. P. Erforschung elastischer Gesteinseigenschaften bei hohem Druck [Investigation of elastic properties of rocks at high pressure]: Freiburger Forschungshefte C 81 Geophysik, p. 231-242, 1960.

This is a review of results of investigations of the elastic properties of rocks under high pressures, undertaken in the high pressure laboratory of the Institute of Physics of the Earth in the U. S. S. R. (See Geophys. Abs. 169-93, -312, -313, -314; 170-68; 175-91; 178-106; 181-168.)—D. B. V.

- 183-196. Hunkins, Kenneth. Seismic studies of sea ice: Jour. Geophys. Research, v. 65, no. 10, p. 3459-3472, 1960.

During the International Geophysical Year, elastic wave propagation in sea ice was studied near Drifting Station Alpha in the central Arctic Ocean. Velocities of longitudinal and transverse waves in ice showed a marked seasonal change which is largely attributable to variations in ice temperature. With these velocity data, plus additional data on density, the calculation of various elastic constants of sea ice throughout the year can be made. Flexural wave dispersion was investigated for different ranges, charge sizes, and ice parameters. Experimental results are in general agreement with theory. Thickness, as determined from the dispersion of flexural waves and from air-coupled flexural waves, is characteristically lower than that found by direct measurement. Both longitudinal and flexural waves crossing leads suffer severe attenuation. Transmission across leads shortened the duration of the normal air-coupled flexural wave train. — Author's abstract

- 183-197. Anderson, D. L. Preliminary results and review of sea ice elasticity and related studies: Eng. Inst. Canada Trans., v. 2, no. 3, p. 116-122, 1958; reprinted in Natl. Research Council Canada Associate Comm. on Soil and Snow Mechanics Tech. Mem., no. 56, 1958.

Preliminary results from data accumulated by the Air Force Cambridge Research Center and the Arctic Institute on elasticity and other parameters of sea ice from 4 inches to 5 feet thick under a variety of conditions are discussed. Methods of determining elasticity may be divided into static and dynamic determinations in both laboratory and field studies.

Two valuable in-place field methods are deflection and seismic. Preliminary results indicate that the elasticity of sea ice is less than that of fresh ice and varies over at least an order of magnitude. Results obtained from the seismic method are generally an order of magnitude greater than small sample static values. Preliminary analysis indicates that elasticity can be related to a parameter that includes temperature and liquid- and air-content. — V. S. N.

- 183-198. Birch, Francis. Elastic constants of rutile—a correction to a paper by R. K. Verma, "Elasticity of some high-density crystals": Jour. Geophys. Research, v. 65, no. 11, p. 3854-3855, 1960.

The appreciable discrepancy between the elastic constants for synthetic rutile found by Verma (see Geophys. Abs. 181-161) and those reported by other investigators are largely removed if Verma's measurements are recalculated on the assumption that the direction that he took for (100) was in fact (110) and vice versa. This assumption has been confirmed by X-ray analysis of one of his samples. Recalculated values, with various derived quantities, are tabulated, together with comparable values from other authors. — D. B. V.

Yashchenko, Z. G., and Yesakov, I. S. On application of electric prospecting to studies of elastic properties of rocks. See *Geophys. Abs.* 183-275.

- 183-199. Diment, W[illiam] H., Stewart, S[amuel] W., and Roller, J[ohn] C. Maximum ground accelerations caused by nuclear explosions at distances of 5 to 300 kilometers, in *Geological Survey research 1960*: U. S. Geol. Survey Prof. Paper 400-B, p. B-160-B-161, 1960.

Seismic recordings were made of most of the nuclear explosions in the 1957 and 1958 series of nuclear tests, Plumbbob and Hardtack-Phase II. For underground nuclear explosions in tuff, the following empirical scaling relation was developed between the maximum single component of acceleration (A, in units of gravity), yield (W, in kilotons), and distance (D, in kilometers): $A=0.6W^{0.8}/D^2$. This relation is based on data obtained in the distance range 20-70 km, and is supported by data obtained in the range 5-300 km. Maximum accelerations recorded on alluvium are several times as high as those recorded on tuff or bedrock; the better contained explosions appear to give higher acceleration than those that are less well contained. No similar scaling relation has been established for maximum accelerations from explosions in air. However, the exponent of yield for explosions in air at identical heights above the ground is at least 0.6 when heights of 500, 750, and 1,500 feet are considered.

Frequency of waves of maximum acceleration for underground explosions ranged from 2-12 cycles per second. Maximum accelerations occurred in both body and surface waves, but more commonly in the latter. Observations within 60 km indicate that explosions in air above a nearly flat surface of alluvium more than 1,000 feet thick are better generators of surface waves than explosions in the tuff. — V. S. N.

- 183-200. McKeown, F. A., and Dickey, D. D. Some relations between geology and effects of underground nuclear explosions at Nevada Test Site, Nye County, Nevada, in *Geological Survey research 1960*: U. S. Geol. Survey Prof. Paper 400-B, p. B-415-B-417, 1960.

Two underground nuclear explosions in the tuff of the Oak Spring formation, Nev., provided data for evaluating geologic control of fracturing within tunnels and at the surface. It was concluded that the extent and intensity of fracturing in different directions, and consequently tunnel damage, may to a significant degree depend upon (a) the relations of beds of different chemical and physical properties to the direction of propagation of stress waves, and (b) the angles between the direction of propagation and sets of fractures in the rock. — V. S. N.

- 183-201. Wilmarth, V. R., and McKeown, F. A. Structural effects of Rainier, Logan, and Blanca underground nuclear explosions, Nevada Test Site, Nye County, Nevada, in *Geological Survey research 1960*: U. S. Geol. Survey Prop. Paper 400-B, p. B-418-B-423, 1960.

The Rainier, Logan, and Blanca nuclear explosions, with energy yields of 1.7, 5, and 19 kilotons, respectively, were detonated in massive to well-bedded, friable to compact tuffs of the Oak Spring formation. Nearly all fractures produced by the explosions are within the 1,000-, 2,600-, and 3,300-foot isodistan lines and are most numerous in the welded and bedded tuffs east of the epicenters; the friable tuffs immediately around the epicenters are less

fractured. Most of the fractures dip steeply and coincide with or are parallel to tectonic fractures. Both normal and overthrust faults were produced. Most thrust faults crop out more than 1,800 feet from the chamber in areas where the bedding planes are nearly parallel to radii from the shot chamber. The steeply dipping normal faults trend northwest to northeast, parallel tectonic fractures, have strike lengths of less than 500 feet, and are displaced from 6 inches to 5 feet.

The maximum radial distance from the explosion of fractures in these tuffs scales empirically as the 0.4 power of the yield in tons of the explosion; this applies also to high-explosive tests. — V. S. N.

- 183-202. Shoemaker, Eugene M. Brecciation and mixing of rock by strong shock, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-423-B-425, 1960.

The mixed breccia underlying the nuclear explosion craters and Meteor Crater, Ariz., is interpreted as strictly homologous with the mixed breccia produced by contained nuclear and dynamite explosions, with the debris expelled from sprung drill holes, and the cavity produced by a 10-ton dynamite shot. The mixing appears to have occurred in the shock wave. The distance of the domain of mixing from the point of origin of the shock obeys a simple scaling law with respect to the total energy released and appears to be virtually independent of the character of the material affected and of the mechanism by which the shock is generated. — V. S. N.

- 183-203. Pomeroy, Paul [W.], and Oliver, Jack [E.]. Seismic waves from high-altitude nuclear explosions: Jour. Geophys. Research, v. 65, no. 10, p. 3445-3457, 1960.

The two nuclear explosions, Teak and Orange, fired in the Johnston Island area in August 1958, generated long-period seismic waves of the same order of magnitude as the long-period waves generated by large near-surface nuclear explosions in the Marshall Islands, in spite of the fact that Teak and Orange were detonated high in the stratosphere. Seismic waves of very short period were apparently much weaker in the case of the high-altitude explosions, however. The high-altitude explosions caused a train of surface waves at Honolulu, a part of which corresponds to the segment of the fundamental Rayleigh wave dispersion curve on the short-period side of the group-velocity minimum at a period of about $13\frac{1}{2}$ seconds. This observation implies that the reason these waves are never recorded when the source is an earthquake lies primarily in the excitation rather than in the propagation of these waves. This means that no major revision of our present models of oceanic crustal structure will be required to account for the absence of these waves when the source is an earthquake. T-phases were recorded on the short-period seismographs at Honolulu from both Teak and Orange. No Love waves were recorded from either of these explosions. — Authors' conclusions

- 183-204. Schwind, Joseph J., Berg, Joseph W., Jr., and Cook, Kenneth L. PS converted waves from large explosions: Jour. Geophys. Research, v. 65, no. 11, p. 3817-3824, 1960.

Four seismograms obtained from quarry blasts at Promontory and Lake-side, Utah, and from the Blanca underground nuclear test at Mercury, Nev., were studied to ascertain whether PS converted waves were recorded, and if so whether they could be used in analysis of crustal structure as suggested by Andreyev (see Geophys. Abs. 169-68). It is concluded that PS converted waves probably were recorded. Arrivals, provisionally interpreted as PS converted waves, were detected on the traces of both the radial horizontal-

component seismometers (2 c natural frequency) and the vertical-component seismometers (2 c). The amplitude of the PS converted waves was usually several times greater than that of the first arrival of the P-wave. The successively later arrivals of PS converted waves from successively deeper horizons showed progressively greater ground-velocity amplitudes, as found by Andreyev on earthquake seismograms, but some variance from this generalization was found. The frequencies of the various PS converted wave arrivals were approximately the same as those of the parent P-wave, between 5-10 cycles per second.

Crustal layering calculated from the PS wave arrival times corresponds well with that given by Berg, and others (see Geophys. Abs. 183-395) for this area. Depths to the successive layers are: 5.5, 9.7, 16, and 26 km at Neola, Utah; 8.6-12, 24-26, and 29-31 km at Gold Hill, Utah; and 12, 22, and 31 km at Elko, Nev. — D. B. V.

183-205. Willis, David E., and Wilson, James T. Maximum vertical ground displacement of seismic waves generated by explosive blasts: Seismol. Soc. America Bull., v. 50, no. 3, p. 455-459, 1960.

An approximate first-power relationship was found between the maximum vertical component of ground displacement and the charge size from a number of quarry shots. The maximum vertical ground displacement, normalized to the Rainier (1.7 kt) underground nuclear shot, is presented for a series of explosive shots ranging in size from 1 ton to 19 kilotons and at distances of 1 to nearly 1,000 km. The following empirical equations were found to fit the observed data:

$$A = \frac{0.65 \pm 0.15}{R^{3/2}}$$

from 1 to 100 km

$$A = \frac{(0.013 \pm 0.003)e^{-(0.0072 \pm 0.0003)R}}{R^{1/2}};$$

from 100 to 1,000 km where A is the maximum vertical component of ground displacement in centimeters and R is the distance in kilometers. — Authors' abstract

183-206. Kogan, S. D. Vremena probega prodol'nykh i poperechnykh voln vychislennyye po dannym yadernykh vzryvov proizvedennykh v rayone Marshalovykh ostrovov [Traveltimes of longitudinal and transverse waves, calculated from the data of nuclear explosions produced in the region of the Marshall Islands]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 371-380, 1960.

Seismic records of nuclear explosions in the Marshall Islands area were used to determine the actual traveltime of seismic waves from the explosions. A comparison of these results with the data of traveltime curves of Jeffreys and Bullen is considered useful not only for the improvement of earthquake coordinates but also in the study of the internal constitution of the earth. The 234 records of 9 nuclear explosions (1 of 1946, 4 of 1954, and 4 of 1956) obtained by seismic stations in the U. S. S. R. and other countries confirm the generally accepted view that the structure of the upper mantle under the oceans is similar to that under the continents. It was found that in all seismograms investigated the P and PcP waves arrive as compressional waves. The possibility of determining the density jump at the mantle-core boundary by using the records of PcP waves is investigated. The fact that the seismograms analyzed show transverse waves having SV components substantially higher than

the SH components indicates that an explosion on the surface of the earth can be considered as a vertical blow and treated as a concentrated vertical force on the boundary of a half space. The true traveltime of the P-wave from the surface source in the western part of the Pacific Ocean was found to be 2 sec shorter, that of the PP wave 5 sec shorter, and that of the PcP wave 3 sec shorter than would follow from the Jeffreys-Bullen traveltime curve; whereas the true traveltime of the transverse wave was found to be 4-5 sec longer. The time differences obtained for the longitudinal waves can be explained by the absence of a granitic layer under the ocean, and the time differences for the transverse waves are probably due to the exaggerated S-wave velocity now assumed for the upper mantle. — A. J. S.

Berg, Joseph W., Jr., Cook, Kenneth L., Narans, Harry D., Jr., and Dolan, William M. Seismic investigation of crustal structure in the eastern part of the Basin and Range province. See *Geophys. Abs.* 183-395.

183-207. Martin, Hans. Schwingungstechnische Untersuchungen der Kammersprengungen im Steinbruch der Rappbodesperre [Vibrational-technical investigations of chamber blasts in the Rappbodesperre quarry]: *Freiberger Forschungshefte C 81 Geophysik*, p. 18-32, 1960.

Ground vibrations from a series of chamber blasts in the vicinity of a dam-site in the Saale River valley in Germany were investigated in order to determine whether the two requirements of foundation and construction safety and of a profitable supply of rock material for the dam were being met adequately. Results were inconclusive. — D. B. V.

183-208. Sponheuer, Wilhelm, Gerecke, Friedrich, and Martin, Hans. Seismische Untersuchungen zum Gebirgsschlag von Merkers/Rhön am 8 Juli 1958. [Seismic investigations of the Merkers-Rhön rockburst on July 8, 1958]: *Freiberger Forschungshefte C 81 Geophysik*, p. 64-79, 1960.

Engineering seismology investigations were made in the potash mining area of Germany following the rockburst at Merkers on July 8, 1958. This was the third such occurrence in the district in two decades. The Krugershall cave-in occurred on May 24, 1940, and the Heringen on February 22, 1953.

Isoseismal maps constructed from macroseismic evidence are presented for the three shocks, and focal depths, magnitudes, and energies are calculated. All three focuses were about 1 km deep and the magnitudes were of the same order (Krugershall 5.5, Heringen 5.4, Merkers 5.2). The energy corresponding to $M=5.2$ is 2.24×10^{18} ergs. It is concluded from the macroseismic data that none of the shocks could have been of tectonic origin, but were a consequence of the mining operations.

The instrumental records of the Merkers shock at 46 seismic stations were analyzed. P-wave velocities were found to be 5.70, 6.95, and 8.35 km/s in the granitic, basaltic, and peridotitic layers, respectively, and corresponding S-wave velocities to be 3.35, 4.00, and 4.82 km/s, respectively. The average crustal thickness calculated from the traveltime curves is 31 km, which is in agreement with explosion seismology data. Focal depth (5 km), focal time ($05^h 02^m 26^s \pm 0.3^s$ G.m.t.), position of epicenter (shown on a map), and magnitude (5.2) were calculated from the instrumental data; the last agrees exactly with the value calculated from the macroseismic data. The initial motions were dilatational, showing that the shock was a vertical release from tension; the possibility of a natural earthquake as a trigger of the rockburst is thus ruled out by the microseismic evidence also.

Inclination measurements made in the mine after the Merkers shock, beginning in August 1958, showed tilt to the north in the north-south component but no appreciable tilt in the east-west component. Measurable effects were still present in May 1959. — D. B. V.

- 183-209. Tandon, A. N. Seismographic recording of blasts at Bhakra: Indian Jour. Meteorology and Geophysics, v. 11, no. 2, p. 205-208, 1960.

Ground movements from 12 large blasts (10-200 lb of dynamite) at and near the Bhakra damsite in India on December 27-29, 1959, were recorded at different distances by two Wood-Anderson seismographs. A table gives for each shot the charge weight, shot-point distance, amplitude and period of the components parallel to and transverse to the dam. Millisecond firing of 2,258 lb in 60 holes, with a maximum of 70 lb in any one hole, gave ground displacements at 2,660 feet that were unexpectedly of the same order as those expected from a single charge of 2,258 lb. — D. B. V.

- 183-210. Kasahara, Keiichi. Wave generation by small explosions, (1) [in Japanese with English abstract]: Butsuri-Tanku, v. 12, no. 3, p. 118-123, 1959.

A spectral analysis of P-waves recorded at underground stations 10-30 m from the shot point is made. The fundamental characteristics of the waves may be explained by the theory of spherical origins provided that the apparent radius of the explosion origin is taken to be several times as large as that of the region subject to crushing. The effect might be attributed to the propagation of nonelastic stress waves outside the region of crushing.

The total amount of energy radiated as seismic waves from the explosion is also discussed. — V. S. N.

- 183-211. Riihimaa, J. Timing equipment for explosion seismology: Geophysica [Helsinki], v. 7, no. 2, p. 121-124, 1960.

The development of timing equipment for use in explosion seismology was part of the program carried out in the Gulf of Bothnia in July 1958 as part of the International Geophysical Year program of the Seismological Station, University of Helsinki. The communication system between ship and coastal seismographic station that was used to synchronize the recorders with the mine firings at sea is described. A direct detonating pulse transmission was used to produce corresponding firing marks on the recording paper, and the system delay was experimentally measured. A block diagram of the signal transmission system and a sample of the recording paper with the timing signals recorded on the lower edge are shown. — V. S. N.

- 183-212. Lyamzina, G. A. Opreddeniye skorosti rasprostraneniya uprugikh voln na malykh bazakh pri izuchenii seysmicheskikh svoystv gruntov [Determination of velocity of propagation of elastic waves on small bases in the study of the seismic properties of foundations]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 217-225, 1960.

A contact seismoscope for measuring elastic wave velocities over short distances is described and schematic diagrams are presented. The instrument is powered by a small dry cell battery. Accuracy is sufficiently high to allow the use of a low-sensitivity galvanometer with direct reflection recording, which is very convenient in the field. Best results are obtained on heavy mediums such as concrete, brickwork, bedrock, or wood.

Over distances as short as 0.5-2 m the form of the elastic impulses is virtually unchanged in passing from one seismoscope to another. As in all devices of this type, only the velocity of the first elastic impulse is measured; no information can be obtained on the rest of the wave process.

The high sensitivity, small size, simple construction, and small power consumption permit the use of the seismoscope to detect regional earthquakes under field conditions. Connected in the electrical circuit, the seismoscope can automatically adapt the operation of a seismograph to suit the amplitude of ground oscillations. — D. B. V.

- 183-213. Adachi, Ryuzo. On a vibration and its galvanometric registration and their initial states [in Japanese with English summary]: *Bu-tsuri-Tanko*, v. 12, no. 2, p. 87-94, 1959.

A vibration and its registration by the transducer-galvanometer method are discussed. A solution is obtained to the problem to find one of a vibration when the other is arbitrarily given and satisfies a given set of initial conditions. Approximate formulas which express the initial states are given. — V. S. N.

ELECTRICAL EXPLORATION

- 183-214. Onodera, Seibe. The kernel function in the multiple-layer resistivity problem: *Jour. Geophys. Research*, v. 65, no. 11, p. 3787-3794, 1960.

An explicit expression in terms of symmetric auxiliary functions is developed for the kernel function in the integral representation of the potential at the surface of a medium composed of homogeneous isotropic, horizontal layers. As an example, the explicit form is given for the case of seven layers. — Author's abstract

- 183-215. Koefoed, O. A generalized Cagniard graph for the interpretation of geoelectrical sounding data: *Geophys. Prosp.*, v. 8, no. 3, p. 459-469, 1960.

The Cagniard method of interpreting geoelectrical sounding data is based on the use of an empirical graph which expresses the relation between the resistivity and thickness of the second subsurface layer on one side, and on the other side the replacement resistivity and replacement thickness which are derived from the two-layer sounding curve which is asymptotic to the second branch of the observed sounding curve. In his method separate groups of this type are required for different values of the resistivity of the third subsurface layer. In the present paper a generalized Cagniard graph is derived which has the advantage of being independent of the value of the resistivity of the third subsurface layer. Finally, the accuracy of the method is discussed, and a procedure is described for extending its use to cases where more than three subsurface layers intervene. — Author's abstract

- 183-216. Overholt, K. J. Note on the impedance of a grounded wire: *Geophys. Prosp.*, v. 8, no. 3, p. 470-473, 1960.

The self-inductance of a straight grounded wire lying on the surface of the earth is computed from a (slightly corrected) formula given by A. Wolf and compared to approximate formulas. — Author's abstract

- 183-217. Kolbenheyer, Tibor. Über die Randwertaufgabe der Geoelektrik für ein homogenes und isotropes dreiachsiges Ellipsoid [On the boundary value problem of electrical exploration for a homogeneous and isotropic triaxial ellipsoid]: Freiburger Forschungshefte C 81 Geophysik, p. 160-166, 1960.

Theoretical equations have previously been derived by various authors for the electrical field of spheres and ellipsoids of rotation. This paper is a similar treatment of the more complex case of a homogeneous isotropic triaxial ellipsoid, which represents a more general form of disturbing body. First the primary potential of a point source, and therefore the reciprocal distance $1/R$ between two points, is developed in a series according to the Lamé functions of the ellipsoidal coordinates of the two points. Once this has been accomplished, the corollary potentials within and without the ellipsoid, which are harmonic functions in the regions in question, can be established in the usual way as series of the Lamé products with coefficients whose values are easily obtained from the known boundary conditions. (See also Geophys. Abs. 181-186.)—D. B. V.

- 183-218. Vendel'shteyn, B. Yu. O prirode diffuzionno-adsorbtsionnykh potentsialov [On the nature of diffusion-adsorption potentials]: Prikladnaya Geofizika, no. 26, p. 186-217, 1960.

Formulas are proposed for calculation of diffusion-adsorption electromotive force (membrane potential) arising at the boundary of a rock and an external solution or between two solutions separated by a rock. Diffusion-adsorption electromotive force of external solutions of low concentration and diffusion-adsorption activity of Devonian clastic rocks are discussed. Diffusion-adsorption activity is correlated with specific surface and porosity. The probable error in porosity determined by the proposed formulas is found to range between 7.7 and 40 percent. — A. J. S.

- 183-219. Kudymov, B. Ya., and Shmarova, V. I. O svyazi membrannogo potentsiala gornyykh porod s podvizhnost'yu ionov v membrane [On the relation of membrane potential to the ion mobility in the membrane]: Prikladnaya Geofizika, no. 26, p. 218-223, 1960.

The problem of the relation between natural electric polarization of rocks and their porosity, permeability, and microstructure is investigated. Two prevailing explanations of the phenomenon exist: the membrane-potential and the diffusion-adsorption hypotheses. Experiments with various membranes and 0.01 normal solution of KCl indicated that the observed natural electric polarization was formed as a membrane potential. — A. J. S.

- 183-220. Tyapkin, K. F. Do pitannya klasifikatsii anomal'nykh potentsial'nykh poliv [On classifying anomalies of potential fields]: Akad. Nauk Ukrainy. RSR Dopovidī, no. 4, p. 407-410, 1958.

A new method is proposed for classifying potential fields as plane or spatial by applying known solutions to the potential theory boundary problem. A field is assumed to be plane when the values of its intensity components calculated by the formulas for plane and spatial problems are equal within the available limits of accuracy. If not, the field should be considered spatial. — Author's summary, A. J. S.

- 183-221. Wait, James R. Some solutions for electromagnetic problems involving spheroidal, spherical, and cylindrical bodies: U. S. Natl. Bur. Standards Jour. Research, v. 64B, no. 1, p. 15-32, 1960.

Solutions are presented for the low-frequency electromagnetic response to an oscillating magnetic dipole by conducting bodies of simple shape. The quasi-stationary approximation is employed throughout, which is valid when the relevant dimensions of the problem are all small compared to the free-space wavelength. This amounts to matching solutions of the wave equation within the bodies to solutions of Laplace's equation outside. The results have application to geophysical prospecting. — Author's abstract

- 183-222. Frischknecht, F[rank] C., and Ekren, E. B[artlett]. Mapping conductive strata by electromagnetic methods, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-121-B-125, 1960.

The application of electromagnetic methods to mapping bedrock geology in areas of extensive glacial drift in Minnesota, Wisconsin, and Maine, is discussed briefly. The slingram method (Frischknecht, Geophys. Abs. 180-128), which is well suited for reconnaissance work even in heavy forest and brush, was used in most of the work.

The study was concerned with lithologic units that contain concentrations of conductive minerals; although these beds comprise only a small part of the total volume of metasedimentary rocks in the areas studied, they are sufficiently numerous and continuous to be used in tracing bedrock geology. In Minnesota and Wisconsin, studies were made over iron formations in the Cuyuna, Mesabi, and Gogebic ranges where both oxidized and unoxidized iron ores are present. In Maine the conductors are: (1) graphitic or carbonaceous beds associated with black pyritic slates and schists, and (2) massive sulfide deposits occurring in mafic intrusive igneous masses. — V. S. N.

- 183-223. Paterson, Norman R. Comments on paper entitled "Some model experiments relating to electro-magnetic prospecting with special reference to airborne work" by E. H. Hedström and D. S. Parasnis: Geophys. Prosp., v. 7, no. 4, p. 435-447, 1959.
Hedström, E. H., and Parasnis, D. S. Reply to comments by N. R. Paterson: *ibid.*, p. 448-470, 1959.

Paterson believes that Hedström and Parasnis in their paper (see Geophys. Abs. 180-113) showed the "Canadian" dual frequency out-of-phase method in an unnecessarily poor light, challenges some of their statements and conclusions, and points out deficiencies in the ABEM two-plane rotary field method. In reply, Hedström and Parasnis vigorously defend their position and also the ABEM method; they maintain that their claims, but not Paterson's, can be substantiated by laboratory experiments and other data. The relative merits of the two systems are discussed in both papers not only with regard to their accuracy but also in connection with practical details of aircraft operation, safety, and economy. — D. B. V.

- 183-224. Nikitina, V. N. Raschety peremennogo elektromagnitnogo polya nad naklonnym platom [Calculations of an alternating electromagnetic field over a dipping layer]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 495-512, 1960.

A theoretical investigation of the character of the anomaly of a plane electromagnetic wave propagating over a horizontally elongate ore vein dipping at an angle θ is presented. An extensive mathematical analysis is carried out in order to determine the characteristics of the anomaly and to interpret those characteristics in terms of the parameters of the disturbing ore body. This method of prospecting is called the method of radio comparing and direction

finding. Formulas for distribution of currents induced in the vein, formulas for the anomalous field at the surface, and the specific formulas and graphs for the anomalous field over a dipping ore vein are given. — A. J. S.

- 183-225. D'yakonov, B. P. Vliyaniye poverkhnosti Zemli na elektromagnitnoye pole tsilindricheskoy neodnorodnosti [The effect of the earth's surface on the electromagnetic field of a cylindrical inhomogeneity]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 336-342, 1960.

The problem of the effect of the earth-air interface on an anomalistic field generated by a cylindrical inhomogeneity is studied. The problem is analyzed and treated from the point of view of diffraction of electromagnetic waves on a circular cylinder located within a homogeneous isotropic half space (see Geophys. Abs. 180-111). It was found that the absolute value of the anomalistic electric field of such a disturbing body is greater under the earth-air interface than in the case of a continuous homogeneous medium. This difference increases with an increasing value of h/a (h is depth of the axis of the cylinder from the surface, a is the radius of the cylinder), although the depth of the deposit has a predominant effect. The effects of the earth's surface on the electric and magnetic anomalistic fields are opposite to each other; the magnitude of the former increases, and that of the latter decreases when h/a increases. — A. J. S.

- 183-226. D'yakonov, B. P. Asimptoticheskiye vyrazheniya dlya elektromagnitnykh poley tsilindricheskoy neodnorodnosti [Asymptotic expressions for electromagnetic fields of a cylindrical inhomogeneity]: Akad. Nauk SSSR Izv. Geofiz., no. 7, p. 954-958, 1960.

Asymptotic representation of anomalistic electromagnetic fields for a massive cylindrical inclusion at a considerable depth is obtained from the solution of the diffraction problem of electromagnetic waves on a circular cylinder located in a homogeneous and isotropic half space (see Geophys. Abs. 181-178). The vertical component of the magnetic anomalistic field was found to decrease along the surface of the earth as $1/y^3$, while the electric component and the horizontal component of the magnetic anomaly decrease along the same surface as $1/y^2$, y being the coordinate across the axis of the cylinder. — A. J. S.

- 183-227. Gel'fand, I. S. Elektromagnitnoye pole ramki i kabelya nad dvukhsloynoy sredoy so slabo provodyashchim osnovaniyem [Electromagnetic field of the frame and the cable over a two-layer medium with a low conductivity basement]: Sverdlovsk. Gornyy Inst. Trudy, Voprosy Razvedochnoy Geofiz., no. 34, p. 5-10, 1959.

This paper is a continuation of Gel'fand's previous papers (see Geophys. Abs. 175-116, -117) on the magnetic field over a two-layered medium. A special case for $(k_2r) \gg 1$, and $(k_3r) < 1$ is treated mathematically, and the fields of the antenna frame and of the cable grounded at its ends are discussed and defined for a two-layered medium resting on low conductivity basement rock. — A. J. S.

- 183-228. Gel'fand, I. S. Elektromagnitnoye pole gorizontal'nogo elektricheskogo dipolya v sloistoy srede [Electromagnetic field of a horizontal electric dipole in a layered medium]: Sverdlovsk. Gornyy Inst. Trudy, no. 34, Voprosy Razvedochnoy Geofiz., p. 11-19, 1959.

This is a vectorial treatment of the problem of determination of the electromagnetic field set up by a horizontal electric dipole placed on the plane inter-

face $z=0$ of the earth's surface and the atmosphere, over a two-layered geologic medium. It is assumed that in the first layer (the air) $z \gg 0$; in the upper layer of the earth $0 \gg z \gg -h$, and in the lower layer $z \ll -h$. Introducing an auxiliary vector \vec{A} whose components satisfy the wave equation $\Delta \vec{A} + k^2 \vec{A} = 0$, and assuming that $\vec{H} = \text{rot } \vec{A}$, and $\vec{E} = \text{grad div } \vec{A} - K^2 \vec{A}$ where 1 is the ratio of specific conductivity to the speed of light, the horizontal and vertical components of vectors \vec{A}_n are determined. From the found values of \vec{A}_n and the assumed $\vec{H} = \text{rot } \vec{A}$, the magnetic field of the horizontal dipole is determined, while from the found $\text{div } \vec{A}$ of the field, the electric field of the horizontal dipole is evaluated. — A. J. S.

- 183-229. Al'pin, L. M. Kol'tsevov induktsionnyy integrator [Ring induction integrator]: Vyssh. Ucheb. Zavedeniy Izv., Geologiya i Razvedka, no. 8, p. 131-137, 1959.

A mathematical analysis is given for a system in which a homogeneous medium is cylindrically symmetrical with respect to an axis, induction of the electromagnetic field is coaxial with the cylindrical symmetry of the medium, and the frequency range is moderate (displacement current can be disregarded). Three variants of the method are discussed: (1) logging variant for re-production of ring induction logging with models; (2) layer variant for ring modeling of electromagnetic field investigation of layers with low dip; and (3) ore variant for modeling electromagnetic field in prospecting for ores. — A. J. S.

- 183-230. Kunori, Shoichi, and Yokoyama, Hidekichi. Experimental studies for electromagnetic prospecting (pt. 1) [in Japanese with English abstract]: Tohoku Kozan, v. 6, no. 3, p. 85-91, 1959.

A two coil method for scale model experiments in electromagnetic methods of geophysical exploration is described and discussed. Devices for the differentiation of secondary components in phase and in quadrature from total magnetic fields induced in the search coil employed a switching current with four balanced germanium diodes and with a precise RC phase shifter and microammeter. — V. S. N.

- 183-231. Kruszewski, Zdisław. Sondowania Kompensacyjnie [Compensation sounding]: Przegląd Geol., v. 7, no. 11, p. 510-514, 1959.

The compensation method of electric sounding for detecting faults in gently dipped strata is discussed. The method consists of measuring a drop in potential between the dipole points M and N collinear with symmetrically placed electric circuits AB and A_1B_1 , carrying currents I and I_1 , respectively. A reversal of I and I_1 results in a zone of compensation having a zero current at the surface of a deposit and a maximum current at a depth k_m at a fault. (See also Geophys. Abs. 173-152.) — A. J. S.

- 183-232. Gintzburg, M. A. Opredeleniye tolshchiny sloya l'da radiolokatsionnym metodom [Determination of ice layer thickness by the radio-location method]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 872-874, 1960.

A method of determination of thickness of layers of ice, permafrost, and other dielectrics up to 100 m is discussed. A radar transponder is placed at a height h over the layer investigated. The impulses sent from the transponder are reflected from the surface of the ice layer and from its lower boundary and produce two impulse images on the screen of the radio-receiver oscillograph. The thickness of the layer is then determined from the time in-

terval τ between the first and the second impulse by the formula $d=1/2c\tau/\epsilon^{1/2}$, where c is speed of light in vacuum, and ϵ is dielectric constant of ice. A frequency modulation radio-altimeter (10^7 - 10^{10} cycles per second) is suggested for use in a modification of this method. — A. J. S.

- 183-233. Glyuzman, A. M., and Plokhikh, N. A. Resheniye nekotorykh ploskiikh zadach v elektrorazvedke [Solutions of some plane problems in electric exploration]: Akad. Nauk SSSR Izv. Ser. Geofiz. no. 7, p. 998-1004, 1960.

The cases of geoelectric anomaly fields of a linear electrode located on the surface of the earth over a vertically layered medium, over a dipping interface of two different layers, and over a conducting semicircular cylinder are treated mathematically. Solutions for the components of the normal fields and the potentials at a given point are provided for the above cases. A bilogarithmic master chart is given for determination of the thickness of the cap layer and the resistance of the basement rock from the potential gradient curves of a profile across the strike. — A. J. S.

- 183-234. Sakovtsev, G. P. Sravneniye chuvstvitel'nosti raznykh metodov elektroprofilirovaniya k poverkhnostnym i glubinnym neodnorodnostyam [Comparison of the sensitivity of various methods of electric profiling to surface and deep inhomogeneities]: Sverdlovsk. Gornyy Inst. Trudy, no. 34, Voprosy Razvedochnoy Geofiz. p. 36-50, 1959.

The sensitivity of combination profiling (KP), symmetric arrangement profiling (SP), and the method of superposition of fields (NP) or unipolar profiling is discussed and compared. It was found that the latter method is the least sensitive to surface inhomogeneities and compares favorably in sensitivity with the KP method in respect to deep-seated inhomogeneities. — A. J. S.

- 183-235. Sakovtsev, G. P. Nekotoryye voprosy teorii metoda VEZ v svyazi s primeneniyyem yego pri poiskakh rudnykh tel konechnykh razmerov [Certain problems of the theory of VEZ in connection with its application in prospecting for ore bodies of finite dimensions]: Sverdlovsk. Gornyy Inst. Trudy, no. 34, Voprosy Razvedochnoy Geofiz., p. 51-63, 1959.

The theory of VEZ (vertical electric sounding) in prospecting for ore bodies of finite dimensions is treated, and an attempt is made to improve geologic interpretations of apparent resistivity of vertical profiles. The following problems for spherical bodies and semispherical depressions are studied and treated mathematically: the effect of the distance between measuring electrodes on the shape of apparent resistivity curves for sounding over a sphere; the shape of apparent resistivity curves for two variants of the electrodes arrangement with respect to the sphere; and the shape of vertical profiles of apparent resistivities obtained in sounding over a semispherical depression on the surface of the earth. It was noticed that the anomalistic field increases with a decrease in the length of the sounding line. — A. J. S.

- 183-236. Kozyrin, A. K. Interpretatsiya krivykh VEZ pri pomoshchi kombinirovannykh paletok [Interpretation of VEZ curves with the aid of combination master-charts]: Sverdlovsk. Gornyy Inst. Trudy, no. 34, Voprosy Razvedochnoy Geofiz., p. 71-77, 1959.

Two combination master-charts VEZ-K1 and VEZ-K2 that speed up and simplify VEZ (vertical electrical sounding) interpretation technique are de-

scribed. Examples of VEZ interpretation are given for 3-layer and 4-layer curves. The method of combined master-charts could be used for an approximate construction of multiple-layer curves and for a graphical solution of theoretical problems such as an investigation of the error in determination of the parameters of the third layer as a function of the errors in parameters determined for the second layer. — A. J. S.

- 183-237. Dorofeyev, B. V. Kachestvennaya interpretatsiya krivyykh VEZ [Qualitative interpretation of VEZ curves]: Sverdlovsk. Gornyy Inst. Trudy, No. 34, Voprosy Razvedochnoy Geofiz., p. 95-99, 1959.

The theoretical curves of VEZ (vertical electrical sounding) are analyzed, and the effect of variations in thickness and resistivity of the investigated strata is studied. — A. J. S.

- 183-238. Dzhafarov, Kh. D. Interpretatsiya krivyykh VEZ sposobom ekstremal'nykh tochek [Interpretation of VEZ curves by means of extremum points]: Vyssh. Ucheb. Zavedeniye Izv., Neft' i Gaz, no. 4, p. 23-27, 1960.

In the absence of parametric measurements made in boreholes, existing methods of interpretation of multilayered curves of vertical electrical sounding (VEZ) result in large errors in determination of the depth to a marker horizon. Therefore, the necessity has arisen for working out a method for quantitative interpretation that will be sufficiently accurate for practical purposes in regions without exploration drill holes.

A new method of interpretation of vertical electrical sounding curves in a multilayered section is described. The thickness and resistivity of the first layer is determined in the usual manner. These parameters are found for a second and third layer according to formulas given. The depth to a marker horizon is equal to the sum of the thickness of these several layers. The resistivity of the section is determined similarly. An example is given. Tests show that the relative error in determining thickness does not exceed 10 percent and that for resistivity does not exceed 15 percent. — J. W. C.

- 183-239. Kozyrin, A. K. Nekotoryye rezul'taty provedeniya elektrorazvedki iz skvazhin [Some results of carrying out electrical prospecting in boreholes]: Sverdlovsk. Gornyy Inst. Trudy, no. 34, Voprosy Razvedochnoy Geofiz., p. 77-90, 1959.

On the basis of electrical prospecting for ores conducted by the Sverdlovsk Mining Institute since 1954 in the vicinity of existing boreholes in the Urals, the effectiveness of electric prospecting is discussed. The correlation method of AM_g and AM_gB electrode arrangements is analyzed, tested in the field, and recommended for application. Consideration is given to seismic and magnetic prospecting for ores from existing boreholes. — A. J. S.

- 183-240. Dorofeyev, B. V. K voprosu interpretatsii krivyykh tipa H i A [On the problem of interpretation of H and A type curves]: Sverdlovsk. Gornyy Inst. Trudy, no. 34, Voprosy Razvedochnoy Geofiz., p. 91-94, 1959.

A nomogram for interpretation of VEZ (vertical electric sounding) curves of type $H(\rho_1 > \rho_2 > \rho_3)$, when ρ_2 is unknown, is proposed. The double sheet master-chart GP2-1 is used for the interpretation, supplemented with an auxiliary master-chart LGH. The value of $H^1 = h_2 + h_1$ can be found with an error less than 10 percent (for $V=9$). — A. J. S.

- 183-241. Shabanov, B. A. Kol'tsevaya ustanovka dlya elektricheskikh zondirovaniy postoyannym tokom [A ring arrangement for electric sounding with direct current]: *Prikladnaya Geofizika*, no. 26, p. 70-77, 1960.

The electric field produced by a ring pattern of n electrodes with a point source of opposite sign at its center and equal central angles between them is discussed. The field potential outside and inside the ring is derived, and the theory is applied to the reflection method in two- and multi-layered horizontally homogeneous mediums. — A. J. S.

- 183-242. Fomina, V. I. Primeneniye kachestvennoy interpretatsii krivyykh zondirovaniya dlya geotektonicheskogo rayonirovaniya [Application of a qualitative interpretation of sounding curves to geotectonic regionalization]: *Razvedochnaya i Promyslovaya Geofizika*, no. 33, p. 3-23, 1959.

Several variants of the electric profile where $\rho_1 > \rho_2'$, $\rho_2' > \rho_2''$, $\rho_2'' < \rho_2'''$, and $\rho_2''' < \rho_3$ (when $\rho_3 = \infty$) are discussed. ρ_1 is the resistivity of the surface layer, ρ_2' , ρ_2'' , and ρ_2''' are the resistivities of sublayers in the second layer, and ρ_3 is the resistivity of the basement. On the basis of these qualitative data and on analysis of mutual variations of all the elements of the qualitative characteristics of sounding graphs and their correlation with other geophysical-geologic data, it was possible to subdivide the area into zones of identical conditions of sedimentation. — A. J. S.

- 183-243. Zavelev, A. I. Opyt raboty po sposobu otnosheniya gradientov potentsiala [Experimental work by the method of the ratio of potential gradients]: *Razvedka i Okhrana Nedr*, no. 6, p. 45-48, 1960.

The potential ratio method is discussed, and the results of its application in 1957 by an electrical prospecting team in trans-Baykal region are reported. A map of equal amplitude contours of the alternating current field potential of the region was prepared, and a pegmatite lode was thereby discovered. The potential ratio method (OGP) described introduces the concept of potential gradients of low frequency alternating current in high resistivity media for $2 > \rho > 1$, where $\rho = 4\pi l(5f\sigma)^2$, l being the spread AB, f working frequency, and σ the medium specific conductivity in (1/ohm cm). The proposed method of contour maps of equal amplitude of an alternating current field potential is analogous to the d-c equipotential lines method. Data are provided on detailed features of the geological structure. — A. J. S.

- 183-244. Shibato, Kihei. Study on the spontaneous polarization source of the silicified zone [in Japanese with English abstract]: *Butsuri-Tanko*, v. 12, no. 4, p. 156-165, 1959.

The physical characteristics of silicified rocks are described, and the source of spontaneous polarization in a uniform and nonuniform state is discussed. A field example is given of the use of spontaneous polarization to determine the height of a silicified zone in a uniform state above the water table. Lastly, the special physical characteristics that determine the physical sources of spontaneous polarization in a silicified zone above the water table are considered. — V. S. N.

- 183-245. Meidav, Tsvi. An electrical resistivity survey for ground water: *Geophysics*, v. 25, no. 5, p. 1077-1093, 1960.

An electrical resistivity survey was carried out in Grundy, Chariton, and Carroll Counties, Missouri, in connection with a ground water project of the Missouri Geological Survey. The aim of the project was to locate buried channels under the glacial cover. The resistivity data obtained were interpreted both empirically and quantitatively. The empirical method was found to be satisfactory wherever the uniformity of electrical properties was maintained by either the glacial cover or bedrock, and the resistivity contrast was high. The quantitative technique used most commonly in this study was Spicer's (1956) modification of Hummel's (1932) procedure, used in conjunction with standard two-, three-, and four-layer master curves. The limitations of the quantitative methods of interpretation are indicated in a series of resistivity distribution curves. — Author's abstract

Zablocki, C[harles] J. Measurements of electrical properties of rocks in southeast Missouri. See Geophys. Abs. 183-269.

Keller, G[eorge] V. Electrical properties of zinc-bearing rocks in Jefferson County, Tennessee. See Geophys. Abs. 183-268.

Anderson, L. A. Electrical properties of sulfide ores in igneous and metamorphic rocks near East Union, Maine. See Geophys. Abs. 183-267.

183-246. Sarcia, J., Bonnet, J., and Combe, R. Application des mesures de résistivité à la recherche des éléments structuraux dans le bassin uranifère du Nord-Limousin (France) [Application of resistivity measurements to the investigation of the structural elements in the uranium-bearing basin of north Limousin (France)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 2, p. 148-155, 1960.

In the Limousin uranium basin of France, satisfactory results have been obtained with electrical methods by using a variety of techniques. The effect of depth of penetration on the geologic interpretation of resistivity maps is illustrated by means of superposed surveys using different configurations. Subsequent drilling and mining operations provided a control and check of the accuracy of different surveys, leading to improvements in technique. The "rectangle map" was found to give the general structural picture, but where greater precision was required it was necessary to use closer spacing of the MN electrodes or more sensitive methods such as potential-drop-ratio. — D. B. V.

183-247. Sell Cantalapiedra, Juan I. Investigación geoelectrica en Murcia [Geoelectrical investigation in Murcia (with English summary)]: Rev. Geofísica, v. 18, no. 72, p. 357-377, 1959.

Resistivity surveys were made at two ranches in Murcia province, Spain, in connection with ground-water exploration. Resistivities were determined in place rather than in the laboratory, using the Wenner configuration. As the attitude of the formations is subhorizontal in both areas, the vertical electrical sounding method was used with the Schlumberger-Siñeriz configuration. Soundings were made at 16 places, at half of them in two mutually perpendicular directions. The results are interpreted and presented in the form of stratigraphic columns.

Wells were drilled mechanically at favorable sites. The stratigraphic boundaries were found within 2 or 3 m of the depth indicated by the resistivity data. — D. B. V.

- 183-248. Krayev, A. P. Opyt primeneniya rechnykh dipol'nykh zondirovaniy [Experience in the use of dipole sounding in rivers]: Leningrad Univ. Uchenyye Zapiski, v. 249, no. 10, p. 5-14, 1958.

A description of methods of dipole electric sounding in the Volkhov River from Volkhov to Staraya Russa is presented, and the results are interpreted. A total of 12 soundings were made in the river bed with the spacing between the electrodes at 4-7 km. An equal number of soundings were made at the centers of the receiving electrodes at distances up to 640 m between the electrodes. The surface of the Precambrian basement was found to subside in steps of about 300 m vertically. The depth to the basement was determined by the method of vertical electrical sounding. — A. J. S.

- 183-249. Homma, Ichiro; Takagi, Shinichiro; Furuya, Shigemasa; and Tamura, Yoshio. Electrical prospecting for the ground water in the eastsouthern part of Gumma Prefecture [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 10, no. 11, p. 55-60, 1959.

A resistivity survey was carried out in southeastern Gumma Prefecture, Japan, in 1957 in order to locate favorable sources of ground water. Study of rock outcrops in relation to the four resistivity layers found indicates that the layer of lowest resistivity corresponds to a bed of Tertiary clay. — V. S. N.

- 183-250. Research Group for Spontaneous Polarization Method [Japan]. Study of the spontaneous polarization method at the Oage pyrite mine, Aomori Prefecture [in Japanese with English abstract]: Butsuri-Tanko, v. 12, no. 3, p. 107-117, 1959.

Results of measurements of spontaneous polarization and resistivity in the gallery, in boreholes, and on the surface at the Oage pyrite mine, Aomori Prefecture, Japan, are presented. These results are compared with data from past electrical surveys and logs and with maps based on cores. — V. S. N.

- 183-251. Milton, B. E. Electro-magnetic prospecting for graphite—Uley mine area: South Australia Dept. Mines Mining Rev., no. 109, p. 67-77, 1960.

An electromagnetic survey was conducted in the vicinity of the Uley graphite mine to detect possible extensions of known graphite bodies. Several anomalous area were outlined in the region of general graphitization, and sites are recommended for shallow drilling to test the relationship between the electromagnetic anomalies and the graphite bodies. — V. S. N.

ELECTRICAL LOGGING

- 183-252. Mathieu, J[ean] L[éon]. Latest developments in the field of electrical measurements in drill holes: World Petroleum, v. 30, no. 6, sec. 2, p. 34, 37-38, 1959.

The developments in the field of electric logging since World War II are discussed, and the history of electric logging prior to this time is reviewed briefly. The development since 1939 of the microlog, microlog-neutron log, gamma-ray log, laterolog, microlaterolog, sonic log, and of the continuous dipmeter have made it possible for the first time to obtain the true value of the formation resistivity regardless of conditions, to calculate the connate water resistivity, to predict according to the porosity value whether oil or wa-

ter or both will be produced, to complete a logging program when salt muds are used in drilling, and to obtain a correct appraisal of dips all along the formations traversed by the drill hole. — V. S. N.

- 183-253. Schlumberger Well Surveying Corporation. Log interpretation charts: Houston, Texas, Schlumberger Well Surveying Corp., 74 p., 1959.

This series of charts can be used in determining such parameters as interstitial water resistivity, porosity, formation resistivity factor, water saturation, and others. Each chart is accompanied by an explanation of its purpose and use; an example demonstrating use is also given. Basically the book serves as a reference to give graphical aids for applying established techniques. Additions will be made as new tools are introduced. — V. S. N.

- 183-254. Bennett, Gordon D., and Patten, Eugene P., Jr. Borehole geophysical methods for analyzing specific capacity of multiaquifer wells: U. S. Geol. Survey Water-Supply Paper 1536-A, 25 p., 1960.

Conventional well-logging techniques, combined with measurements of flow velocity in the borehole, can provide information on the discharge-drawdown characteristics of the several aquifers penetrated by a well. The well is pumped at a given discharge rate for a certain length of time while measurements are made of drawdown in the well and of discharge rates of individual aquifers tapped by the well. Flow measurements are made by a subsurface flowmeter or by techniques involving injection of electrolytic or radioactive tracers. A normal-resistivity logging device is used to locate the possible aquifers, and a well caliper is used to obtain borehole area at points of velocity measurement.

In the testing of the method, electric logs including self-potential, single-point resistance, normal-resistivity, temperature, fluid-resistivity, gamma-ray, and caliper logs were made prior to the testing. Velocities of internal flow in the well between aquifers were measured by injecting brine into the flow at selected depths and by tracing the movement of the brine with a fluid-resistivity electrode. A continuous recording was made of resistivity data against depth. — V. S. N.

- 183-255. Dakhnov, V. N., ed. Voprosy Promyslovoy Geofiziki [Problems of geophysical logging]: Moscow, Gostoptekhizdat, 489 p., 1957.

This is a collection of 31 papers in the field of geophysical logging translated from English. Brief evaluations and comments on the original papers are given in the foreword, and editorial comments are presented in footnotes to most of the papers. — A. J. S.

- 183-256. Nikitina, V. N. Obshcheye resheniye osesimmetricheskoy zadachi teorii induktsionnogo karotazha [A general solution of the axial symmetry problem in the theory of induction logging]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 607-616, 1960.

A general solution of the induction logging problem is given for the case where the borehole is filled with drilling mud, and two methods of induction are applied, one using an alternating magnetic dipole and the other using a circular current. This leads to a rigorous solution of the problem by the method of gradual transition from a dipole to a single turn with current. In this procedure a correlation between different variants of excitation was established, and Doll's and Ruzin's formulas were derived. — A. J. S.

- 183-257. Chukin, V. T. Bokovoy karotazh [The laterolog]: Prikladnaya Geofizika, no. 21, p. 134-172, 1958.

The 7-electrode laterolog method is discussed, and specific cases using the method are analyzed. The apparent resistivity determined by the usual formula $\rho=k(V/I_0)$ is treated for cases of homogeneous and nonhomogeneous mediums, for a stratum of infinite thickness (with and without infiltration of drilling mud into the stratum), and for a stratum of finite thickness. The laterolog curves obtained with 5 different models are shown and compared. A process of determining the true resistivity of a stratum from its apparent resistivity is described. The method is recommended for low porosity mediums and for highly saline drilling muds. — A. J. S.

- 183-258. Safontsev, A. A., and Yudin, G. T. O kharaktere zavisimosti ot nositel'nykh amplitud PS ot granulometricheskogo sostava terrigennykh porod na primere ryada mestorozhdeniy Stavropol'ya [On the character of the relation between relative amplitudes of SP and the grain size of detrital rocks as exemplified by several Stavropol fields]: Prikladnaya Geofizika, no. 22, p. 224-229, 1960.

A study was made of the relation between grain size and relative amplitude of SP curves for Aptian-Albian fields in the gas-bearing areas of eastern Stavropol. Graphs of SP amplitude versus grain size are plotted; a strong correlation is found. This aids in locating zones of coarse-grained rocks of high reservoir capacity. — A. J. S.

- 183-259. Sokhranov, N. N. Izucheniye perekhodnoy zony produktivnykh plastov po elektrokartazhu [Study of the transition zone of producing strata by electric logging]: Prikladnaya Geofizika, no. 24, p. 159-189, 1960.

A model study was made of the transition zone between the gas-oil- and water-bearing parts of a producing stratum by the method of electric logging. Resistivity curves are given for the potential sounding, gradient sounding, and the laterolog methods. The procedures for these methods are given and illustrated by two examples. It was found that the potential sounding method gives better values of resistivities and better differentiation than do the other two methods. — A. J. S.

- 183-260. Al'pin, L. M. Vyrazheniya dlya koeffitsiyentov ekranirovannykh kol'tsevykh zondov [Expressions for the coefficients of shielded ring-shape sondes]: Vyssh. Ucheb. Zavedeniy Izv., Geologiya i Razvedka, no. 10, p. 95-102, 1959.

This is a continuation of Al'pin's previous work (see Geophys. Abs. 178-147, -151) in the theory of ring logging. A mathematical treatment is given to the three ring electrodes, A, M, and N shielded from the drilling mud by a nonconducting cylinder coaxial with the ring electrode system used in this method of electric logging. — A. J. S.

- 183-261. Kaufman, A. A., and Shapiro, R. P. Razrabotka kol'tsevogo induktsionnogo karotazhnogo integratora [Development of a ring-induction logging integrator]: Vyssh. Ucheb. Zavedeniy Izv., Geologiya i Razvedka, no. 10, p. 103-110, 1959.

A method of measuring an alternating field produced in a borehole by a coaxial magnetic dipole having its moment along the borehole axis is proposed.

The study of the field variation as a function of the borehole length L in meters, resistivity ρ in ohms, and frequency f in cycles per second of the field was carried out with models prepared of conducting nonmagnetic plates of copper, aluminum, tin, lead, and graphite in solutions of salts. The models are described, and their behavior when L , ρ , and f are varied separately or in combination was analyzed and discussed. — A. J. S.

- 183-262. Buryakovskiy, L. A. Izucheniye strukturnykh kharakteristik porovogo prostranstva podannym elektrokartazha [Study of the structural characteristics of pore space according to data of electric logging]: Vyssh. Ucheb. Zavedeniy Izv., Neft' i Gaz, no. 6, p. 9-16, 1960.

In study of the electrical and filtration properties of pore space, attention should be given to tortuosity, clearance, the structural coefficient, and the index of cementation. Graphs are presented in which tortuosity is related to porosity, clearance to resistivity, and tortuosity to structural coefficient. — J. W. C.

- 183-263. Fujiwara, Chuichi. Studies on electrical well log analysis (pt. 2) [in Japanese with English abstract]: Tohoku Kozan, v. 6, no. 4, p. 123-129, 1959.

Results of an experimental investigation of the effects of the formation factor on the electrical properties of a reservoir rock are described. The relation between the electrical properties and geological characteristics of formations was derived from the laboratory results. These relationships may be used to estimate oil content of a shaly reservoir. — V. S. N.

- 183-264. Pomerants, L. I., and Kaplunov, A. I. Laboratoriya avtomaticheskoy karotazhnoy stantsii na odnozhil'nom kabele OKS-56 [Laboratory of the automatic single-cable well logger OKS-56]: Razvedochnaya i Promyslovaya Geofizika, no. 28, p. 33-91, 1959.

The OKS-56 well logger is designed to operate in holes up to 6,000 m deep, at pressures up to 1,000 atm, and temperatures up to 120°C. Simultaneous recordings are made of the resistivity, self potential, radioactivity (gamma and neutron-gamma methods), temperature, hole diameter, and inclination of the well. Sketches and schematic diagrams are given. This apparatus is now in mass production. — J. W. C.

- 183-265. Aksel'rod, S. M. O graduirovke apparatury induktsionnogo karotazha [Calibration of apparatus of induction electrical logging]: Vyssh. Ucheb. Zavedeniy Izv., Neft' i Gaz, no. 5, p. 19-25, 1960.

Induction logging apparatus, like any other electrical apparatus, must be calibrated periodically. A method is discussed in which a collar is connected to a master coil and a receiver coil placed at a definite distance from one another along the axis. The resistance developed in the collar is suitable for calibration purposes. — J. W. C.

- 183-266. Melik-Shakhnazarov, A. M., Alizade, G. A., Mel'nikov, A. G., and Aliev, T. M. Apparatura bokovogo karotazha s semielektrodnym zondom na odnozhil'nom kabele (BK-7-AzINEFTEKHIM) [Apparatus for laterolog with a seven-electrode sonde on a single strand cable (BK-7-AzINEFTEKHIM)]: Vyssh. Ucheb. Zavedeniy Izv., Neft' i Gaz, no. 5, p. 121-126, 1960.

The instrumentation for the seven-electrode, single-cable laterolog sonde BK-7-AzINEFTEKHIM is described. The components are an electron auto-compensator, a system of telemasuring, a sonde, surface apparatus, and input apparatus. A schematic diagram is given for the circuit as a whole and also for the sonde and surface apparatus. The main deficiency of the equipment has been an instability of the autocompensator in some parts of the well, particularly in strata of high resistivity (more than 400-500 ohms). An auto-compensator with an intermediate phase-sensitive block was designed and tested; it exhibited sensitivity in all parts of the borehole. — J. W. C.

- 183-267. Anderson, L. A. Electrical properties of sulfide ores in igneous and metamorphic rocks near East Union, Maine, *in* Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-125-B-128, 1960.

The electrical properties of rocks in and around a large sulfide deposit near East Union, Maine, were measured using in-hole logging methods which included resistivity, self-potential, and induced polarization. In addition, laboratory measurements were made for resistivity, induced polarization, grain density, and porosity on core samples from the area.

The in-hole logging measurements show conductive zones that may be attributed to sulfide content or to the presence of graphite. The resistivity response could not be related quantitatively to sulfide percentage because of the apparent continuity of sulfide grains where the content is in excess of approximately 5 percent by weight. The self-potential log can be used in some cases to distinguish between sulfides that exist in quantities greater than a few percent and graphite zones by their more negative self-potentials. Laboratory measurements show that induced polarization is an excellent method for estimating the relative sulfide concentration. — V. S. N.

- 183-268. Keller, G[eorge] V. Electrical properties of zinc-bearing rocks in Jefferson County, Tennessee, *in* Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-128-B-132, 1960.

Electric logs were run in drill holes in a belt of zinc ore between Mascot and Jefferson City, Tenn., to determine whether anomalous electrical properties were associated with sphalerite mineralization and might serve as a guide for geophysical exploration. The resistivity log showed a large resistivity contrast between the ore and the barren rock but no quantitative relation between resistivity and ore grade. Neither the self-potential nor the induced-polarization logs show as striking a change in the ore zone as does the resistivity log.

It was also found that the conducting zone could be readily located by using electromagnetic methods even where the zone is deeply buried. — V. S. N.

- 183-269. Zablocki, C[harles] J. Measurements of electrical properties of rocks in southeast Missouri, *in* Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-214-B-216, 1960.

Electrical-property measurements were made of the rocks penetrated by six drill holes in southeast Missouri using inhole logging methods. Properties studied included self-potential, resistivity, induced polarization, and magnetic susceptibility. The holes ranged from 2,000 to 3,000 feet in depth and penetrated sedimentary rocks of Late Cambrian age underlain by a Precambrian complex. The average values of the properties measured for the major rock types encountered are shown in a table. Typical electric logs are reproduced. — V. S. N.

- 183-270. McCrossan, R. G. Resistivity mapping of the subsurface Upper Devonian inter-reef Ireton formation of Alberta: *Am. Assoc. Petroleum Geologists Rocky Mt. Sec. Geol. Rec.*, 9th, p. 69-73, 1959.

This is the same paper as that published in the *Alberta Soc. Petroleum Geologists Jour.*, v. 7, no. 6, p. 121-130, 1959 (see *Geophys. Abs.* 180-143). — V. S. N.

- 183-271. Itenberg, S. S. Unifikatsiya stratigraficheskikh granits eotsenovykh otlozheniy tsentralnogo i Vostochnogo Predkavkaz'ya po geologo-geofizicheskim dannym [Unification of stratigraphic boundaries of Eocene deposits of the central and eastern Ciscaucasus according to geologic geophysical data]: *Prikladnaya Geofizika*, no. 26, p. 230-245, 1960.

Self-potential and resistivity logs were used to solve several stratigraphic problems in the Eocene of the central and eastern Ciscaucasus. The boundary between the Paleocene and Eocene as well as several marker horizons within the Eocene were determined. — J. W. C.

- 183-272. Itenberg, S. S., and Yepifanov, Yu. G. Vozmozhnosti otsenki kollectorskikh svoystv i opredeleniya gazonasyschennosti alevritovykh plastov khadumskogo gorizonta Bezopasnenskogo gazovogo mestorozhdeniya Tsentral'nogo Predkavkaz'ya [Possibilities of estimating the reservoir properties and of determining the gas saturation of silty strata of the Khadum horizon of the Bezopasnen gas field of the central Ciscaucasus]: *Vyssh. Ucheb. Zavedeniye Izv., Neft' i Gaz*, no. 4, p. 15-22, 1960.

The initial specific resistance of the producing strata of the Khadum horizon can be determined with sufficient reliability by the laterolog under the conditions of the low resistivity section of the central Ciscaucasus. This is facilitated by the presence of a marker horizon at the top of the reservoir unit. Using the logging data in conjunction with core determinations and analyses of formation water, it is possible to determine such parameters as the gas saturation and the effective porosity. — J. W. C.

ELECTRICAL PROPERTIES

- 183-273. Hatherton, T. Electrical resistivity of frozen earth: *Jour. Geophys. Research*, v. 65, no. 9, p. 3023-3024, 1960.

Apparent resistivities of permanently frozen ground were measured at two stations in Antarctica. At Scott Base resistivities near the surface are about 100 ohm-m in one place and about 300 ohm-m in another; apparent resistivities at depth are 1,500-3,000 ohm-m. At the time of measurement the ground temperature at 15 cm was -5°C , and the temperature below 10 m about -21°C . At Hallett Station the resistivity near the surface was only about 30 ohm-m and at the greatest electrode separation (30.5 m) it was about 400 ohm-m.

These d-c resistivities are surprisingly low for frozen ground. They are similar to the values measured by Cook on synthetic salty ice and frozen earth (see *Geophys. Abs.* 182-213). — D. B. V.

- 183-274. Volarovich, M. P., and Bondarenko, A. T. Issledovaniye elektricheskogo soprotivleniya v obraztsakh gornyykh porod pri vsestor-

onnem davlenii do 1,000 kg/cm² [An investigation of electric resistance in rock samples under a confining pressure up to 1,000 kg per cm²]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 946-958, 1960.

Methods of determination of the electric resistance of rock samples are described for confining pressures up to 1,000 kg per cm². Measurements were made on shale, sandstone, arenaceous marl, calcareous sandstone, sandy loam, basalt, diabase, and peridotite. The form of the curve of electric resistance versus confining pressure is similar to the curves of elastic waves velocity, Young's modulus, and compressibility of rock samples. The drop in resistance of various rocks under confining pressure of 1,000 kg per cm² is 18-74 percent. — A. J. S.

- 183-275. Yashchenko, Z. G., and Yesakov, I. S. O primeneni elektrorazvedki dlya izucheniya uprugikh svoystv gornyx porod [On application of electric prospecting to studies of elastic properties of rocks]: Razvedochnaya i Promyslovaya Geofizika, no. 33, p. 23-29, 1959.

Measurements made on diabase in place in the bed and banks of a Siberian river show that the value of Young's modulus for this rock is directly proportional to the resistivity. An electrical sounding method proposed can be applied to studies of elastic properties of other rocks in addition to that used in this study. — A. J. S.

EXPLORATION SUMMARIES AND STATISTICS

- 183-276. Patrick, Homer G. Geophysical activity in 1959: Geophysics, v. 25, no. 5, p. 1100-1118, 1960.

Geophysical activity in the petroleum industry in 1959 was reduced in all the major areas outside the communist-bloc nations except in the Far East, where a small overall gain was reported. An average of 957 geophysical crews of all types operated in worldwide exploration, compared to the record high of 1,136 in 1956. Details of use of different methods in different areas are presented.

The average number of professional people employed in mining geophysics increased from 796 in 1958 to 885 in 1959, but expenditures decreased somewhat in the same year. Breakdowns are shown for different parts of the world. — D. B. V.

- 183-277. Blanpied, B. W. Exploratory drilling in 1959: Am. Assoc. Petroleum Geologists Bull., v. 44, no. 6, p. 657-682, 1960.

A total of 13,191 exploratory holes were drilled in the United States during 1959. Of these, 7,031 were new-field wildcats, 3,355 were new-pool tests, and 2,805 were outposts; 772 of the first group, 941 of the second group, and 901 of the third group were successful. The total footage drilled was 63,252,521 feet, an average of 4,800 feet per hole. These figures compare with 61,483,911 feet drilled in 13,199 holes with an average depth of 4,661 feet in 1958. — D. B. V.

- 183-278. Roy, Amalendu. A new approach to geophysical methods of finding oil: Oil and Gas Jour., v. 58, no. 45, p. 208-211, 1960.

More oil must be found at highly reduced costs if the oil business is to survive. Methods must be developed for successfully tracking the oil concealed

in stratigraphic and low-relief traps, and to do this the structural basis of exploration should be abandoned. It seems inescapable that the only methods which will ultimately succeed in locating such oil in a routine manner are those that will look for oil directly. The various possible methods that might be used include geochemical, radioactive, sandex and longcolog, seismic, electric, and electromagnetic techniques.

In developing new methods there is promise for a twofold reduction in expenditure because the method itself will be more economical and the number of dry holes is likely to be drastically reduced. — V. S. N.

183-279. Slichter, Louis B. The need of a new philosophy of prospecting: *Mining Eng.*, v. 12, no. 6, p. 570-575, 1960.

The primary importance of appraising the expectations of finding ore is emphasized, and a few of the many kinds of statistical data needed for guiding geophysical prospecting are discussed. As a basic consideration in rational planning of prospecting, a statistical approach is presented for the consideration of the distribution of ore bodies in space and in size and of the probability of discovering targets of various sizes and shapes by aerial surveys having various traverse spacings. — V. S. N.

183-280. Oil in Canada. Muskeg conquest chief objective of exploration research in 1960: *Oil in Canada*, v. 12, no. 40, p. 46-47, 1960.

Nearly half of the geophysical crew months worked this year in Canada will have been concentrated in the first three months. This is a reflection of the trend to the north in exploration work. The proportion of total geophysical work done in the first quarter has risen steadily in the past several years while at the same time the actual number of crews at work has dropped steadily. Forecasts indicate that the average monthly crew count in Canada this year will reach an all time low of just half the maximum number.

Research on methods and equipment dominates the 1960 geophysical scene as a means of cutting costs in a highly competitive environment. Vehicles and equipment that can be used under all terrain conditions are now available. The magnetic tape has greatly improved interpretive techniques, and the development of multiplexing digital recording systems promises greater refinement and accuracy of records. — V. S. N.

183-281. Morales, Luis G. General geology and oil possibilities of the Amazonas Basin, Brazil [with French abstract]: *World Petroleum Cong.* 5th, New York 1959, Proc., sec. 1, paper 51, p. 925-941, 1959.

Geophysical methods used in conjunction with isopachous, clastic ratio, and biofacies maps are spear-heading the search for commercial oil production in the Amazon. Oil reserves are believed to exist on the flanks of major structural arches and in association with Devonian faulting and possible reef growths in the Carboniferous. Seismic surveys are the chief exploratory tool in this geologically unexplored area. Because of the complexity of techniques required for reflection shooting under jungle conditions, the refraction method is used. All lines are anchored to wells; therefore, identification of refractors is reasonably certain.

Some gravimeter surveys were instituted, although the significance of the results is not fully understood at this time, and other gravimeter surveys still continue. Horizontal and vertical magnetometer surveys were carried out during the early phase but were discontinued as unsatisfactory. A later airborne magnetometer project, however, gave promising results.

General conclusions concerning the geology and oil possibilities are presented. — V. S. N.

- 183-282. Breyer, Friedrich, and Dohr, Gerhard. The structures of the folded molasse in western Bavaria investigated by means of geophysical measurements [with French abstract]: World Petroleum Cong., 5th, New York 1959, Proc., sec. 1, paper 44, p. 815-826, 1959.

This is virtually the same paper as published in Ver. Schweizer. Petroleum-Geologen und Ingenieure Bull., v. 25, no. 68, p. 29-35, 1958 (see Geophys. Abs. 176-337). — V. S. N.

- 183-283. Nosske, G[erhard], and Särchinger, H. Geophysikalische Untersuchungen zwischen den Mineralquellengebieten von Bad Elster und Bad Brambach [Geophysical investigations between the mineral-spring regions of Bad Elster and Bad Brambach (with English abstract)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 2, p. 137-147, 1960.

Electromagnetic (Turam), magnetic, and geochemical investigations were undertaken between the spas of Elster and Brambach in southwestern Saxony in order to determine which of the various joint systems is the deeper, and therefore the preferred tectonic direction along which the mineral waters ascend.

The electromagnetic survey showed a system of joints with a Hercynian trend connecting some of the acid springs. This system coincides with a magnetic minimum which is interpreted as a zone of intense alteration. Drilling showed that small positive magnetic anomalies are produced by a mica schist containing magnetite and pyrrhotite, rather than by basalt as was expected. — D. B. V.

- 183-284. Skorupa, Jan. Résultats géologiques des recherches géophysiques au Nord-Est de la Pologne [Geological results of geophysical investigations in northeastern Poland (with English abstract)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 2, p. 182-188, 1960.

Northeastern Poland lies within the East European (Russian) platform; it contains both true platform and marginal structures. Regional magnetic and gravimetric surveys together with some seismic refraction work have thrown light on the tectonics and deep structure of the typically platform area and part of the marginal area. A map has been compiled on the basis of the geophysical results and borehole data from Poland and the adjacent part of the U. S. S. R. In the marginal zone the crystalline basement is shallower than in the platform proper. Several smaller tectonic units are distinguished within the latter; some of these are continuations of units known across the border in the U. S. S. R. — D. B. V.

- 183-285. Mustafayev, K. A. Kvprosu o tektonike srednego Kaspiya [On the problem of the tectonics of the middle Caspian]: Prikladnaya Geofizika, no. 21, p. 104-110, 1958.

Data of pendulum and airborne magnetic surveys, bottom gravimeter data of the Caspian Sea, and seismic data of the Caspian and adjacent regions were used to determine the boundary between the Alpine geosyncline and Paleozoic platform and for an interpretation of this boundary. It was found that the

Caspian depression can be subdivided into two zones: a zone of Alpine folding and a zone of epi-Hercynian folding. It was also found that the Apsheron Shallows is a complex feature of the relief rather than a tectonic link between the Greater Caucasus and the Greater Balkhan of the Trans-Caspian region. — A. J. S.

183-286. Westgate, Robert. Red China claims large oil resources are being developed: *World Oil*, v. 151, no. 6, p. 138, 144, 146-148, 153-154, 157-158, 1960.

A massive program is now in progress to develop the petroleum industry of China. The rise in annual production during both 1958 and 1959 is reported to have been on the order of 50 percent. More significant, however, is the exploration during recent years. The Yumen, Yenchang, and Tushantzu oilfields in Kansu and Shensi Provinces have been expanded, and new fields have been discovered at Karamai in Sinkiang Province, at Lenghu in Chinghai Province, and in central Szechwan Province. Modern methods of geophysical and geochemical prospecting are employed.

China claims to be 90 percent self-sufficient in oil prospecting, drilling, and production equipment. A Sian factory specializing in geophysical prospecting instruments began production in 1956, making electric logging units, seismic instruments, and gravimeters. In 1959 it started mass producing a gas logging instrument, an autoelectrical logging instrument, a radiometer, acoustic logging apparatus, a high-speed thermal logging instrument, a low frequency seismodetector, and a low frequency seismograph. A workshop under the Sinkiang Petroleum Administration in Urumchi recently made China's first light weight (160 lb) seismograph, suitable for exploration in deserts and marshes. — J. W. C.

183-287. Masuda, Hideo. Geophysical exploration of the dam foundation [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 1, p. 25-35, 1960.

The relation between the geologic structure and the stress of a dam upon the bedrock, and the bearing-power, elasticity, and permeability of the bedrock must be understood in order to determine the reliability of a proposed structure. In designing the arch of a dam, the ratio of Young's modulus in concrete to that in the bedrock, $E_C/E_R=n$, must be known.

As the value of Young's modulus from velocity measurement is usually larger than the values from other methods and from the value used in dam design, Masuda proposes to use E'_R in place of E_V in the determination of Young's modulus of bedrock:

$$E'_R = 1/2 \frac{\bar{V}}{V_m} E_V \text{ where } E_V = \rho \bar{V}^2 (1+\sigma)(1-2\sigma)/(1-\sigma),$$

\bar{V} is average velocity in the field, and V_m the velocity of a sample with no fractures. — V. S. N.

183-288. Bureau of Mineral Resources, Geology and Geophysics. Summary of oil-search activities in Australia and New Guinea to June, 1959: Australia Bur. Mineral Resources, Geology and Geophysics Rept., no. 41A, 68 p., 1960.

Information on geological, geophysical, and drilling activities in the search for oil, and on well status to September 1959 in Australia and New Guinea is presented. Petroleum tenements to June 30, 1959, and expenditures to December 31, 1958, are also discussed and listed in appendixes. Each possibly petroliferous area in Papua, New Guinea, and Australia is discussed; the re-

port concludes with a general summary to give a perspective view of the search for oil throughout the areas.

Geological and geophysical information in most of the areas is known only in the broadest outline. Gravity and (or) magnetic surveys of reasonable reconnaissance standards have been completed in some areas but numerous others remain to be made. Seismic surveys are desirable to check subsurface structure before drilling.

Two promising oil discoveries have been made: one at Rough Range, Western Australia, and the other at Puri, Papua. These discoveries are important in that they may lead to further discoveries in the immediate vicinity. Areas where available geological and geophysical information indicate a possibility of commercial oil are listed in order of present potential. — V. S. N.

- 183-289. Blackwell, M. J. Recent scientific activities at Halley Bay: International Geophysical Co-operation, 1959: *Nature*, v. 187, no. 4742, p. 982-984, 1960.

This is an outline of the main activities of the team that took over the Royal Society's station at Halley Bay, Antarctica, on January 10, 1959. Various meteorological observations were made. The most significant work of the year was the determination of the movement of the ice shelf, both by conventional and by less usual methods. Snow accumulation was measured. The geomagnetic program consisted of local observations on the ice shelf (these will have to be corrected for movement of the magnetic hut relative to the seabed) and vertical intensity measurements on a 33-mile traverse to the east-northeast of the base. Results of both surveys show that a complex system of magnetic contours covers the whole region so far explored. Auroral, oceanographic, and seismological programs were continued, and two distinct biological programs were carried out. — D. B. V.

- 183-290. Model', Yu. M., and Nudel'man, A. V. Ledyanoy pokrov Antarktidy [The ice sheet of Antarctica]: *Priroda*, no. 11, p. 93-97, 1959.

A review of thickness determinations of the ice sheet over the Antarctic continent is given. Several profiles showing depth to bedrock have been established by seismic methods combined with gravimetric and magnetometer surveys. Data are given from expeditions by several countries. On the basis of material gathered during the International Geophysical Year a schematic relief map of Antarctica was constructed. — A. J. S.

- 183-291. Ladd, Harry S., and Schlanger, Seymour O. Drilling operations on Eniwetok Atoll: U. S. Geol. Survey Prof. Paper 260-Y, p. 863-903, 1960.

Descriptions of equipment and procedures together with generalized logs of all holes drilled on Eniwetok Atoll during the years 1950 through 1952 are presented. The deep drilling revealed the presence of olivine basalt beneath shallow water limestone of Eocene age at a depth of more than 4,000 feet; this firmly establishes the fact that the foundation of Eniwetok is a basaltic volcano that rises 2 miles above the floor of the ocean, and confirms one of the important features of Darwin's subsidence theory which postulates that atolls may develop on the tops of slowly sinking mountains. — V. S. N.

GENERAL

- 183-292. Longman, I. M. A technique for the numerical solution of geophysical problems: *Jour. Geophys. Research*, v. 65, no. 11, p. 3795-3800, 1960.

The theoretical analysis of problems in geophysics, and particularly in seismology, leads in many cases to solutions expressed in terms of integrals that cannot be evaluated by conventional numerical methods. The usual difficulties are connected with the oscillatory nature of the integrand and with the presence of one or more poles in the path of integration. In the simpler problems these difficulties can sometimes be circumvented by appropriate transformations in the complex plane, though this often involves lengthy analysis. A method is presented for the direct and accurate evaluation of such solutions with a minimal use of algebraic manipulations. By way of illustration the method is applied to Lamb's problem with an oscillatory source. — Author's abstract

183-293. Baranov, V[ladimir] [I.]. Rôle des mathématiques dans l'art de l'interprétation [Role of mathematics in the art of interpretation]: *Geophys. Prosp.*, v. 8, no. 2, p. 141-147, 1960.

When the imagination is subjected to a discipline based on reasoned knowledge, an occupation becomes an art; in this sense, applied geophysics is an art, guided by the sciences of physics, geology, and mathematics. Geologic data set the limits within which the physical measurements made in the field can be interpreted, and this task is controlled by mathematical reasoning and calculations. Only mathematics can demonstrate whether theories are well grounded.

Mathematical interpretation methods are lagging behind techniques of measurement. Interpretation problems in seismic surveying and gravimetry are discussed to illustrate this point. The future of applied geophysics will depend largely on the effectiveness and precision of interpretation of data. Interpretation becomes more difficult as more complex problems are attacked; but instead of "simple and rapid" formulas, more precise formulas should be sought for use with the aid of calculating machines. — D. B. V.

183-294. Geophysics Research Directorate. Handbook of geophysics (revised edition): New York, Macmillan Co., 680 p., 1960.

This handbook was prepared by scientists of the U. S. Air Force's Cambridge Research Center primarily for the use of those interested in space research. Its chapters include current information on such topics as the atmosphere, geomagnetism, meteors, the surface of the earth, the ionosphere, thermal radiation, the sun, cosmic radiation, and atmospheric exploratory devices. — V. S. N.

183-295. McDonald, James E. Remarks on correlation methods in geophysics: *Tellus*, v. 12, no. 2, p. 176-183, 1960.

From consideration of several studies of the sampling properties of the product-moment coefficient r it is concluded first that undue concern has been expressed for the problem of non-normality in correlation studies in geophysics, and second, that use of geophysically adequate significance tests and confidence limits for r can almost always be achieved through use of the simple standard error of r . A growing tendency in climatology and hydrology to employ unnecessarily elaborate methods appears to stem from unrealistic emphasis which mathematical statisticians frequently place upon theoretical refinements, emphasis that loses sight of the limits of accuracy inherent in the very type of data usually subjected to statistical analysis. — Author's abstract

183-296. Dominici, P. Un'osservazione sull'andamento annuo dei valori orari di grandezze geofisiche a controllo solare [An observation on the

annual course of hourly values of geophysical quantities controlled by the sun (with English abstract)]: *Annali Geophysica*, v. 12, no. 3, p. 273-282, 1959.

This paper examines the possibility that geophysical values which depend on the zenith distance χ of the sun are affected by the fact that these values are computed with reference to local time rather than to solar time. The amount of such "distortion of form" is calculated for the particular case of the meridional values of the maximum electron density N of an ionospheric layer in which the electronic balance is given by the equation $\partial N / \partial t = f(\chi) - \beta N$ (t = time, β is a constant). The results indicate that the effect in question must be taken into consideration, especially for medium- and high-latitude stations whose position in their respective time zones is eccentric. — D. B. V.

183-297. Cobb, Howard. Operations research—a tool in oil exploration: *Geophysics*, v. 25, no. 5, p. 1009-1022, 1960.

Operations research is a tool which may be used by the exploration man to help in planning exploration activities and in making decisions. Electronic computers and mechanized data handling may be used in the analyses which are a part of operations research. Various types of exploration data which we put on punch cards are readily available for operations research studies. Mathematical models of various activities play a large role. They are often built up from data of past experience. Thus, statistics and probability theory are important to the studies. Other techniques commonly associated with operations research studies are linear programming, game theory, queueing theory, Monte Carlo, and search theory. Operations research has been defined as quantitative common sense. It is probably the cheapest and one of the more effective of our exploration tools. We use it when we plan optimum control for a geophysical survey. We use it when we analyze the future of a frontier oil province. — Author's abstract

183-298. Stumpff, Karl. Planet earth: Ann Arbor, Univ. Michigan Press, 191 p., 1959.

This book, written for the layman, presents current scientific knowledge about the nature of the planet earth, its form and size, movement and inner structure, relationship to the surrounding cosmos, and the conditions created for life on its surface. The first chapter, Man looks at the earth, is a brief historical review of man's knowledge of the earth. Other chapters are as follows: the earth is a sphere; the earth rotates; direction finding on the earth's surface, the earth travels around the sun; the life-giving sun; terrestrial poles and terrestrial magnetism; the earth's structure; the air around the earth; and earth, universe, and life. — V. S. N.

183-299. Taylor, J. H. Recent geophysical work in Britain: *Nature*, v. 185, no. 4715, p. 739-740, 1960.

This is a report on the symposium entitled "Geological implications of recent geophysical work in the British Isles," held by the Geological Society of London at its meeting on January 27, 1960. — D. B. V.

183-300. Saxov, Svend [E.]. Mining geophysics: *Nature*, v. 185, no. 4711, p. 436-437, 1960.

This is a report on the second Nordic Meeting for Mining Geophysics, held in Copenhagen on December 7-8, 1959. — D. B. V.

- 183-301. Meisser, Otto. Probleme der angewandten Geophysik für Industrie und Bergbau [Problems of applied geophysics for industry and mining]: Freiburger Forschungshefte C 81 Geophysik, p. 243-245, 1960.

This is a brief preliminary statement of the relationship of applied geophysics to engineering and mining operations and to petroleum and ore prospecting. Applied geophysical research has doubled in the last few years, and present trends and specific practical problems are bringing about a substantial intensification of pertinent research and development work that will be of great value to mining and industry in the next few years. — D. B. V.

- 183-302. Bike, Peter B. New exploration trend: The seismic exchange center: Oil and Gas Jour., v. 58, no. 39, p. 269-270, 272-273, 1960.

The geophysical exchange service or library is a new exploration concept that has developed since the midfifties. The exchange, started initially as a source of seismic data for sale or trade, has expanded into gravity and magnetic data coverage. Today there are at least six firms performing this service with little overlap of data. The six firms are listed and the areas covered by each given. — V. S. N.

- 183-303. Doll, H. G., Martin, Maurice, and Tixier, M. P. Review of the progress of well logging since the 4th World Petroleum Congress [with French abstract]: World Petroleum Cong., 5th, New York, Proc., sec. 1, paper 35, p. 645-665, 1959.

Improvements and developments in the past 4 years in the following well-logging instruments and techniques are discussed: the induction-electric log, laterolog, and proximity log; interpretation of the electric log; methods of gamma ray and neutron logging, and the density (gamma-gamma) log; the short-interval sound velocity log; combination logs (induction-electric, sonic and gamma-ray or SP logs, laterolog, gamma ray and neutron logs; and gamma ray-perforator); hot-wire techniques in mud logging, mass spectrometry, infrared spectrometry, and gas chromatography; the formation tester; and modern electronic computers as aids in the interpretation of log data. — V. S. N.

- 183-304. Doll, H. G., Martin, Maurice, and Tixier, M. P. Application of wire-line well logging to subsurface geology: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 2, p. 121-136, 1960.

Wire-line well logging devices (those in which the sonde is lowered into the hole at the end of a cable, and the measured values are recorded at the surface) are reviewed. In addition to their main use in connection with petroleum geology, well logs are also used in the search for potash, uranium, ground water, and coal. The paper is illustrated with numerous examples of electrical, radioactivity, temperature, caliper, and sonic logs. — D. B. V.

- 183-305. Chombart, L. G. Well logs in carbonate reservoirs: Geophysics, v. 25, no. 4, p. 779-853, 1960.

To play an important role in the evaluation of carbonate reservoirs, well logs must be selected and interpreted with due regard for the specific rock types and pore structures encountered by each well. First, the cuttings or cores should be described precisely as to rock types and depths. Second, any techniques used should permit the largest possible number of determinations through the reservoir, so that any existing relations between pore-size dis-

tribution, porosity, and water saturation may be established on a sound statistical basis; focusing logging tools meet this requirement best. Third, the reservoir should be cored and logged in key wells starting early in its development; the cores should be subjected to capillary pressure and other petrophysical tests, and all potentially diagnostic logs should be run and analyzed in the light of all other data. Fourth, the logging programs in nonkey wells should include only those logs proved in the key wells to be more reliable for the conditions encountered. — D. B. V.

- 183-306. Itenberg, S. S., and Yepifanov, Yu. G. Ob opredelenii fizicheskikh parametrov neftesoderzhashchikh porod po geofizicheskim dannym [On determination of physical parameters of oil-bearing rocks according to geophysical data]: *Prikladnaya Geofizika*, no. 26, p. 246-252, 1960.

The problem of correlation between geophysical parameters and the reservoir properties of oil-bearing strata is discussed. It was found that the correlation is of a statistical, rather than functional, nature; therefore, a unique equation for determination of reservoir properties from geophysical data cannot be formulated. — A. J. S.

- 183-307. Keller, George V. Physical properties of tuffs of the Oak Spring formation, Nevada, in *Geological Survey research 1960: U.S. Geol. Survey Prof. Paper 400-B*, p. B-396-B-400, 1960.

Extensive physical properties studies have been made of the tuffs of the Oak Spring formation in support of the Atomic Energy Commission's underground weapons test program at the Nevada Test Site. The amount of water in the rock was found to be the most important single factor in determining the physical properties. Variations in thermal conductivity, bulk density, enthalpy, and electrical properties of the tuff are all determined by the water content, directly or indirectly. Variations in strength and acoustic velocity are probably controlled by the fractures as well as by water content. — V. S. N.

- 183-308. Kobranova, V. N., and Leparskaya, N. D. Opredeleniye fizicheskikh svoystv gornyykh porod [Determination of the physical properties of rocks]: Moscow, Gostoptekhizdat, 160 p., 1957.

Laboratory methods of determination of the physical properties of rocks are presented in this textbook written for students of geophysics and geology and for the oil industry. Properties discussed include specific gravity; porosity; permeability; specific surface; moisture content; oil saturation; electrical resistance of waters and rocks; diffusion-absorption, filtration, and oxidation-reduction activities of rocks; radioactivity of rocks; thermal and temperature conductivities; magnetic susceptibility; and elastic properties of rocks. — A. J. S.

- 183-309. Brown, Randall E. The use of geophysics and geochemistry to confirm geological interpretations at the Hanford Works of the Atomic Energy Commission, USA: *Internat. Geol. Cong., 21st. Copenhagen 1960, Proc.*, pt. 2, p. 75-82, 1960.

Geochemical and geophysical data have been used to determine geologic and hydrologic features in the vicinity of the Hanford Works of the U.S. Atomic Energy Commission, where quantitative knowledge of these features is important in the problem of disposal of low-level radioactive waste. Beds are correlated between many wells by detailed comparisons of samples and drill-

ling records, clay mineral studies, exchange capacity, particle size distribution studies, and data from ground water studies. The use test, a form of tracer test where discharged wastes are traced by sampling and testing of many monitor wells, provides the final evaluation of the significance of the determined features. — D. B. V.

GEODESY

183-310. Heiskanen, W. A. The latest achievements of physical geodesy: Jour. Geophys. Research, v. 65, no. 9, p. 2827-2836, 1960.

The fact that the present accuracy of computations of geoidal undulations from gravimetric data is not as high as desirable is due to a lack of gravity data rather than to a fault in the method. The large masses of the earth, such as high mountains and ocean basins, are 85-90 percent isostatically compensated. It is not claimed that complete hydrostatic equilibrium prevails.

The first gravimetrically computed geoid, the "Columbus geoid," was presented in 1957 (see Geophys. Abs. 171-149); it was based on the international ellipsoid's flattening value of $\alpha=1/297.0$. The Columbus group has used only the gravimetric method and has not extrapolated anomalies more than 15° from the computation point. The Army Map Service geoid is based on values of $\alpha=1/298.49$ or $1/298.3$; the latter value has been obtained several times by satellite, gravity, and arc-measuring methods. When converted from one to the other, the Columbus and Army Map Service geoids agree rather well in most areas of the Northern Hemisphere, where there is a fairly good network of gravity stations.

Using spherical harmonic analysis, Uotila has obtained third order harmonics similar to those obtained by O'Keefe (see Geophys. Abs. 180-183) from satellite data. The undulations associated with the pear-shaped form are of the order of ± 15 m. O'Keefe's geoid heights at the north and south poles were brought about solely by the fact that he used a flattening value ($1/299.8$) that does not correspond to reality. — D. B. V.

183-311. Hirvonen, R. A. New theory of the gravimetric geodesy: Acad. Sci. Fennicae Annales, ser. A-3, no. 56, 50 p., 1960.

In the classical theory of gravimetric geodesy the altitudes of observation points have been determined in two steps: (1) orthometric heights above the geoid have been calculated; then (2) the elevations of the geoid above the reference ellipsoid. A new theory has been developed in which normal heights above the ellipsoid are determined first, then the height anomalies. The intermediate surface between the two steps is no longer the geoid but a new surface called the "telluroid."

Unlike the geoid, the telluroid has no physical reality; if the reference ellipsoid is changed, the telluroid is also changed. The telluroid follows topographic irregularities of the surface very closely. In order to avoid the latter disadvantage Molodenskiy measures height anomalies upward from the ellipsoid and introduces another intermediate surface called the quasi-geoid (see Geophys. Abs. 178-199). This contrivance merely makes theoretical explanations more difficult.

The practical advantages of the new theory outweigh the disadvantages mentioned above. Normal heights can be computed rigorously on the basis of legitimate geodetic measurements, whereas for orthometric reductions the gravity within the crust should be known. Deflections of the vertical refer to the earth's physical surface; hence the observed direction of gravity can be used without any reductions and the direction of normal gravity, obtained principally on the basis of triangulation at the ellipsoid, can be reduced by

the aid of the normal curvature of the plumbline. As only normal free air anomalies are used, the observed gravity can be used without reductions and normal gravity can be computed easily for elevated stations by means of the geopotential numbers. No mass transports with hypothetical densities need be performed, and cumbersome topographic and isostatic reductions with corresponding indirect effects can be neglected.

The new theory does not invalidate the classical formulas of Stokes and Vening Meinesz, which still give good first approximations for the height anomalies and deflections of the vertical. Only the interpretation of these quantities is changed; they belong to the physical surface of the earth rather than to the geoid.

Some difficulties are caused by the fact that free air anomalies vary irregularly in rough mountainous regions, but when proper computation methods have been developed these should be less cumbersome than the old reductions. — D. B. V.

- 183-312. Uotila, Urho A. [K.]. Investigations on the gravity field and shape of the earth: Acad. Sci. Fennicae Annales, ser. A-3, no. 55, 92 p., 1960; reprinted as Ohio State Univ. Inst. Geodesy, Photogrammetry, and Cartography Pubs., no. 10, 92 p., 1960.

The world-wide gravity project initiated by Heiskanen is a program under which observational gravity data from various agencies all over the world are channeled to Columbus, Ohio, adjusted to one reference system (the Potsdam), translated into mean free-air anomalies, and finally used for computation of geoid undulations and deflection of the vertical. A variety of new methods and techniques has been developed to handle the voluminous and complex computations involved. The most important of these are described in this work; they are the following: (1) a practical high-speed computer method of determining geoid undulations; (2) a high-speed computer method for the numerical integration of the effect of distant areas on the deflection of the vertical; (3) a method for manual computations of the effect of distant areas on the deflection of the vertical, in which templates of original design are used with mean anomaly stereographic charts; (4) a system for uniform high-speed handling of vast amounts of data with IBM machines; (5) a high-speed integration method for determining the shape of geopotential surfaces at high elevations (>100 nautical miles); (6) a simple graphical method of correlating free-air anomalies and elevations on land; (7) a general technique for determining and estimating $1^\circ \times 1^\circ$ mean free-air anomalies; and (8) a method of relating national reference stations to the same world gravity system. (See also Geophys. Abs. 182-246, -247.) — D. B. V.

- 183-313. Arnold, Kurt. Relationen zwischen neueren Verfahren der Theorie der Figur der Erde [Relations between recent treatments of the theory of the figure of the earth (with English summary)]: Gerlands Beitr. Geophysik, v. 69, no. 3, p. 140-149, 1960.

Molodenskiy's method of determining the figure of the earth and deflections of the vertical, based on the quasi-geoid (see Geophys. Abs. 178-199), is outlined briefly and compared with the method based on the geoid. — D. B. V.

- 183-314. King-Hele, D. G. Evaluation of the second, fourth, and sixth harmonics in the earth's gravitational potential: Nature, v. 187, no. 4736, p. 490-491, 1960.

Values of the second, fourth, and sixth harmonics of the earth's gravitational potential have been calculated from the widely different orbits of Sput-

nik 2 (1957 β , inclination $i=65^\circ$), Vanguard 1 (1958 β , $i=34^\circ$), and Explorer 7 (1959 α , $i=51^\circ$) as follows: $J_2=(1082.79\pm 0.15)\times 10^{-6}$, $J_4=(-1.4\pm 0.2)\times 10^{-6}$, and $J_6=(0.9\pm 0.8)\times 10^{-6}$. It is assumed that the odd-numbered J_n 's have little or no effect on the orbit.

If the earth's flattening f is defined as the difference between the equatorial and polar diameters divided by the equatorial diameter, and if the meridional section is taken as elliptic as has been customary, the new J_2 value gives $1/f=298.24\pm 0.02$ as compared with the value $1/297.1$, which was generally accepted before the advent of satellites. — D. B. V.

183-315. Cohen, C. J., and Anderle, R. J. Verification of earth's "pear shape" gravitational harmonic: *Science*, v. 132, no. 3430, p. 807-808, 1960.

Predictions of the orbit of the Transit 1 B satellite were systematically in error until account was taken of a third-order gravitational harmonic. The amplitude deduced for this harmonic by O'Keefe [see *Geophys. Abs.* 176-159] from the Vanguard 1 orbit serves very well, even though the orbits and the methods of observation and orbit fitting for the two satellites are quite different. — Authors' abstract

183-316. Corpacius, Alexander. Hiran geodesy and photographic observations: *Jour. Geophys. Research*, v. 65, no. 9, p. 2837-2838, 1960.

New formulas are developed for computing the azimuth and distance between two Hiran ground stations with data obtained from the photographs; orientation calibration of the cameras is not necessary. Thereby, a method of determining the orientation of Hiran network is obtained. — Author's abstract

183-317. Poder, Knud. Determinations of latitude 1956: [Denmark] *Geod. Inst. Skr.*, ser. 3, v. 33, 36 p., 1960.

Astronomical determinations of latitude at 7 stations in the Danish triangulation net were executed in 1956 in order to procure data for determinations of deflection of the vertical. The instruments used, method of observations, and selection of stars are discussed, and the observations and results for each station are tabulated. — D. B. V.

GEOTECTONICS

183-318. Belousov [Belousov], V. V. The conditions of fold formation: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 326-333, 1960.

Three kinematic types of folding are recognized. In order of increasing complexity these are block folding, injection folding, and general crumpling (holomorphic folding). Any type of folding is a reaction of stratified rocks to differential vertical movements of basement blocks. Block folding is the simple reflection of this vertical movement. Injection folding is associated with horizontal redistribution of some of the more plastic material, resulting from a shifting of gravitational equilibrium due to the vertical movements. Salt diapir domes and folds are the extreme case of injection folding.

The importance of general crumpling has generally been overestimated. Several cases are outlined to show its ultimate dependence on vertical movements. Pressure of the upper part of a relatively elevated block, under the influence of gravity and "squeezing out," on an adjacent downdropped block,

together with flexuring and upward squeezing of layers, leads to general crumpling. — D. B. V.

- 183-319. Khain, V. E. [Ye]. Main types of tectonic structures, their principal features and probable origin: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 215-226, 1960.

Continents and oceans are first-order structures of the earth's crust; they extend to the bottom of the C layer of the mantle. Mobile belts (subdivided into intraoceanic, geosynclinal, and geanticlinal) and stable regions (subdivided into continental and oceanic platforms) are second- and third-order structures; they reach the B layer of the mantle. Fourth-order structures are the major elements of geosynclinal regions and of continental and oceanic platforms; they involve the whole crust and are reflected in the relief of the M-discontinuity.

The origin and evolution of all these structures are related and to some degree are influenced by movement along deep faults bordering them. The crust as a whole and its individual structural features have a block-fold character. The plastic tectonics of folded zones partly mask the block structure of the basement. The main causes of tectonic evolution lie in interrelated processes of differentiation in the mantle and core and global changes in volume. This change is mainly contractive, resulting in general centripetal movement of the crust; differential movements between blocks create the large negative features. Possibly contraction is replaced by expansion from time to time. Differentiation results in an increase of thickness of the basaltic layer, forming median oceanic ridges or geanticlinal mobile belts; or of the granitic layer, forming mobile belts of normal geosynclinal type. The deep faults create paths for rising basaltic lavas and granitizing solutions.

The origin of the planetary pattern of these deep faults or lineaments, their differences in trend, and the cyclic nature of tectonic processes must be connected with rotation of the earth and cosmic causes in general. — D. B. V.

- 183-320. Azhgirey, G. D. O nekotorykh vazhnykh zakonmernostyakh tektonicheskogo stroyeniya i dvizheniy zemnoy kory [On some important regularities of tectonic structure and movements of the earth's crust]: *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 8, p. 3-19, 1960.

The relationship of folded belts to deep fractures in the earth's crust is pointed out. The main features of deformation in mobile belts are outlined in theory and then applied to the Caucasus; some general conclusions are then drawn concerning the kinematic and dynamic similarity of deformation in oceanic and continental arcs, the age of deep fractures and their order of magnitude, and recognition of individual arcs.

"Regional structural analysis" constitutes a new method of analyzing the genesis and development of local tectonic zones and formations in the light of the general regional structure and orogenic history. — D. B. V.

- 183-321. Kraus, E[rnst] C. Das Orogen, Begriff, Bildungsweise, und Erscheinungsformen [The orogen; concept, manner of formation, and manifestations]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 236-247, 1960.

An orogen is defined as the product of a geosyncline. The latter is defined as a mainly sinking and very labile zone of stoppage in the earth's crust that goes through the oromagmatic cycle. This cycle is marked by a first (hyporogenic or cataorogenic) main phase of subsidence and folding accompanied by differentiation of Pacific type magmas and migration, and a second (epio-

rogenic) main phase of elevation, denudation, formation of foredeeps, and gradual transition to Atlantic type magmas. The resulting orogen is as thick as a continent, resistant to subsequent folding, and flares out on both sides but not equilaterally. — D. B. V.

- 183-322. Wolfe, C. W. Volume change forces in geologic processes: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 287-294, 1960.

The expansion thrust mechanism involves formation of open fractures in a solid either by contraction or by expansion from below, filling of the fractures with material which becomes part of the solid, and a return to original temperature or space conditions with the concomitant development of a lateral thrust equivalent to the area of fracture filling.

Ice-push debris ridges around northern lakes are described as an example of this mechanism. It is suggested that similar mechanisms operate, on different scales, in the case of polygonal ground and raised polygons, in the major part of glacial movement, and in the apparent crustal shortening during orogenesis. In the last case, tension fractures in the crust are induced by subcrustal expansion and may be filled with dikes or vein minerals; subcrustal contraction is then accompanied by an apparent crustal shortening equivalent to the surface area of the introduced material. — D. B. V.

- 183-323. Schofield, J. C. Some theoretical structures associated with transcurrent faulting applied to the Alpine fault: New Zealand Jour. Geology and Geophysics, v. 3, no. 3, p. 461-466, 1960.

During transcurrent faulting arcuate fold trends are produced and the regional stress is resolved into a series of oblique, lower order stress systems which enable cross folds to develop without any necessary changes to the direction of the regional stress. If a transcurrent fault dominates the structural and sedimentary patterns during geosynclinal folding, then similar tectonic, stratigraphical, and volcanological environments may be present in diagonally opposed positions at the ends of the fault. Under these circumstances the amount of shift along a transcurrent fault may be much less than the apparent movement indicated by the relative position of similar rock units. — Author's summary

- 183-324. Gastil, Gordon. Continents and mobile belts in the light of mineral dating: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 9, p. 162-169, 1960.

A study of mineral dates from all portions of the earth shows that belts of crustal mobility, analogous to those now active, have recurred throughout at least 2,700 million years. These belts have developed on, along, and between continents, repeatedly rejuvenating older orogenic terrains. It appears reasonable that oceanic areas have also participated in past mobility as they do today. Considering the earth as a whole, mineral-date evidence tends to refute the supposition that the sialic basement of continent margins is younger than that of continent interiors, and fails to confirm the idea that areas of longest stability correspond to continental or oceanic centers. The continent-ocean subdivision of the earth's surface appears to be older than geologic records and to have only passive relation to crustal mobility.—Author's abstract

Zotov, P. P., Lyustikh, Ye. N., and Magnitskiy, V. A. Is the earth heated by gravity force? See Geophys. Abs. 183-176.

- 183-325. Egyed, L[ászló]. Some remarks on continental drift: *Geofisica Pura e Appl.*, v. 45, p. 115-116, 1960.

Continental drift can be explained only by an expanding earth. It is nothing more than the formation of new ocean basins along rifts that come into existence between continents, and does not necessitate any motion of the continents with respect to the mantle. Expansion of the whole mantle takes place, and material from the subcrustal shells fills the newly formed fissures. The difference in heat flow values between continents and oceans is shown to be compatible with this theory.

It is suggested that the rate of expansion of the earth might be verified on the basis of paleomagnetic data. If two points on an ancient shield at Δl distance apart have paleomagnetic latitudes ϕ_1 , and ϕ_2 (determined on rocks of identical age t), then the paleoradius R_t for that time should be

$$R_t = \frac{\Delta l}{\phi_2 - \phi_1};$$

if the earth is expanding, R_t should be smaller than the present radius. — D. B. V.

- 183-326. Harpum, J. R. The concept of the geological cycle and its application to problems of Precambrian geology: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 9, p. 201-206, 1960.

In broad outline, one geologic cycle is very similar to the next. The complete cycle has three main phases—the geosynclinal, orogenic, and epeirogenic, each divided into episodes. The main elements of the ideal cycle are given in an extensive table.

Subdivision and correlation of the Precambrian is most logically effected by reference to cycles of events. Recognition of the geotectonic environment of any given rock unit, and hence its place within a geologic cycle, may be regarded as one of the most valuable contributions to the interpretation of Precambrian geologic history. — D. B. V.

- 183-327. Thompson, George A. Problem of late Cenozoic structure of the Basin Ranges: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 62-68, 1960.

The Basin Ranges of west central Nevada and adjacent California constitute a structural unit with the Sierra Nevada. This elevated landmass forms a topographic wave with an amplitude of more than 3 km and a wavelength of about 250 km. The topographic upwarp and the superimposed basins and ranges were developed largely during the latter part of the Cenozoic era. Gravity measurements indicate that the topographic swell is isostatically compensated but the measurements neither prove nor disprove compensation of individual basins and ranges. Study of the horizontal components of regional strain which occurred during the formation of the topographic upwarp shows that the region has expanded laterally roughly 5 percent or more by deformation along normal faults. This expansion cannot be accounted for by tilting or folding of strata. Simultaneous lateral and vertical expansion by phase change at the M-discontinuity could qualitatively account for the deformation but is inadequate quantitatively. A combination of phase change and subcrustal flow, however, does seem adequate to explain the deformation. — Author's abstract

- 183-328. Crowell, John C. The San Andreas fault in southern California: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 45-52, 1960.

The San Andreas fault juxtaposes rocks whose relative position can be explained only by great strike-slip movement. The system has been intermittently active throughout the Cenozoic. Strike-slip displacement can be measured back through time as follows: 21 feet in the 1960 earthquake, 3-10 miles during the Pleistocene shown by terrace offset, 35 miles in Pliocene rocks, 30-65 miles in Miocene rocks, 175 miles in Oligocene rocks, and perhaps more in older rocks. New evidence for about 160 miles of combined displacement (30 miles on the San Gabriel fault and 130 miles on the San Andreas) is presented, based on apparent offset of basement terranes. The reliability and significance of the displacements must be taken into account in a satisfactory theory of orogeny. — D. B. V.

- 183-329. Bemmelen, R. W. van. New views on East-Alpine orogenesis: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 99-116, 1960.

In contrast to current opinion that the Alps are the result of crustal shortening in the mobile Tethys belt, van Bemmelen suggests that the structural overlap of the large East Alpine and Pennine nappes can be explained without buckling. His "causality concept" involves the effect of "primary tectogenesis" in the form of differential vertical movements of the basement complex, plus the effect of "secondary tectogenesis" in the form of gravitational reactions to the primary tectogenesis, causing mainly lateral movement. The primary tectogenesis in the Tethys geosyncline was in the nature of "undulation cycles," wave-like deformations of the basement that spread from a number of mountain-building centers. The Alps between Genoa and Vienna belong to the North Adriatic center. Three sections along the 31° E. meridian illustrate the structural evolution of the East Alps. — D. B. V.

- 183-330. Vening Meinesz, F. A. The difference of the tectonic development of the east and west side of the Pacific: Koninkl. Nederlandse Akad. Wetensch. Proc., ser. B, v. 63, no. 1, p. 20-31, 1960.

The great difference in the tectonics on the east and west sides of the Pacific is explained in terms of the convection current hypothesis. Convection in a crystalline mantle would have two consequences: drag forces acting on the rigid crust would not only bring about strong deformations but would exert a moment on the crust as a whole, tending to shift it. Horizontal uniaxial compressional stress causes plastic downbuckling leading to the development of a geosyncline. This downbuckling occurs in belts enclosing angles of about 55° with the direction of stress, a direction which may be considered identical with that of the subcrustal currents causing the drag on the crust.

On the west side of the Pacific, subcrustal currents flow out from under the continent of Asia. The fact that the tectonic arc is found farther away from the continent rather than at the continental border where the crust is weakest may be explained by a gradual inward shift of the crust in its rotation around the earth. The geosyncline development, being caused by the drag exerted by the mantle current, may be supposed to remain more or less in place.

If crustal shift has been worldwide, North and South America must have covered the area where mantle currents flowing toward the Pacific cause the greatest compressive stress. Therefore, the strain of the crust should be exerted in the weak coastal belt without following the angles of 55° with the direction of mantle currents. This would explain why the ranges on this side of the Pacific follow the coast and why ocean troughs are found along the foot of the continental slope.

The convection current hypothesis also can explain the shape of island arcs. The central downbuckling parts occur where the drag on the crust causes max-

imum compression, and the lengths of the wings depend on the amount of crustal shift; details depend on local circumstances. — D. B. V.

- 183-331. Chingchang, Biq [Biq, Chingchang]. Circumpacific tectonics in Taiwan: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 203-214, 1960.

Taiwan is a short, concave island arc which exhibits almost all structural features typical of circumpacific tectonics: an inner basin with intermediate earthquakes, an inner arc with recent volcanoes, a very narrow interdeep, a principal outer arc with negative gravity anomalies and shallow earthquakes, and a foredeep (less well developed) where gravity anomalies begin to be positive.

The deformation that produced the Taiwan arc at the end of the Tertiary is postulated to be northward movement of the Philippine Sea basin relative to Asia. The movement was oblique-slip; it dislocated the island both lengthwise and left-laterally along big wrench faults and also, perhaps uniquely among modern island arcs, thrust the island as a block on to the continental shelf.

Together with the convex Samar arc on the south and the convex Ryukyu arc on the northeast, Taiwan forms a sigmoid arc, constituting a distinct type in the island- and mountain-arc classification. — D. B. V.

- 183-332. Ehara, Shingo. Median line of southwestern Japan, the boundary between both the movements, Pacific and continental [in English with Japanese abstract]: Geol. Soc. Japan Jour., v. 66, no. 774, p. 131-146, 1960.

This is an extension of Ehara's earlier studies (see Geophys. Abs. 176-169) showing how the opposing forces, the overthrusting action of the Asiatic continental margin and the underthrusting action of the Pacific basin, have resulted in the tectonic structures of the Japanese islands. The Median line which has separated the inner and outer zone of southwestern Japan since Mesozoic time may be regarded as the boundary between the two movements.

In part 1 of this paper the geologic evidence for the underthrusting movement of the Pacific as seen in the Ashizuri and Kii Peninsulas, in the Paleo-Akaishi, and in the island of Shikoku is discussed. In part 2 the Miocene Ishizuchi orogenesis is discussed as an example of the overthrusting action of the continental margin. — V. S. N.

- 183-333. Ma, Ting Ying H. The current rate of uplift of the coastal regions of western Pacific and the present velocity of shift of the continental margin of Eastern Asia, in Jubilee Publication in commemoration of Professor H. Fujimoto's Sixtieth Birthday: Tokyo, Tokyo Univ., p. 406-409, 1958.

Topographic and tide gauge records show that the coastal regions of Eastern Asia and the islands on the geanticlinal ridges in the western Pacific are continuing to rise at a rate of 17 cm per century. The similarity in the rate of rise for the various areas is proof that an uplift of wide extent is taking place as a result of the same tectonic cause. The areas in question are on the edges of crustal masses protruding above sea level; the coastal areas rise when these crustal masses are shifted as a result of the centrifugal force of the rotation of the earth. The shift takes place along shear planes which are delineated by earthquake focuses and which dip at 33° on an average. The amount of horizontal shift may be calculated as: $H = V \cot 33^\circ = 1.7V$; averaging the values of the amount of uplift per century for China, Taiwan, and Japan as 19 cm per century and multiplying by 1.7, the present velocity of shift of the margin of Eastern Asia is 30 cm per century. (See also Geophys. Abs. 174-171.) — V. S. N.

- Havemann, Hans. The Pacific is no moon-scar. See *Geophys. Abs.* 183-91.
- Petruskevskiy, B. A. Geologic conditions of origin of earthquakes. See *Geophys. Abs.* 183-143.
- 183-334. Greene, Gordon W., and Hunt, Charles B. Observations of current tilting of the earth's surface in the Death Valley, California, area, in *Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B*, p. B-275-B-276, 1960.

Data from seven tiltmeter stations established across Death Valley, Calif., during 1958 and 1959 appear to give good evidence that tilting is occurring at the present time in the Death Valley area. The direction and amount of tilting measured thus far agree with the known geologic structure and movements in the recent geologic past. A summary of the tilting observed is given in a table. — V. S. N.

- 183-335. Steinbrugge, Karl V., and Zacher, Edwin G. Creep on the San Andreas fault. Fault creep and property damage: *Seismol. Soc. America Bull.*, v. 50, no. 3, p. 389-396, 1960.

Measurements of the separation of pairs of reference marks adjacent to the line of creep at the W. A. Taylor winery near Hollister, Calif., have been repeated periodically since 1956, and damage to structures provides a good measure of the total creep since 1948. Reports of damage to older buildings on the same site suggest that the creep may have been going on at the present rate (about a half inch per year) for 50 or more years. — D. B. V.

- 183-336. Tocher, Don. Creep on the San Andreas fault. Creep rate and related measurements at Vineyard, California: *Seismol. Soc. America Bull.*, v. 50, no. 3, p. 396-404, 1960.

Creep recorders designed to measure continuously the differential lateral movement of adjacent sections of a concrete floor have been installed in the main building of the W. A. Taylor winery south of Hollister, Calif. For the past 2 years the creep thus measured has been right-lateral at a rate of one half inch per year. Creep accumulates largely in spasms of rather short duration (on the order of a week) separated by intervals of weeks or months during which no creep takes place. In a recent 371-day period, 92 percent of the movement took place in 4 spasms with a total duration of 34 days. Three of these spasms began at times when no local earthquakes were recorded on nearby seismographs; the fourth began with sudden movement of 3 mm at the time of a sharp local earthquake (Richter magnitude 5.0). — D. B. V.

- 183-337. Whitten, C. A., and Claire, C. N. Creep on the San Andreas fault: Analysis of geodetic measurements along the San Andreas fault: *Seismol. Soc. America Bull.*, v. 50, no. 3, p. 404-415, 1960.

Resurveys over monumented points established near the W. A. Taylor winery south of Hollister, Calif., yield a rate of slippage or creep along the faultline of about one half inch per year. A new method of analyzing data obtained by retriangulating over monumented points at wide time intervals (10-20 yr) is presented and applied to two networks which cross the San Andreas fault in central California. Results from a network near Hollister show an average creep of about one half inch per year, and from a network near Cholame (about 75 miles to the southeast) of about one-tenth inch per year. The results also give an angular value which represents the deformation in the

crust adjacent to the faultline; the average angle of deformation in both networks is about +2 sec. — D. B. V.

- 183-338. Haites, T. Binnert. Transcurrent faults in western Canada: Alberta Soc. Petroleum Geol. Jour., v. 8, no. 2, p. 33-73, 1960.

Transcurrent faults occur in the Canadian shield as well as in the Interior Plains and the Cordillera. They play a major role in the fabric of western Canada, and their preferential azimuths fit into a worldwide tectonic shear pattern. A Precambrian initiation of this fault system has been postulated. The association of earthquakes with transcurrent faults is strongly suggested.

The master faults not only affected the rocks in a direct way but were also instrumental in the formation of a host of other phenomena. During Late Pleistocene, linear disintegration ridges may have formed above preexisting faults, and at the present time drainage in western Canada largely follows the two master directions, suggesting post-glacial fault movements and the omnipresence of faults in the three geological provinces. — V. S. N.

- 183-339. Sargent, John D. Geophysical implications of Viking exploration in North America: Internat. Geol. Cong. 21st, Copenhagen 1960, Proc., pt. 2, p. 179-181, 1960.

Archeological, botanical, and historical evidence indicates that the Great Lakes region was inundated to a depth of more than 450 m only a thousand years ago. Evidence left by Viking explorers makes it possible to delineate the shores of this inland sea.

The reason for the existence of such a deep epicontinental sea is isostatic oscillation. Land surfaces that had been depressed at least a thousand meters below sea level under the ice rose past the point of isostatic equilibrium after the load was removed, owing to momentum of the landmass and underlying magma. The overcorrected landmass sank, again passing the point of equilibrium and causing the inundation. The name Henderson Sea is proposed for this body of water. At present we are still in the emergent phase of the Henderson Sea overcorrection. — D. B. V.

- 183-340. VouÛte, Caesar. La nature et l'âge des derniers mouvements en bordure du graben de la mer Rouge [The nature and the age of the last movements on the border of the Red Sea graben]: Soc. Géol. France Comptes Rendus, no. 4, p. 86-87, 1960.

Nesteroff's dating of the last tectonic movements of the Red Sea graben, based on carbon-14 determinations (see Geophys. Abs. 182-47), is compared with the sequence of events in the Assab region on the opposite coast. It is concluded that movements have not been absolutely synchronous in different sectors and border regions of the graben. Correlation of tectonic movements and Quaternary sediments or volcanics should be made on the basis either of stone age artifact assemblages or carbon-14 dating. — D. B. V.

- 183-341. Honkasalo, Tauno. On the land uplift in Fennoscandia: Geophysica [Helsinki], v. 7, no. 2, p. 117-119, 1960.

Recent uplift in Finland has been accurately determined by comparison of the precise levelings of 1892-1910 with those of 1935-1956. This comparison shows that uplift, particularly in the central part of the area, has not been regular; near Lake Oulujärvi the uplift has been exceptionally great. The numerous small earthquakes in Finland, recorded since new seismological stations were established in Finland during the International Geophysical Year, are apparently caused by this uplift.

A gravity anomaly map of northern Europe from the Atlantic Ocean to eastern Karelia shows many belts following the direction of the Scandinavian mountains. Earthquakes usually coincide with places where the gravity gradient is steep. — V. S. N.

- 183-342. Köster, Rolf. Gegenwärtige tektonische Bewegungen in der Umgebung der westliche Ostsee [Recent tectonic movements in the vicinity of the western Baltic Sea]: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 89-98, 1960.

Investigations of shoreline levels on the Baltic Sea coast of Schleswig-Holstein and Mecklenburg-Vorpommern in Germany indicate a relative rise of sea level in the recent geologic past. This rise becomes greater with increasing distance from the "Forchhammerske Line," which is assumed to mark the limit of late glacial and post glacial isostatic uplift. By correcting for 30-40 cm of eustatic rise in the last millenium, the amount and direction of recent tectonic movements in the border zone between the Fennoscandian uplift and the parageosynclinal area of northwestern Germany are obtained.

It is concluded that the Forchhammerske Line represents the average position of equilibrium between isostatic and eustatic rise. The true isostatic (tectonic) zero isobase lies more to the south, in the Fehmarn Belt. Its position has shifted slowly as the intensity of uplift of Fennoscandia has decreased. The position of the morphological zero isobase has varied depending on eustatic fluctuations around the Forchhammerske Line. — D. B. V.

- 183-343. Birkenmajer, K. Recent vertical movements of Spitsbergen: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 21, p. 281-294, 1960.

The amount of recent uplift of Spitsbergen has been calculated on the basis of remains of whale boats and whale bones dating from 17th century whaling operations and drifted pumice fragments on the raised beaches. The east coast of the whole Svalbard Archipelago is rising at a rate of 4 m per century. Movement becomes slower toward the west and northwest—3 m per century at Brageneset, 2.8 m in Billefjorden, 2.3 m in Hornsund, 1.4 m in Jonsfjorden, and 0.9 m in Mosselbukta. Isobases of recent uplift of the archipelago are drawn on a map. The point of maximum uplift, obtained by extrapolation, is off the islands in the Barents Sea shelf. Negative movements have been recognized in the northwestern part of Spitsbergen. A hinge line must be situated in the westernmost part of West Spitsbergen near the slope of the Barents Sea shelf. The land east and southeast of this line is rising rapidly; to the northwest it is sinking. The rate of uplift is very high compared to that in other parts of the world. (See also Geophys. Abs. 176-172.)— D. B. V.

- 183-344. Ushakov, S. A. Reaktsiya zemnoy kory na nagruzku materikovykh oledeniy [Reaction of the earth's crust to the load of continental glaciation]: Akad. Nauk SSSR Doklady, v. 133, no. 1, p. 205-207, 1960.

By analogy with East Antarctica and Greenland, where the thickness of the icecaps has been measured, it can be considered that the average thickness of the Pleistocene glaciers that covered Canada was about 3 km and those which covered Scandinavia were 3 and 2-2.5 km. The main geologic evidence that the recent uplift of Canada and Fennoscandia is largely the result of unloading is summarized briefly. It is thought that these areas are now almost in isostatic equilibrium. If the ice retreated 10,000-15,000 yr ago, the time required for establishment of isostatic equilibrium is negligible on a geologic scale—about

20,000 yr. Spitsbergen has risen about 300 m since the disappearance of the ice 10,000 yr ago. Its rate of uplift was faster in the first five or six thousand years than subsequently.

The general conclusion is drawn that all large scale continental glaciations that have occurred in various geologic epochs must have caused depression of earth's crust. — D. B. V.

- 183-345. Hatai, Kotora; Hayasaka, Shozo; and Iwai, Takehiko. Evidence for recent changes in sea-level of the Atsumi Peninsula, Atsumi-Gun, Aichi Prefecture: *Oceanog. Works in Japan Recs.*, Spec. no. 4, p. 171-177, 1960.

The Atsumi Peninsula extends westward in a fingerlike form from the mainland of Atsumi Gun, Aichi Prefecture, southeastern Honshu, Japan. From the positions above present sea level of erosional features in the Paleozoic rocks of the coast south of Oisho and between Otto and Doda such as wave-cut notches, crevices, and benches, shell boreholes, and sea cliffs, it is evident that considerable changes in sea level have taken place since their development. Tilting of the peninsula is indicated by the fact that features of the north shore differ from those of the south. — V. S. N.

Donabedov, A. T., Sidorov, V. A., Timayev, K. V., and Torkhovskaya, L. N. On the problem of the relations between the rates of contemporary vertical movements of the earth's crust, geophysical fields, and geostructural elements. See *Geophys. Abs.* 183-358.

- 183-346. Belousov [Belousov], V. V. Tectonophysical investigations: *Geol. Soc. America Bull.*, v. 71, no. 8, p. 1255-1270, 1960.

The criteria of physical conformity that have been worked out in connection with tectonic experimentation by Hubbert, Shneerson, Lyustikh, and particularly by Gzovskiy place tectonic experimentation on a sound methodological basis and show that it is possible to attain approximate conformity to physical reality.

Tectonic modeling is an essential supplement to structural research in the field. A suitable experimental approach makes it possible to detect important aspects that ordinarily escape the field geologist. Soviet tectonophysical studies are aimed at examining the stress fields that have acted in the crust in earlier geologic periods and at developing appropriate techniques, including the optical study of stressed models. Some recent results are described. — D. B. V.

- 183-347. Köster, Rolf. Experimentelle Untersuchungen zur Mechanik von Schluppung und Faltung [Experimental investigations of the mechanics of imbrication and folding]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 295-302, 1960.

A mixture of fine sand and paraffin was found to be better suited to model experiments of deformation than the usual semifluid clay. Heated above its melting point, the paraffin acts like clay but when cooled it can be sectioned without disturbing the results of the experiment.

Horizontal compression of nearly homogeneous layers led to the development of imbricate zones; folding occurred only as the first stage in the process. When the same compression was applied under loading, the tendency to develop folds became more and more marked as the weight of overlying layers was increased. The tendency to fold was also increased when the layers were inhomogeneous or when pressure was applied more slowly. — D. B. V.

- 183-348. Meier, Mark F. Mode of flow of Saskatchewan Glacier, Alberta, Canada: U. S. Geol. Survey Prof. Paper 351, p. 1-70, 1960.

Measurements made on Saskatchewan Glacier of velocity on the surface and at depth, the surface and bedrock topography, ablation, and structures produced by flow were used to test current theories and to derive new conclusions concerning flow of a valley glacier.

Velocity measured at any one point depends on the time interval of observation, the size of the fluctuations being inversely proportional to the logarithm of the time interval of measurement. The total flow is built up from many minor jumps or jerks along shearing planes. The absolute value of velocity decreases down-glacier along the centerline and toward the margins causing a prevailing compressing strain rate in a longitudinal direction along the centerline which is outweighed near the edge by a shearing strain rate parallel to the margin. A component of velocity (V_d) is defined which represents the rise or fall of the ice surface that would take place if there were no accumulation or ablation; this elevation change of the surface is due solely to translational and deformational motions of the ice. V_d is also useful for computing discharge and velocity distribution at depth.

Investigation of the flow law of ice using data from this glacier and others shows that: Hydrostatic pressure has no appreciable effect on the flow law relation; there is a transition in behavior from a nearly viscous flow at low stresses to a plastic flow at high stresses, the transition occurring at about 0.7 bars (Glen's formula for creep does not apply at low stresses); and two mechanisms of flow probably operate simultaneously—grain-boundary creep at low stresses and intracrystalline gliding at high stresses. Streamlines of flow on a plane along the centerline generally parallel the bedrock suggesting that the longitudinal profile of a glacier tends to adjust so that the component of velocity V_d just balances the ablation at each altitude.

Three main classes of structures are distinguished in the ice: (1) Primary sedimentary layering, (2) secondary flow foliation, and (3) secondary cracks and crevasses. Primary stratification is flatlying but is wrinkled longitudinally in detail. Foliation generally dips steeply, strikes longitudinally, and shears other structures; some foliation attitudes do not relate to measured directions of maximum shearing strain rate at any conceivable point of origin. Orientation of the most prominent set of cracks agrees approximately with measured trajectories of principal compressing strain rate; minor sets of cracks are related to trajectories of maximum shearing strain rate. — V. S. N.

- 183-349. Zumbege, James H. Geologic structures of the Ross Ice Shelf, Antarctica: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 21, p. 60-67, 1960.

The Ross Ice Shelf is a sheet of floating névé ice 196,000 sq mi in extent attached to the Antarctic continent. Its thickness ranges from less than 100 m to more than 400 m, and its density from 0.30 g per cm³ at the surface to 0.90 g per cm³ at depths greater than 100 m. In places the shelf is grounded on bedrock knobs such as Roosevelt "Island."

Where the ice shelf comes together after flowing around this "island," horizontal stresses result in compressional ice anticlines and synclines, the axes of which are cut by transverse tensional crevasses. This process is similar to the folding of layered rocks of the earth's crust, and thus the shelf ice provides a useful model for analyzing the mechanism of orogenic deformations. — D. B. V.

- 183-350. Merrill, William M. Structures in glacier ice, North Ice Cap, northwest Greenland: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 21, p. 68-80, 1960.

Structures in glacier ice, including tension cracks, "blue bands," foliation, planar and linear bubble trends, dirt zones, shear features, and orientation of optic axes of ice crystals, were mapped and studied by conventional methods in a small drainage basin along the cliffed margin of the southeast edge of North Ice Cap, northern Nunatarssuaq, northwest Greenland. Data were obtained from the surface of the glacier, the cliff face, the toe at the base of the cliff, and from ice exposed in two tunnels which were dug a distance about 30 m into the ice cliff. Observations were extended over two field seasons, from mid-June through August in 1955, and from mid-June through July in 1956. Orientation and distribution of bubbles, foliation, and other planar features are temporary, changing rapidly in response to changes in directions and rates of ice motion. Direction of motion generally parallels foliation but motion is erratic in direction and rate so that "turbulence" is generated within the ice mass. Orientation of optic axes is strongest in the most actively moving ice, varies with changes in direction and rate of ice motion, and probably tends to alter somewhat sooner than changes in folia direction. — Author's abstract

- 183-351. Svatkov, N. M. Ledniki Novoy Zemli [The glaciers of Novaya Zemlya]: Priroda, no. 3, p. 96-100, 1960.

The ice sheet of 19,000 km² on Novaya Zemlya in the Barents Sea is described. Glaciological investigations up to 1957 are reviewed, and investigations during the International Geophysical Year are outlined. The thickness of the ice sheet was found by drilling to be between 15 and 30 m (lat 75°52' N. and long 62°44' E.). — A. J. S.

- 183-352. Grave, N. A. Osnovnyye cherty i zakonomernosti razvitiya tolshch merzlykh porod na kraynem severnovostoke Azii [Main features and regularities in development of permafrost formations in far northeastern Asia]: Akad. Nauk SSSR Izv., Ser. Geog., no. 6, p. 22-31, 1959.

An analysis of permafrost data for areas in far northeastern Asia beginning with 1775 and including Grave's recent investigations is given. Physical-geographic and geologic conditions of the area as related to heat and ground water exchange on the surface and in the upper part of the bedrock are investigated. — A. J. S.

- Russell, R. D., Jacobs, J. A., and Grant, F[raser] S. Gravity measurements on the Salmon Glacier and adjoining snow field, British Columbia, Canada. See Geophys. Abs. 183-375.

GRAVITY

- 183-353. Tsuboi, Chuji. Weight function method for computing gravity anomalies at higher elevations, starting from given surface gravity anomalies: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Repts., no. 4, 15 p., 1959.

A weight function method has been developed for computing gravity anomalies at higher elevations, starting from given surface anomalies. Numerical values of weights have been derived such that the sum of (weight) × (surface gravity anomaly at each grid point in a domain) will give the gravity anomaly at a point directly above the middle of the relevant domain. The method has been applied to deduce gravity anomalies at an elevation of 46.7 km above Vening Meinesz' one-dimensional profile No. 17 across the East Indies and also those at an elevation of 27.8 km over a square portion of Sweden. — Author's abstract

- 183-354. Roy, A., and Burman, S. D. Application of relaxation method of upward continuation of gravity and magnetic data: *Geofisica Pura e Appl.*, v. 45, p. 40-52, 1960.

The method of relaxation has been applied to the upward continuation of gravity and magnetic data. The method yields results that are more accurate than those given by Peters' scheme [see *Geophys. Abs.* 139-11491], and has certain added advantages. In an alternative approach, the finite Fourier sine transform has been used to reduce an area relaxation to a series of line relaxations. The results, again, are very satisfactory. Only the two-dimensional problem is considered, but, with the help of a digital computer, the method is directly extensible to three-dimensional problems. — Authors' summary

- 183-355. Mangadze, G. D. K opredeleniyu elementov zaleganiya vertikal'nogo ustupa po krivoy Δg [Determination of the elements of attitude of a vertical step according to the Δg curve]: *Razvedochnaya i Promyslovaya Geofizika*, no. 33, p. 42-47, 1959.

Two methods of interpretation of the gravity anomaly Δg over a vertical ledge are discussed and analyzed mathematically; these are the method of tangents and the method of variational transformations. Formulas derived for determination of the upper and lower boundaries of the step and for the density excess were tested in the field in the Kolkhida depression, Georgian S. S. R. The determinations were found to agree with the borehole data. — A. J. S.

- 183-356. Gladkiy, K. V. O zamene vertical'noy stupeni material'noy poluploskost'yu [On substitution of a vertical step by a material half plane]: *Razvedochnaya i Promyslovaya Geofizika*, no. 18, p. 47-50, 1957.

A material infinite half plane is shown to be similar to an infinite vertical step (vertical fault) whose mass is condensed on the plane at a depth $H = (H_1 + H_2)/2$ and surface density $\mu = \sigma h = \sigma(H_2 - H_1)$, where H_1 and H_2 are depth of the top and the bottom of the layer respectively, μ is surface density, and σ is volume density. A simple formula for computing an approximate value of $\Delta g'$ of the vertical component of gravity is derived. The precise value of $\Delta g'$ is shown to differ from Δg by 7.2 percent at most. — A. J. S.

- 183-357. Klushin, I. G. O transformatsii gravitatsionnykh anomalii (On the transformation of gravity anomalies): *Prikladnaya Geofizika*, no. 24, p. 72-86, 1960.

As the intensity and character of a gravity anomaly is dependent on many factors, transformations of their parametric data are required in order to suppress the unwanted features of the anomaly and to bring out the parameter sought. On the basis of some specific types of transformation by others (see *Geophys. Abs.* 128-8978, 164-162) Klushin attempts to give a general solution for gravity anomalistic field transformation. — A. J. S.

- 183-358. Donabedov, A. T., Sidorov, V. A., Timayev, K. V., and Torkh-ovskaya, L. N. K voprosu o sootnosheniyakh mezhdu skorostyami sovremennykh vertikal'nykh dvizheniy zemnoy kory, geofizicheskimy polyami i geostrukturnymi elementami [On the problem of the relations between the rates of contemporary vertical movements of the earth's crust, geophysical fields, and geostructural elements]: *Akad. Nauk, SSSR Doklady*, v. 132, no. 4, p. 810-813, 1960.

The relations between recent vertical crustal movements and geophysical fields can be studied in two ways, one by observing and comparing the temporal changes in each with the object of establishing direct correlations, and the other, an indirect approach, by determining the types of structures in the crust which in turn are reflected in the geophysical fields, particularly the gravity field.

Using published results of studies in the Caspian basin and its surroundings, a series of profiles are constructed showing the relations of Bouguer gravity anomalies (Δg) to the rate of vertical movements (V). Three types of relations are found. In some areas there is a distinct direct relation between V and Δg , in some a distinct inverse relation, and in others there may be a marked trend in one of the elements but no appreciable change in the other. These different types of relations are interpreted in terms of basement depth and structure. — D. B. V.

- 183-359. Karatayev, G. I. Opredeleeniye otnosheniya intensivnosti namagnicheniya k izbytochnoy plotnosti po gravitatsionnym i slabym magnitnym ΔT -anomaliyam [Determination of the ratio of intensity of magnetization to excess density according to gravity and weak magnetic ΔT anomalies]: Akad. Nauk SSSR Ser. Geofiz., no. 6, p. 905-909, 1959.

Simultaneous quantitative analysis of gravity and magnetic anomalies opens wide possibilities in geological interpretation. By comparing the values of ratio of intensity I to density excess σ , as calculated respectively from magnetic and gravimetric observations at several points of an anomaly, the causes of disturbances can be ascertained. The calculation of a pseudogravitational field from ΔT anomalies is very promising and in some instances provides the possibility of distinguishing gravity disturbances in a sedimentary section. Methods are examined for calculating I/σ from ΔT , since very accurate T-aeromagnetometers are widely used in the U. S. S. R. — J. W. C.

- 183-360. Tyapkin, K. F. Pro vzayemovidnoshennya pohidnykh huavitatsiy-noho i mahnitnoho potentsialiv odnoridno namagnichenoho tila u verkhn omu pivprostori [On the relation between derivatives of gravity potential and derivatives of magnetic potential of a homogeneously magnetized body at an upper semispace]: Akad. Nauk Ukrain. RSR Dopovidī, no. 3, p. 251-254, 1958.

The paper contains formulas for calculating gravity potential derivatives at any point in an upper semispace from data on the magnetic field components at the earth's surface. The practical application of these formulas will increase the efficiency of gravity and magnetic surveys. — Author's summary, A. J. S.

- 183-361. Malovichko, A. K. Gravimetricheskaya s'emka s vyravnivaniyem anomalii po marshrutam [Gravimetric survey with smoothing of anomalies along the traverses]: Prikladnaya Geofizika, no. 21, p. 56-73, 1958.

A method for smoothing gravity survey graphs by selecting a second power polynomial that fits the graph of the survey along the traverse is discussed. The polynomial is found by the least squares method. Analyses of the proposed smoothing with the aid of a linear and parabolic function are given, and conditions under which such a smoothing is practical are stipulated. A comparison of analytical and graphical methods of smoothing is given, and conditions under which the latter method should be used are noted. The methods proposed are illustrated by examples. — A. J. S.

- 183-362. Adzhimamudov, E. B. K voprosu o reduktsiyakh sily tyazhesti [Problem of gravity reduction]: Akad. Nauk Armyan. SSR Izv., v. 11, no. 4, p. 73-76, 1958.

The problem of gravity reduction arose during construction of gravity maps for the mountainous areas of the Armenian S. S. R. The question of the application of statistical reduction and of the use of differential density in introduction of Bouguer corrections is treated. For clarification of the effect of relief on the gravity field and also for checking the effectiveness of the use of statistical reduction, corrections were calculated for the relief at four points. The results show that the ordinary Bouguer anomaly differs much less from the Bouguer anomaly with a correction for relief than does the statistical anomaly. — J. W. C.

- 183-363. Kane, Martin F. Terrain corrections using an electronic digital computer, *in* Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-132-B-133, 1960.

A method is presented that makes use of electronic computers to expedite the computation of terrain corrections for gravity stations in irregular or mountainous terrain. The topography of the entire area is converted to digital form by dividing the terrain into kilometer squares and tabulating the average elevations of the terrain within the squares; the average elevations are punched on cards and stored in the computer memory. The computer correction is limited to an area of 40 km sq with the station at the center, and excludes a central area of 2 km sq. The terrain beyond 40 km usually can be ignored, and the terrain within 2 km of the station can be calculated easily by conventional methods. — V. S. N.

- 183-364. Davis, W[illard] E., Jackson, W[ayne] H., and Richter, D. H. Application of gravity surveys to chromite exploration in Camagüey Province, Cuba, *in* Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-133-B-136, 1960.

The methods and principal results of this survey were published in *Geophysics*, v. 22, p. 848-869, 1957 (see *Geophys. Abs.* 171-191). Some of the results are repeated here to call wider attention to the potential use of gravity methods in the exploration of ultramafic complexes. — V. S. N.

- 183-365. Egyed, László. Zur Frage der Schweremessungen in Bohrlöchern [On the problem of gravity measurements in boreholes]: *Freiberger Forschungshefte C 81 Geophysik*, p. 167-170, 1960.

Density profiling in boreholes can be undertaken if a method can be found for determining the average vertical gradient $\bar{U}_{zz} = (g_2 - g_1)/h$; this is because $g_2 - g_1 = 4\pi f h \chi \sigma = C \chi \sigma$ (σ is the average density between points 1 and 2; χ is a factor depending on the ratio of borehole diameter to measurement interval h ; g_1 and g_2 are gravity acceleration at points 1 and 2; and C is a constant).

Determination of the average vertical gravity gradient should be possible with present technical knowledge. The principles and practical aspects of construction of a borehole gravimeter are discussed. — D. B. V.

- 183-366. Yarosh, A. Ya., and Polyakov, A. B. Rezul'taty proverki bureniyem dostovernosti strukturnoy karty, postroyennoy po gravitatsionnym nablyudeniyam na burougol'nom mestorozhdenii [Results of checking by drilling of the reliability of a structural map, constructed according to gravity observations over lignite deposits]: *Sverdlovsk. Gornyy Inst. Trudy*, no. 34, *Voprosy Razvedochnoy Geofiz.*, p. 99-108, 1959.

A gravity depression was located by variometer observations in a search for lignite, and subsequent drilling confirmed thick deposits of lignite in the depression. A schematic structural map based on a few experimental boreholes in the northern part of the deposits was drawn for the Paleozoic basement of the entire depression. The drilling was continued throughout the entire area on a basis of the map data. The conclusion is reached that the comparatively low cost of the gravity survey justifies its use as a preliminary step in prospecting for coal by drilling. — A. J. S.

- 183-367. Thyssen-Bornemisza, Stephen, and Stackler, W. G. Determination of horizontal gravity gradient with the gravimeter: *Alberta Soc. Petroleum Geologists Jour.*, v. 8, no. 10, p. 261-270, 1960.

The determination of station elevation has been the most cumbersome and the most expensive part of any modern gravity survey. To avoid this problem it is proposed to measure the horizontal gravity gradient with the gravimeter. Preliminary field experiments over the Turner Valley structure are described. It is concluded that this procedure may be used successfully and that it is particularly applicable in remote areas such as the Canadian Arctic. It may also be applied where former gravity surveys have to be supplemented and old station locations are lost. — V. S. N.

- 183-368. Murphy, Thomas. The computation of gravity differences from observations with a Worden gravimeter and the resultant errors: *Geofisica Pura e Appl.*, v. 45, p. 27-39, 1960.

The methods of computation of the gravity difference between two stations depend on the assumed behavior of the zero drift. When this drift is taken as following a quadratic law with respect to time, then the various methods give virtually the same value for the gravity difference and the estimated errors in it are also the same. In adjusting a network of gravity connections it is proposed that, to form a system of weighting, the estimated errors in the connections should be used in the place of the probable errors, which are unobtainable as the number of independent observations is too small. The estimated errors have been based on the standard deviation of an observation which is probably a characteristic of one gravimeter and one observer. The standard deviation of a single observation with a Worden gravimeter was found to be ± 0.014 mgal as a result of a special set of experiments under field conditions. Large random errors have been observed in a Worden gravimeter, and the cause is attributed to changes in the filament of the bulb which produces the reading index line. — Author's summary

- 183-369. Faytel'son, A. Sh. Ob uchete vliyaniya temperatury pri s"emke s gravimetrami tipa GAK-3M [On calculating the effect of temperature in surveys with type GAK-3M gravimeters]: *Razvedochnaya i Promyslovaya Geofizika*, no. 33, p. 48-58, 1959.

The criteria for temperature correction in reduction of data obtained by GAK-3M type gravimeters are given. The correlation between the errors in corrections under different conditions are discussed: the accidental error in reading the thermometer temperature, and the systematic difference between the thermometer and the quartz system temperatures. Formulas are derived for determining the true values of errors by reducing the nonlinear differences between the ambient temperature and the temperature of the quartz system into a linear form. — A. J. S.

- 183-370. Eaton, Gordon P., and Rosenfeld, John L. Gravimetric and structural investigations in central Connecticut: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 2, p. 168-178, 1960.

A detailed gravity survey was undertaken in central Connecticut to determine the approximate structural configuration of the Triassic trough and gneiss dome chain at depth. The results show that the Triassic trough occupies a zone of crustal weakness that was tectonically active before Triassic sedimentation commenced, that the trough is bounded by two quasi-parallel chains of older gneiss domes, and that the last major deformation in the region consisted of broad crustal warping in which the rocks of both the lowland and highland responded as a single unit. — D. B. V.

Andreasen, Gordon E., Kane, Martin F., and Zietz, Isidore. Regional geological interpretation of aeromagnetic and gravity data for the Rowe-Mora area, New Mexico. See Geophys. Abs. 183-486.

- 183-371. Mabey, Don R. Regional gravity survey of part of the Basin and Range Province, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-283-B-285, 1960.

All gravity data collected by the U. S. Geological Survey in the Basin and Range province in Utah, Nevada, and California have been tied to a common datum through a network of base stations referred to four airport base stations. A knowledge of the broad regional variations in Bouguer anomaly values is of great use in the study of the large-scale variations in the thickness and composition of the crust. It is also helpful in isolating the local gravity anomalies superimposed on the regional variations.

The regional Bouguer anomaly values range from about -60 mgal to -240 mgal and show an inverse correlation with the regional topography; this indicates a relative mass deficiency under the regional highlands. Although the gravity data do not indicate the nature of the mass deficiency, which can occur anywhere within the crust or upper mantle, the correlation with topography suggests that some form of regional isostatic compensation exists. — V. S. N.

Joesting, H[enry] R., and Case, J[ames] E. Salt anticlines and deep-seated structures in the Paradox basin, Colorado and Utah. See Geophys. Abs. 183-487.

- 183-372. Diment, W[illiam] H., Healey, D. L., and Roller, J. C. Gravity and seismic exploration at the Nevada Test Site, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-156-B-160, 1960.

Gravity and seismic refraction methods have been used in mapping the pre-Tertiary bedrock surface in parts of the Nevada Test Site. This area is of interest as a case history since little has been published concerning the use of these particular geophysical methods in such an environment. The general geology of the area, density and velocity contrasts, survey methods used, and results obtained are discussed.

The close reflection of the pre-Tertiary surface by the gravity contours illustrates the usefulness of gravity methods in mapping such a surface. Time-distance graphs are presented to illustrate the kinds of information to be obtained from seismic refraction. — V. S. N.

- 183-373. Oliver, H[oward] W. Gravity anomalies at Mount Whitney, California, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-313-B-315, 1960.

Observations at the Mount Whitney gravity station, established on the top of the mountain in August 1957, provide important data for testing the principle of isostasy. Bouguer and isostatic anomalies at Mount Whitney show that there is a large mass deficiency below the Sierra Nevada, and that the gravitational effect of this "defective" mass on Mount Whitney is approximated within 85 percent by Heiskanen and Hayford models that correspond to $T=30$ km and $D=96$ km, respectively. A better isostatic model for the Sierra Nevada would be a combination of the Heiskanen and Hayford models, the parameters for which cannot be determined uniquely except by the application of several geophysical methods. Isostatic anomalies based on present models are probably indicative in many cases of density changes within the earth's crust resulting from orogenic activity. — V. S. N.

- 183-374. McCulloh, Thane H. Gravity variations and the geology of the Los Angeles Basin of California, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-320-B-325, 1960.

The Los Angeles Basin is a topographic lowland and Cenozoic sedimentary basin in southern California; it is bordered on the southeast by the Peninsular Ranges, on the north by the Transverse Ranges, and on the west by submarine basins and ridges of the continental borderland. The Bouguer gravity map shows that the gravitational effects of the local geology are superimposed on a steep basin-wide regional gravity gradient sloping downward toward the north-northeast. Laboratory measurements of bulk "natural" density of the rocks combined with geologic information yield a density model from which it is possible to compute the gravitational effects of local geology. Results indicate that the regional residual gravity gradient sloping downward to the northeast is clearly due to density variations below minus 30,000 feet and could be the effect of landward thickening of the crust. A theoretical profile is computed that satisfactorily matches the residual regional gravity gradient. — V. S. N.

- 183-375. Russell, R. D., Jacobs, J. A., and Grant, F[raser] S. Gravity measurements on the Salmon Glacier and adjoining snow field, British Columbia, Canada: Geol. Soc. America Bull., v. 71, no. 8, p. 1223-1230, 1960.

A detailed gravity survey was carried out on the Salmon Glacier and adjoining snowfield in British Columbia. Reduction of the data was complicated by the extreme irregularity of the terrain and by the fact that the structure of the glacier and location of the stations are time dependent. Maps of Bouguer anomalies, two profiles across the glacier, and one profile along its length are given. Accuracy is discussed, and it is concluded that gravity measurements alone can give a very good indication of the shape of a deep-valley glacier and also of its approximate depth. Other independent data are necessary to determine its precise thickness. — D. B. V.

- 183-376. Nettleton, L. L., and Elkins, Paul. Gravity operations in Guatemala: Geophysics, v. 25, no. 5, p. 1023-1034, 1960.

This paper describes the logistics and field methods used for a gravity survey over a large concession in the northwest corner of Guatemala. Almost the entire network of lines for gravity stations was cut through heavy jungle and heliports were cut at line intersections. Logistics of the operation were heavily dependent on aircraft, using helicopters for transportation from camps to heliports, amphibian aircraft from main base to field camps, and chartered DC-3 aircraft from Guatemala City to main camp. Field conditions and oper-

ations are illustrated by photographs. Statistics of operation and station production are included but no gravity data are shown. — Authors' abstract

- 183-377. Hospers, J., and Wijnen, J. C. van. Gravity measurements in the Venezuelan Andes: *Geologie en Mijnbouw*, v. 39, no. 6, p. 208-212, 1960.

This is a condensed version of the paper published in *Koninkl. Nederlandse Akad. Wetensch. Afd. Natuurkunde*, ser. 1, v. 23, no. 1, 95 p., 1959, (see *Geophys. Abs.* 182-311). — D. B. V.

- 183-378. Lomnitz, C[inna]. Gravity measurements in the central valley of Chile [with French abstract]: *World Petroleum Cong.*, 5th, New York, Proc., sec. 1, paper 43, p. 801-813, 1959.

This is virtually the same paper as that published in *Chile Inst. Inv. Geol. Bol.* no. 4, 19 p., 1959 (see *Geophys. Abs.* 178-241). — V. S. N.

- 183-379. Hohl, Rudolf. Verlauf und Charakter einer Störung im Untergrund des norddeutschen Flachlandes nach geologischen und geophysikalischen (gravimetrischen und geomagnetischen) Befunden [Trend and character of a basement fault in the North German Plain according to geological and geophysical (gravimetric and geomagnetic) evidence]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 435-445, 1960.

Geomagnetic and torsion balance measurements confirm and supplement borehole and geologic evidence concerning the nature and course of the "Halle Market Place Fault" through Halle on the Saale in the North German Plain. The fault, with a vertical throw of up to 1,500 m, continues southeastward toward Saxony. Its trend is Hercynian. About 18 km southwest of Leipzig it bends WNW-ESE, rather than NNW-SSE as previously postulated. — D. B. V.

- 183-380. Dzhafarov, Kh. D. K voprosu geologicheskoy interpretatsii dannikh gravirazvedki v Prikaspiysko-Kubinskoy rayone Azerbaydzhanskoy SSR [On the problem of geological interpretation of gravity exploration data from the Caspian and Kuban River region of the Azerbaijan SSR]: *Vyssh. Ucheb. Zavedeniy Izv.*, *Neft' i Gaz*, no. 10, p. 9-12, 1959.

Gravimetric surveying in the region of the Kuban River and the area adjacent to the Caspian Sea is discussed, and geological interpretations are given for determining tectonic characteristics and regionalization and for finding the location and nature of disturbing bodies. In the areas of complex topography combined seismic and electrical exploration methods should be used. — A. J. S.

- 183-381. Boronin, V. P. Osnovnyye cherty vnutrennego stroyeniya dokembriyskogo kristallicheskogo fundamenta Tatarskoy ASSR po dannym gravitatsionnoy i magnitnoy s'emki [Fundamental features of the internal structure of the Precambrian crystalline basement of the Tatar ASSR according to the data of gravity and magnetic surveys]: *Akad. Nauk SSSR Doklady*, v. 132, no. 2, p. 417-420, 1960.

The structure of the Precambrian basement in the Tatar A. S. S. R. is interpreted in the light of gravity and magnetic survey data. The results are

summarized in a sketch map that shows the four structural units (the Aksu-bayevo-Romaskin, the oldest and most complex both structurally and petrographically; the Melekes-Saraylin-Bavly, a granite-gneiss complex; the Volga-Kama, with large masses of mafic rocks; and the Kasan-Grakhov, also granites and gneisses) and the axes of the magnetic and gravimetric lows and highs. — D. B. V.

- 183-382. Salikhov, A. G., and Stepanov, V. P. O plotnosti i gravitatsionnom effekte porod paleozoya territorii Tatarskoy respubliki [On density and gravity effect of Paleozoic rocks in the territory of the Tatar Republic]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 271-277, 1960.

New data are presented on horizontal density changes in the Paleozoic rocks of the Tatar A. S. S. R. The configuration of density discontinuities is discussed, and data on the gravity effect of such discontinuities are provided. It was found that the mean value of density ranges horizontally from 2.53 to 2.60 g per cm³. This variation was taken into consideration in the gravimetric survey of the Tatar A. S. S. R. and adjacent areas. — A. J. S.

- 183-383. Desio, A., and Marussi, A[ntonio]. On the geotectonics of the granites in the Karakorum and Hindu Kush ranges (central Asia): Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 2, p. 156-167, 1960.

The distribution and structural position of the granitic rocks of the Karakorum and Hindu Kush ranges in central Asia are interpreted in the light of the results of gravity surveys made by the Italian expedition of 1954-55 and of earlier surveys in surrounding areas, including deep seismic sounding by the Russians in central Asia. The isostatic anomalies (reduced according to Airy's hypothesis, using a crustal thickness of 30 km and density contrast of 0.6 g per cm³ between crust and subcrust) are presented in a map and cross section.

The axial belt of negative anomalies in the Karakorum and Hindu Kush is attributed to a thickening of the granitic layer in the form of a synorogenic batholith. The two marginal strips of positive anomalies probably correspond to thinning of the granitic layer due to Hercynian folding in the Kun Lun on the northeast and to granodioritic and mafic rocks in the Deosai and Pir Panjal on the southwest. — D. B. V.

- 183-384. Otaki, Tadao, and Matsuda, Takeo. Gravity survey at the southern part of Ariake-kai and Mitsuse district, Nagasaki Prefecture: Japan Geol. Survey Bull., v. 10, no. 11, p. 61-70, 1959.

Geological and geophysical surveys were made in the area of the Ariake-kai and neighboring districts from 1956 through 1958 to investigate the possibility of a new coal field. The results of a gravity survey conducted in the southern part in 1958 are reported in this paper. One gravity high and two lows were found in the area. An isogal map of the gravity results is included. — V. S. N.

- 183-385. Yokoyama, Izumi, and Tajima, Hirokazu. A gravity survey on Volcano Huzi, Japan by means of a Worden gravimeter: Geofisica Pura e Appl., v. 45, p. 1-12, 1960.

A gravity survey was made of Mount Huzi (Fuji) in Japan in order to determine its underground structure. A Worden No. 60 gravimeter was used, and

123 stations were occupied. The distribution of Bouguer anomalies is shown in several sketch maps.

No remarkable Bouguer anomaly is observed over Mount Huzi, which is a typical stratovolcano and has no caldera. This is in marked contrast to the findings on Mihara volcano and Kuttyaro caldera (see *Geophys. Abs.* 171-184, 176-198).

Comparison with the gravity anomalies of volcanic islands in the middle of the ocean suggests that the mass of Mount Huzi is not isostatically compensated but, like such islands, is supported by the rigidity of the crust. — D. B. V.

HEAT AND HEAT FLOW

183-386. Schössler, Klaus, and Schwarzlose, Jobst. *Geophysikalische Wärmeflussmessungen (Grundlagen und Ergebnisse)* [Geophysical heat flow measurements (Principles and results)]: Freiburger Forschungshefte C 75 Geophysik, 120 p., 1959.

This is a review of the thermal values of the earth. Particular attention is paid to problems of heat sources, heat conduction, and convection currents. The distribution of radioactivity and the corresponding heat flow are considered for different earth models and compared with observed values. In general, the models show that the temperature deep in the interior has been rising throughout geologic time (at the core-mantle boundary it has probably increased about 300°C), and that although radioactivity plays an important role in the thermal history of the earth, the surface relations during the first billion years were dominated by the temperature distribution that prevailed at the time of the earth's formation (hot or cold origin).

The significance of heat flow from the interior in regard to geologic and geophysical theories is shown. The two determinable quantities of heat flow—geothermal gradient and heat conductivity—and the possible ways of measuring them are discussed. Finally, actual measurements of heat flow are given.

In East Germany the highest heat flow values are in the Erzgebirge (average, 1.9×10^{-6} cal per cm^2 per sec); the average value for the rest of East Germany is 30 percent lower (1.40×10^{-6} cal per cm^2 per sec) but still above the average value for the earth as a whole (1.2×10^{-6} cal per cm^2 per sec). In continental Europe heat flow has been measured only in Hungary, the Alps, and East Germany, and estimates have been made for Poland. Data from other countries would be highly desirable. — D. B. V.

183-387. Glyuzman, A. M. *Ob ostyvanii plasta konechnoy moshchnosti pri lucheispushkanii na poverkhnosti, sleduyushchem zakonu Stefana-Bol'tsmana* [On cooling of a layer of finite thickness when radiation from its surface follows the Stefan-Bol'tsman law]: *Sverdlovsk. Gornyy. Inst. Trudy*, no. 34, *Voprosy Razvedochnoy Geofiz.*, p. 27-35, 1959.

The problem of temperature change in a layer of finite thickness is discussed, assuming that the layer radiates heat from its surface according to the Stefan-Bol'tsman law. Tikhonov's method is used in solving an ordinary differential equation of heat transfer directly proportional to the fourth power of temperature difference between the layer and the surrounding medium. The method leads to a nonlinear integral equation of Volterra type solved by the method of successive approximation within the integration range $0 \leq z \leq z_0$. — A. J. S.

- 183-388. Glyuzman, A. M. K teorii issledovaniya skvazhin metodom iskustvennogo teplovogo polya [On the theory of investigation of boreholes by the method of artificial thermal field]: Sverdlovsk. Gornyy Inst. Trudy, no. 34, Voprosy Razvedochnoy Geofiz., p. 20-27, 1959.

The heat exchange problem of a borehole is discussed and treated mathematically. The Stefan-Bol'tsman law, $k[\delta U(R, t)/\delta r] = \alpha_n \sigma [U^4(R, t) - \theta^4(R, t)]$, uses the absorption coefficient of radiant energy in rocks at the interface of two mediums, the borehole and the rock surrounding it. $U(R, t)$ is the borehole temperature in cylindrical coordinates (considering the hole as an infinitely long cylinder); $\theta(R, t)$, a constant, is the temperature of the surrounding rock; k is thermal conductivity; α_n is the reduced absorption coefficient; and R is radius of the borehole. The differential equation for the initial conditions $U(r, 0) = T_0$ and the boundary conditions $-\delta U(R, t)/\delta r = v(t)$; $\delta U(0, t)/\delta r = 0$ results in a nonlinear equation of Volterra type, which is solved by Picard's method of successive approximations and yields a formula from which the theoretical curves of temperature change on the axis of the borehole can be found for various values of the parameter α_n . — A. J. S.

- 183-389. Woodside, W., and Messmer, J. H. Molecular effects in heat conduction through porous rocks: Jour. Geophys. Research, v. 65, no. 10, p. 3481-3485, 1960.

Thermal conductivity measurements were made on a natural Berea sandstone sample of porosity 22 percent, with the pore space filled with various fluids at atmospheric pressure. The results indicate that the effective conductivity of the sample, when filled with a gaseous saturant, is lower than when filled with a liquid saturant of the same conductivity as the gas. This effect is qualitatively accounted for by the reduction in thermal conductivity of the gas which occurs when the gas occupies spaces which are small relative to its mean free path. The presence of such spaces is confirmed by pore size distribution data and by the increase in effective conductivity with increase in gas pressure. The effect on the thermal conductivity of a simulated net overburden pressure of 275 bars was also investigated. — Authors' abstract

- 183-390. Ramazanade, M. G., and Rostomyan, P. M. Vliyanie izmeneniya energii nefi na lokal'nye geotermicheskiye anomalii v neftyanykh mestorozhdeniyakh [Effect of change of energy of oil in local geothermal anomalies in oil fields]: Vyssh. Ucheb. Zavedeniy Izv., Neft' i Gaz, no. 7, p. 15-20, 1960.

Reactions occurring in oil over long periods of geologic time (natural aging) produce heat, which causes geothermal anomalies to develop in an oil-bearing stratum. Calculations show that the presence of oil in a stratum increases its temperature about 1°C above that of the same stratum at the same depth beyond the margin of the pool. — J. W. C.

- 183-391. Ananyan, A. L., and Yegogyan, V. L. K voprosu o postanovke geotermicheskikh issledovaniy v Armenii [Question of setting up geothermal investigations in Armenia]: Akad. Nauk Armyan. SSR, Izv., v. 11, no. 4, p. 23-36, 1958.

A large number of thermal springs, generally associated with travertine deposits, are located in Armenia. These occur along faults of various size and orientation and are confined largely to the Chatmin and Yerevan downwarps. Others occur along the eastern border of the Araks depression.

Few data are available on the geothermal gradient in Armenia. It is 3.3°C per 100 m in the Avan drill hole and 3.2°C per 100 m in the Oktemberyan drill hole. Both of these are in Tertiary sediments and exhibit an increase in gradient with depth. It is concluded that heat of igneous origin is superposed on the normal geothermal field. — J. W. C.

- 183-392. Babenkov, Ye. F. O registratsii sostavlyayushchikh radiatsionnogo balansa v sudovykh usloviyakh [Recording of the component radiation balance under ship conditions]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 930-932, 1959.

The components of the radiation balance at sea have been little studied because of difficulties in recording under ship conditions. A method is described whereby the effects of the vessel's hull are eliminated and the various components of the radiation balance are recorded, including direct solar radiation as well. The method is based on the use of a system of one-way balance meters covered by polyethylene filters and mounted in such a way around the vessel's hull that none of the meters is exposed to radiation from the hull. A wiring diagram is presented. — J. W. C.

Wyllie, P. J., and Tuttle, O. F. Melting in the earth's crust. See Geophys. Abs. 183-393.

INTERNAL CONSTITUTION OF THE EARTH

- 183-393. Wyllie, P. J., and Tuttle, O. F. Melting in the earth's crust: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 227-235, 1960.

Investigation of the effect of volatile materials on the melting temperatures of rocks suggests that partial melting occurs readily within the earth's crust. Granites and shales begin to melt at 660°C in the presence of water vapor at 4,000 bars pressure. If the water contains 4 weight percent hydrogen fluoride, the melting temperature of granite is lowered to 590°C. At 1,000 bars the minimum liquidus temperature in the system CaO-CO₂-H₂O is 675°C; at 4,000 bars the liquidus minimum is 640°C. Addition of MgO lowers the melting temperature at 1,000 bars to 625°C. A value of 30°C per km is reasonable for geothermal gradient in geosynclines and if this remains constant with increasing depth, a temperature of 620°C is attained at 20 km (about 5,000 bars pressure). The compositions of many geosynclinal rocks may be represented in terms of granite, shale, and carbonates, and the above experimental results indicate that such rocks will be partially melted at 20 km depth provided volatiles are present. The extent of melting will depend upon bulk composition and especially upon the proportion of available volatiles. Partial melting therefore plays an important role in the metamorphism and deformation of rocks in orogenic zones. — Authors' abstract

- 183-394. Lyustikh, Ye. N. Energiya obrazovaniya zemnoy kory [Energy of formation of the earth's crust]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 402-408, 1960.

It is assumed that the crust of the earth has originated by two processes: physical-chemical differentiation of material in the mantle leading to formation of sial in its upper part, and rising of this sial toward the surface of the earth due to gravity. The potential energy liberated in the second process is considered to be of the order of 10^{26} ergs per year, which may be sufficient to maintain the tectonism of the earth. Estimating the total geotectonic ener-

gy to be $10^{28\pm 4}$ ergs per year, and the potential energy liberated during the 3 billion years of geologic history to be of the order of 3.10^{35} ergs, it is concluded that this hypothesis of the formation of the earth's crust is not objectionable from the point of view of energy. — A. J. S.

- 183-395. Berg, Joseph W., Jr., Cook, Kenneth L., Narans, Harry D., Jr., and Dolan, William M. Seismic investigation of crustal structure in the eastern part of the Basin and Range province: *Seismol. Soc. America Bull.*, v. 50, no. 4, p. 511-535, 1960.

Results are presented of seismic studies of 9 quarry blasts ranging in size from 50,000 to 2,138,000 lb of explosives at Promontory and Lakeside, Utah, during 1956 to 1959, and also of the Rainier (1.7 kt) and Blanca (23 kt) nuclear explosions near Mercury, Nev., in September 1957 and October 1958, respectively. Records were obtained at 17 temporary seismic stations to a distance of about 280 km and 15 permanent stations to a distance of about 1,009 km.

The time-distance plot of first arrivals from Promontory, Utah, to Eureka, Nev., (nearly 355 km) shows the following velocities: 5.73 km/s to a horizontal distance of about 76 km, 6.33 km/s from 76 to 132 km, and 7.59 km/s from 132 to 355 km. These data are interpreted to indicate two discontinuities, one at a depth of about 9 km and the other about 25 km. A composite time-distance plot of arrivals from all the Utah blasts shows a change of velocity from 7.59 to 7.97 km/s at a distance of about 650 km; assuming flat-lying layers, the depth to this third discontinuity is computed to be 72 km.

There is no strong evidence of a material that would have a velocity intermediate between 6.33 and 7.59 km/s. The existence of a material having a velocity of about 7.5 km/s under the eastern part of the Basin and Range Province is confirmed, and the data indicate that any deepening of the top of this layer beneath the mountains does not exceed a few kilometers. — D. B. V.

- Schwind, Joseph J., Berg, Joseph W., Jr., and Cook, Kenneth L. PS converted waves from large explosions. See *Geophys. Abs.* 183-204.

- 183-396. Shor, George G., Jr. Crustal structure of the Hawaiian Ridge near Gardner Pinnacles: *Seismol. Soc. America Bull.*, v. 50, no. 4, p. 563-573, 1960.

A series of seismic refraction profiles has been made across a flat bank at Gardner Pinnacles (a pair of volcanic islets on the western Hawaiian Ridge) down the side of the ridge and across the adjacent deep to the floor of the Pacific basin. The ridge is composed principally of material with velocities typical of volcanic islands. The high-velocity oceanic crust, found in the oceanic areas adjacent, extends beneath the ridge and up into the center of the rise. The total crustal section is thickened and the M-discontinuity depressed beneath the deep as well as beneath the ridge. The smooth "archipelagic apron" on the north side of the ridge has at most 20 m of sediment over a layer with a velocity of 3 km/s, which could be volcanic and is definitely of higher velocity than normal oceanic sediments. — Author's abstract

- 183-397. Penttilä, E[sko], and Nurmi, M. Determination of the thickness of the granitic layer in S. W. Finland: *Geophysica [Helsinki]*, v. 7, no. 2, p. 97-99, 1960.

An investigation of the thickness of the granitic layer in Finland was made in 1958. Single and double P-reflections from the Conrad discontinuity were obtained from nine submarine explosions offshore from the city of Pori,

southwest Finland. The results from different shocks were in good agreement and indicated a thickness of 17.9 km for the granitic layer. This thickness is in general agreement with those obtained in central Europe by others (see Geophys. Abs. 144-12548, 159-155). — V. S. N.

183-398. Moiseyenko, F. S. Geologicheskaya priroda Tsentral'no-Kazakhstanskogo gravitatsionnogo minimuma (ob odnoy oshibke v stat'yakh D. N. Kazanli) [The geological nature of the central Kazakhstan gravity minimum (about an error in the papers of D. N. Kazanli)]: Sovetskaya Geologiya, no. 1, p. 123-125, 1960.

Earlier views on the nature of the central Kazakhstan gravity minimum are discussed and criticized. Instead of the previously proposed thickening of the earth's crust and sinking of its roots into the Mohorovičić zone, Moiseyenko proposes a concentration of granitic masses in the upper 10-15 km of the earth's crust. — A. J. S.

183-399. Porkka, M. T. Surface wave dispersion for some Eurasian paths. I. Rayleigh waves from Kamchatka and Japan to Finland: Geophysica [Helsinki], v. 7, no. 2, p. 101-106, 1960.

This is the first in a planned series concerning Rayleigh wave dispersion in the north and northeast of the Eurasian continent. Rayleigh waves from 6 earthquakes that occurred in Kamchatka and Japan are investigated using records from seismological stations in Finland. The resulting dispersion curve in the period range of 18-60 sec is compared with Dorman's theoretical curves. The comparison suggests an average crustal thickness of about 37-38 km along the paths investigated. This crustal structure is also indicated for a path crossing the Arctic continental shelf. — V. S. N.

Godin, Yu. N., Vol'vovskiy, B. S., and Vol'vovskiy, I. S. Seismic investigations of the earth's crust in the region of the Fergana intermontane basin. See Geophys. Abs. 183-576.

183-400. Ringwood, A. E. Olivine-spinel transition on nickel orthosilicate: Nature, v. 187, no. 4742, p. 1019, 1960.

High pressure experiments have been made on nickel orthosilicate, Ni_2SiO_4 , which normally crystallizes with an olivine structure, in order to explore the problem of olivine-spinel transitions in the earth's mantle. Intimate mixtures of $\text{Ni}(\text{OH})_2$ and silicic acid in orthosilicate ratios were subjected to pressures up to 50,000 atm at 650°C for periods between 1 and 6 hr. At pressures below 15,000 atm the phases produced were Ni_2SiO_4 olivine, NiO, and nickel talc. Above 20,000 atm olivine disappeared and a spinel phase appeared, together with NiO and talc. Between 15,000 and 20,000 all these phases appeared simultaneously. At 50,000 atm, a mix containing 20 percent excess $\text{Ni}(\text{OH})_2$ produced spinel and NiO; talc was absent. When a sample of prepared Ni_2SiO_4 olivine was subjected to 50,000 atm at 700°C for 2½ hr, about 80 percent was converted to the spinel form; at 20,000 atm a small amount of spinel was observed, but, curiously, no spinel formed at 30,000 atm.

It is concluded that the equilibrium pressure for the olivine-spinel transition in Ni_2SiO_4 at 650°C is about 18,000 atm. Wentorf's (1959) failure to synthesize Ni_2SiO_4 spinel at much higher pressures than those used here might have been due to the fact that his quenching was not rapid enough to prevent inversion of spinel back to olivine. — D. B. V.

ISOTOPE GEOLOGY

- 183-401. Hoering, T. C. Stable-isotope geochemistry: Am. Geophys. Union Trans., v. 41, no. 2, p. 298, 1960.

This is a bibliography of 29 entries that covers the work done in the United States during the period 1957-59 on the geochemistry of the stable isotopes. The listing is subdivided into the following categories: hydrogen, carbon, nitrogen, oxygen, sulfur, copper, and general discussions and reviews. — D. B. V.

- 183-402. Picciotto, E[dgard E.], Maere, X. de, and Friedman, I[rving]. Isotopic composition and temperature of formation of Antarctic snows: Nature, v. 187, no. 4740, p. 857-859, 1960.

Variations in the hydrogen isotopic composition in the same snowfall samples whose oxygen isotopic compositions were studied previously (see Geophys. Abs. 180-249) are reported here. The samples were collected during 1948 at the King Baudouin Base in Antarctica. The pattern of variation of deuterium/hydrogen ratios is very similar to that of the O^{18}/O^{16} ratios. These two parameters represent a veritable thermometer of the temperature of the middle troposphere, where the clouds causing the precipitation are formed. A variation of $1^{\circ}C$ corresponds to a relative variation of about 1 permil in the oxygen isotope ratio and of 0.8 percent in the hydrogen isotope ratio.

It has been shown (see Geophys. Abs. 181-327) that the isotopic composition of snow is conserved for at least several hundreds of years, even through compaction and transformation into ice. A very important application of the results reported here would be a study of recent climatic variations in Antarctica. — D. B. V.

- 183-403. Broecker, Wallace S., Gerard, Robert, Ewing, Maurice, and Heezen, Bruce C. Natural radiocarbon in the Atlantic Ocean: Jour. Geophys. Research, v. 65, no. 9, p. 2903-2931, 1960.

The natural C^{14} concentration in the dissolved bicarbonate of 135 samples representing the major water masses of the Atlantic Ocean has been determined with a precision ranging from 0.5 to 1.3 percent. Standard deviation within a given water mass is close to that predicted from experimental error, but measurable differences exist between the major water masses; the total range in C^{14}/C^{12} is about 10 percent.

The surface water ratios show a progressive increase from south to north, ranging from 120 permil lower than the preindustrial atmospheric value in the Antarctic to 50 permil lower in the North Atlantic. Deep water masses originating in the high latitudes of the Southern Hemisphere have consistently lower ratios than those from the high latitudes of the Northern Hemisphere. A layer with high C^{14}/C^{12} ratio at depths between 1,200 and 2,400 m in the western North Atlantic may represent a wedge of younger water penetrating older deep water. The ratio in bottom water in the eastern basin of the North Atlantic is 20 permil lower than that in corresponding water in the western basin. According to a steady-state circulation model, most of the water below 600 m in the North Atlantic remains at depth for about 650 yr; corresponding residence times for water masses of Antarctic origin are less than 350 yr.

When used in conjunction with oceanographic information and other isotope data, C^{14} data will provide estimates of large scale mixing rates within the ocean. — D. B. V.

- 183-404. Broecker, Wallace S., and Olson, Edwin A. Radiocarbon from nuclear tests, II: Science, v. 131, no. 3429, p. 712-721, 1960.

Due to continuous spiking of the troposphere with bomb-produced radiocarbon, changes in the C^{14} concentration throughout the carbon cycle are now occurring faster by several orders of magnitude than changes due solely to radioactive decay. Consequently, processes carried out in from 1 yr to 100 yr are now measurable or will be so in the next few years. This potentially useful tracer can be used in the study of a number of problems in the natural sciences. Examples of such use are given for the fields of soil science, biochemistry, limnology, and oceanography. — D. B. V.

183-405. Dontsova, Ye. I. Metod opredeleniya sootnosheniy izotopov kisloroda v gornykh porodakh i mineralakh [Method of determining the oxygen isotope ratios in rocks and minerals]: *Geokhimiya*, no. 8, p. 669-678, 1959.

A method of reducing rocks and minerals by graphite for the purpose of oxygen isotope analysis is described. The apparatus consists of a quartz vacuum furnace, a Langmuir pump to maintain a vacuum of about 10^{-5} Hg, a thermocouple pressure gauge and ionization pressure gauge, a Toepler pump to compress the carbon monoxide obtained in the furnace into a calibrated volume of the pressure gauge, and ampoules in which the gas is sealed off to be taken to the mass spectrometer for isotopic analysis. The required amount of carbon monoxide (30-40 cm^3) can be obtained from a 50-mg sample.

The batches are ground in an agate mortar with a quantity of graphite two or three times in excess of the stoichiometric amount. Before reduction, the graphite resistance of the furnace, the graphite boat, and the sample are degassed at a temperature between 900°C and 2,100°C, depending on the composition and structure of the material. The temperature at which the reaction begins differs for different materials: 1,300°C-1,400°C for quartz and granite, 1,200°C for olivine and dunite, and 1,000°C-1,100°C for basalt, diabase, and stony meteorites. For all materials the reduction is practically completed at 1,900°C. The yield of carbon monoxide ranges from 95 to 100 percent. Nitrogen and hydrocarbon impurities are virtually absent. Sources of error are analysed; relative accuracy is generally ± 0.02 percent or better, but in a few cases reaches as much as ± 0.04 percent.

The applicability of the method to different materials, particularly to aluminosilicate rocks containing alkaline and alkali-earth metals, is discussed. (See also *Geophys. Abs.* 181-60.) — D. B. V.

183-406. Dansgaard, W[illi]. The content of heavy oxygen isotope in the water masses of the Philippine Trench: *Deep-Sea Research*, v. 6, no. 4, p. 346-350, 1960.

The H_2O^{18} content of a group of 11 water samples from 7,558 to 9,864 m depth was compared with that of another group of 4 samples from 3,830 to 4,202 m depth in the Philippine Trench. The difference was 0.1 ± 0.2 ppm which indicates that no significant fractionation has occurred. Thus, the time for a complete exchange of water masses in the trench is very short relative to the time needed for the sedimentation process to reach equilibrium. This latter time is very long, probably on the order of 10^8 yr. — V. S. N.

183-407. Gavelin, S[ven], Parwel, A., and Ryhage, R. Sulfur isotope fractionation in sulfide mineralization: *Econ. Geol.*, v. 55, no. 3, p. 510-530, 1960.

The results of sulfur-isotope determinations are reported, and the methods and instruments used are described. Sulfides representing a continuous mineralization process are not significantly different from one another with re-

spect to the sulfur isotopes, nor is there any correlation between the isotopic composition and the zonal arrangement of minerals or metals around emanative centers. Where a considerable range in isotopic composition exists within a single ore body or ore district the range seems to be wider in the low-temperature than in the high-temperature sulfides. Supergene oxidation of sulfide minerals is not marked by isotopic fractionation. Subsequent redeposition of supergene sulfides, however, may be accompanied by enrichment in light sulfur. Significant divergencies in the S^{32}/S^{34} ratios in contemporaneous hypogene sulfides and sulfates appear to reflect isotopic fractionation. This fractionation seems to be more pronounced at lower temperatures and to have variations over distances of a few centimeters. — J. W. C.

183-408. Rama. Investigations of the radioisotopes Be^7 , P^{32} , and S^{35} in rain water. *Jour. Geophys. Research*, v. 65, no. 11, p. 3773-3776, 1960.

The concentrations of the radioisotopes Be^7 , P^{32} , and S^{35} in rainfall at Bombay and at Kodaikanal have been measured. The average concentrations in rainfall at Bombay during the period from June to October 1959 were 2,900 atoms per ml of Be^7 , 12 atoms per ml of P^{32} , and about 400 atoms per ml of S^{35} . It is shown that the observed fallout of Be^7 and of P^{32} is almost entirely of cosmic-ray origin; the fallout of S^{35} may possibly contain an appreciable amount of bomb-produced S^{35} . — Author's abstract

183-409. Kollar, F., Russell, R. D., and Ulrych, T. J. Precision inter-comparisons of lead isotope ratios: Broken Hill and Mount Isa: *Nature*, v. 187, no. 4739, p. 754-756, 1960.

A new mass spectrometer has been constructed and new techniques developed at the University of British Columbia, by means of which lead isotope ratios can be compared with a precision substantially better than that previously obtained. The principal differences that contribute toward the increased precision are the greater stability of the filament emission control and the use of a servo voltmeter to measure the ion currents. Small variations (0.1 percent) in the ratios measured in a single sample were still observed from day to day; in order to minimize this effect each sample was compared with a standard by observing alternately two pairs of the sample spectra and two pairs of the standard spectra.

The results of precise intercomparison of Australian samples from Broken Hill, New South Wales, and Mount Isa, Queensland, are presented and analysed. Previous analyses had failed to show any convincing relationship between these samples. The difference in precision with the new instrument and technique is striking. The cluster of points presenting the Broken Hill analyses is smaller by a factor of 10, and a distinction between Mount Isa and Broken Hill samples is clear. Reproducibility over a period of several weeks is quite good.

In the Broken Hill samples the Pb^{207}/Pb^{204} and Pb^{206}/Pb^{204} ratios differ from their average by less than 0.7 percent; the Pb^{208}/Pb^{204} ratio is more variable, suggesting that these leads have been contaminated by small amounts (0.2 percent) of radiogenic leads formed from an environment with a uranium-thorium ratio three times the mean crustal or subcrustal value.

The Mount Isa samples are less constant, but their relations can be explained on the assumption that these are slightly anomalous leads contaminated by thorium and uranium leads in their crustal environment. The Mount Isa leads are 40-80 million years younger than the Broken Hill leads, if the least radiogenic sample from each location is considered. — D. B. V.

- 183-410. Naydenov, B. M., and Cherdyntsev, V. V. *Izmeneniye izotopnogo sostava svintsa pri vydelenii iz prirodnykh mineralov* [Change in isotopic composition of lead during separation from natural minerals]: *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 5, p. 40-49, 1958.

The problem of possible fractionation of lead isotopes on solution of lead minerals in nature was investigated by measuring the relative amounts of the common, radioactive, and radiogenic lead isotopes in different lead minerals and in extractions from those minerals by water and (or) various reagents.

It is concluded that the ease of separability is as follows: common lead and $Pb^{212} > Pb^{210} >$ radiogenic lead. This finding agrees both with the general laws of separation of radioactive isotopes and with the data of Tilton and others (see *Geophys. Abs.* 162-163) on the differential separation of common lead with respect to radiogenic lead.

In most minerals the lead occurs in subordinate amounts in comparison with radioactive elements; lead predominates only in secondary and altered minerals. Two secondary forms are generally present in wolframite. In these cases no difference was observed in the value of Pb^{210} /common lead in the solutions and in the minerals. — D. B. V.

- 183-411. Taylor, S. R. The abundance of the rare earth elements in relation to their origin: *Geochim. et Cosmochim. Acta*, v. 19, no. 2, p. 100-112, 1960.

The abundances of the rare earth elements given by Suess and Urey (1956) are correlated with the processes of formation of the individual nuclides listed by Burbidge and others (1957). It is shown that the smoothing process carried out by Suess and Urey leads to relative depression of the s-process nuclides and elevation of those formed by the r-process. Later abundances published by Cameron (1959) accentuate this trend. His Ce/Nd ratio necessitates major fractionation between the earth and chondrites. — Author's abstract

- 183-412. Hamer, A. N., and Robbins, E. J. A search for variations in the natural abundance of uranium-235: *Geochim. et Cosmochim. Acta*, v. 19, no. 2, p. 143-145, 1960.

The results of a comparison of the isotopic compositions of the uranium in 12 ore concentrates by high-precision, gas-source mass spectrometry are described and the data are tabulated. Maximum deviation is 0.046 percent. It follows that, within the limits of 95 percent confidence, variations in the relative abundance of the principal uranium isotopes are less than 0.05 percent. — D. B. V.

Kashkarov, L. L., and Cherdyntsev, V. V. Neutron emission from minerals and the origin of Ne^{21} in the earth's atmosphere. See *Geophys. Abs.* 183-508.

SEE ALSO COSMOGONY

MAGNETIC FIELD OF THE EARTH

- 183-413. Beard, David B. Interaction of the solar plasma with the earth's magnetic field: *Phys. Rev. Letters*, v. 5, no. 3, p. 89-91, 1960.

This letter shows by mathematical calculations how the earth's magnetic field, which in a vacuum could be well approximated by a simple magnetic dipole field, is shaped and terminated by the incident current of what amounts to a diamagnetic medium, the solar plasma. — D. B. V.

- 183-414. Aslanyan, A. T. Magnitoye pole zemli kak relativistskiy effekt [The earth's magnetic field as a relativity effect]: Akad. Nauk Armyan. SSR Izv., v. 13, no. 1, p. 75-77, 1960.

From Plank's equation $\bar{p} = \bar{S}/c^2$, and the change of momentum according to $(dI/dt) = \bar{V} \times \bar{P}$, Aslanyan arrives at a force \bar{F} correlated with the impulse \bar{P} by the equation $\bar{P} = \tau \bar{F}$, where $\tau = RV/c^2(1 - Ve^2/c^2)^{1/2}$ is the time required by the theory of relativity for the gravitational compression force to travel from the center of a rotating conducting body of radius R to its surface. By equating the moment of rotation $\bar{N}_M = \bar{Q} \times \bar{B}$ of the body to the energy U of its magnetic field, and making $U = W$, the latter being the work performed in the body by the radial force \bar{F} , a formula $B^1 = (Ve^2/c)(\frac{2}{3}\pi\rho)^{1/2}$ is obtained for induction B of a homogeneously magnetized sphere of mean density ρ . This formula applied to the earth gives a value $B^1 = H = 0.24$ gauss for its magnetic field H. — A. J. S.

- 183-415. Lyakhov, B. M. Zemnoye magnitnoye pole kak summa poley dvukh dipoley [The earth's magnetic field as a sum of two dipole fields]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 601-606, 1960.

An analysis of the earth's general magnetic field is given, and the idea discussed as to whether this field can be explained as a sum of two magnetic dipole fields. It is proposed that the earth's magnetic field originates by the vortical motion of highly ionized matter within the core of the earth. Explanation of the residual world magnetic anomalies and their displacements is sought in the vortical current on the surface of the core. The world magnetic anomalies are considered as being apparent and having appeared as a result of movement in the core; the two dipole fields can be approximated from these movements. Since different combinations of the two dipoles may exist in different epochs, the origin of the general field and its secular variations may be explained by the superpositions of the vortical motions in the core of the earth and displacements of the vortexes. — A. J. S.

- 183-416. Bailey, V. A. Net electric charges on stars, galaxies and "neutral" elementary particles: Royal Soc. New South Wales Jour. and Proc., v. 94, pt. 2, p. 77-86, 1960.

The orthodox assumption in astronomy that stars cannot carry an appreciable net electric charge is abandoned, and as a result of the contrary assumption it has been found possible to account for the known orders of magnitude of 5 different astronomical phenomena and the directions relating to 3 of them, as well as to explain qualitatively or semiquantitatively at least 13 other phenomena. The first 5 are: (1) the maximum energy of about 5×10^{18} ev found for a primary cosmic ray particle, (2) the sun's polar magnetic field vectors, (3) the approximate equality for the sun and for Blackett's average of five magnetic stars of the ratio of the magnetic moment to the angular momentum of the star concerned, (4) the present state of magnetization of the earth, and (5) the existence and position of the outer Van Allen belt. Two alternative hypotheses are advanced to provide a source for the charge on a star. — V. S. N.

- 183-417. Herzenberg, A. Geomagnetic dynamos: Royal Soc. (London) Philos. Trans., ser. A, v. 250, no. 986, p. 543-585, 1958.

This is an expanded version of a work which was published in a condensed form in Annales Geophysique, v. 14, no. 4, p. 522-525, 1958 (see Geophys. Abs. 176-245). — D. B. V.

- 183-418. Cowling, T. G. Magnetic field of the earth: Nature, v. 183, no. 4666, p. 937-938, 1959.

This is a review of Herzenberg's paper proposing a dynamo model of the geomagnetic field, published in Royal Soc. [London] Philos. Trans., ser. A, v. 250, no. 986, p. 543-585, 1958 (see Geophys. Abs. 183-417). — D. B. V.

- 183-419. Kautzleben, H. Ergänzung zur Arbeit "Über das geomagnetische Normalfeld nach Fanselau" [Supplement to the work "On the geomagnetic normal field according to Fanselau"]: Zeitschr. Geophysik, v. 26, no. 1, p. 41-49, 1960.

The illustrations of normal fields given in Kautzleben's earlier paper (see Geophys. Abs. 182-379) are revised. — D. B. V.

- 183-420. Alldredge, L. R. A proposed automatic standard magnetic observatory: Jour. Geophys. Research, v. 65, no. 11, p. 3777-3786, 1960.

Present-day standard magnetic observatories employ an extensive amount of routine hand labor in determining absolute values of magnetic components and in scaling magnetograms. An automatic observatory is proposed in which the proton precession magnetometer is used as the detecting element. Two mutually perpendicular pairs of coils control bias fields in a plane perpendicular to the mean magnetic field vector. A preliminary calibration procedure involving reversals of the bias fields and rotations of the coil system eliminates uncertainties in coil geometry. Subsequently, measurements are automatically recorded in digital form so that a value of each magnetic component can be computed with high accuracy once a minute. The data are automatically handled in a computer to obtain all the statistical output which is typical of standard observatories. — Author's abstract

- 183-421. Bryunelli, B. Ye., Raspopov, O. M., and Yanovskiy, B. M. Mikrovariationsnaya stantsiya LGU i resul'taty yeye raboty v Borke vesnoy 1959 g. [LGU microvariation station, and the results of its operation at Borok during the spring of 1959]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 671-679, 1960.

A description of the construction and performance of a microvariation apparatus at the Borok geophysical station in the U. S. S. R. is given. The apparatus consists of three components: (1) a highly sensitive short period magnetometer for observations of short period oscillations of the earth's magnetic field; (2) an apparatus for observation of the earth's natural short period electric current variations; and (3) a device for recording the corresponding components of electric and magnetic field on the same tape. — A. J. S.

- 183-422. Heirtzler, J. R., and Hirshman, J[ulius]. Measurements of the geomagnetic field near Capetown: Jour. Geophys. Research, v. 65, no. 9, p. 3016-3018, 1960.

This is a preliminary report on recent magnetic measurements made off the southwest coast of Africa. Total magnetic field intensity was measured with a towed flux-gate magnetometer during the Vema-12 (April 19-May 13, 1957) and Vema-14 (March 27-April 6, 1958) cruises. Localized fluctuations are believed to be of geologic origin. During the first period the A-p index did not exceed a value of 27 (54 γ) for any day except April 19, when it reached 60 (120 γ); during the second period the A-p index did not exceed 36 (72 γ). None of the fluctuations exceeding 150 γ are believed to be due to short time variations of the field.

These results are not in accord with the 1955 United States chart of total field intensity; they appear to coincide more closely with the U. S. S. R. isomagnetic maps for 1955. — D. B. V.

- 183-423. Pomerantz, Martin A., Potnis, Vasant R., and Sandström, Arne E. The cosmic-ray equator and the earth's magnetic field: *Jour. Geophys. Research*, v. 65, no. 11, p. 3539-3543, 1960.

The positions of the cosmic-ray intensity minimum off the west coast of Africa and in the Indian Ocean, respectively, have been determined from measurements obtained with a shipboard neutron monitor during two voyages between Scandinavia and Australia. The cosmic-ray equator is in accordance with the prediction based upon calculations of modified cutoff rigidities at the first location, but differs by 4° at the second. Contemporary observations of zero magnetic dip indicate that the cosmic-ray intensity minimum coincides with the dip equator at 14° W., but differs in geographic latitude by 2° in the vicinity of long 60° E. — Authors' abstract

- 183-424. Onwumechilli, C. A. The relation between H- and Z-variations near the equatorial electrojet: *Jour. Atmos. Terrest. Physics*, v. 16, no. 3/4, p. 274-282, 1959.

The parallelism in the variations in the geomagnetic horizontal and vertical components observed at Ibadan, Nigeria (see *Geophys. Abs.* 182-386), is investigated. During the day, when the effect of the electrojet is dominant, H and Z vary proportionately. The indentations in daytime variation curves attain their maximum values simultaneously, and 86 percent of daytime and 54 percent of nighttime disturbances also begin and end simultaneously.

The ratio r of amplitude of an indentation in H to the same one in Z shows a remarkable diurnal variation that is constant for most of the daytime; this ratio is independent of magnetic disturbance but decreases with increasing duration (T). The indentations are attributed to fluctuations in the quantity and quality of ionizing agents from the sun, and the decrease of r with increase in T is attributed to vertical movements of the E-layer of the ionosphere (or the S_q layer). — D. B. V.

- 183-425. Sonett, C. P., Smith, E. J., Judge, D. L., and Coleman, P. J., Jr. Current systems in the vestigial geomagnetic field. *Explorer VI: Phys. Rev. Letters*, v. 4, no. 4, p. 161-163, 1960.

Preliminary data from the magnetometer carried by the Explorer VI satellite indicate the existence of a temporally and spatially variable current system which strongly perturbs the geomagnetic field at geocentric distances of 5-7 earth radii. A possible relationship between these currents and auroral activity is under investigation. — D. B. V.

- 183-426. Gall, Ruth. The secular variation and the geomagnetic theory of cosmic radiation: *Jour. Geophys. Research*, v. 65, no. 11, p. 3545-3558, 1960.

This paper discusses the effect of the secular variation of the geomagnetic field on the elements of the eccentric dipole and eccentric dipole-quadrupole models. It studies the migration during the period between 1845 and 1955 of geomagnetically equivalent points and examines the conditions for the invariance of the differential equation of motion of charged particles in the geomagnetic field. Formulas and practical rules are given for adapting calculations of cones, cutoff momenta and energies, and directions of incidence, valid for

any arbitrary year to any specific year of observation. Time corrections for the curves of cutoff momenta versus geomagnetic latitude were calculated for the period 1845-1955 for points of observation distributed over the southern and northern hemispheres. — Author's abstract

183-427. Kodama, Masahiro. Cosmic rays at sea level and the earth's magnetic field: *Sci. Papers [Tokyo]*, v. 54, no. 1, p. 20-42, 1960.

Measurements of cosmic-ray nucleon and meson components were carried out along a sea-level course between Japan and the Antarctic in 1956-57 and in 1958-59. The following results were obtained: (1) At geographic long 107° E. the position of the cosmic-ray equator is at geomagnetic lat 5° S. This position coincides with the geomagnetic dip equator measured simultaneously. (2) The position of the latitude knee is located at the same geomagnetic latitude, 35° S., in both surveys. This position is at about geographic long 20° E. and is much lower in geomagnetic latitude than the knee at any other longitude; it corresponds to 6.4 Bv in cut-off rigidity calculated for the eccentric dipole model of the earth's magnetic field. (3) Comparison of results of the two surveys shows that the rigidity spectrum changed in the region 6-8 Bv of the cut-off rigidity. Furthermore, by using the above results together with the available results of latitude surveys obtained by many investigators, the world-wide distribution of cosmic-ray neutron intensity at sea level is determined. From comparison of the world map thus obtained with various models for the earth's magnetic field, it is concluded that the world-wide distribution of cosmic-ray neutron intensity at sea level can be explained by the geomagnetic field including the effect of the nondipole parts. — V. S. N.

183-428. Komarov, A. G. Vekovoye dvizheniye polyusov zemli [Secular motion of the poles of the earth]: *Priroda*, no. 2, p. 8-14, 1960.

The evidence in favor of secular displacement of the poles of the earth during the geologic past is summarized. Cenozoic salt deposits, especially the potassium salts in the climatic belts 37°-48° on both sides of the equator, are very important in these considerations. Similar salts in Devonian and Silurian formations in the Angara-Lena basin between 50° N. and 74° N., where a cold and moist climate should have prevented formation of alkaline salts, indicates that this basin was in the arid belt 37°-48° from the equator during the time of its formation. The earth's poles migrated approximately 30° between the Silurian and Cenozoic. Paleomagnetic investigations of remanent magnetism indicate a variation in the distance between the geographic and magnetic poles of the earth and support the idea of the origin of the earth's general magnetic field as a result of its rotation. An attempt is made to explain the secular displacement of the poles by seasonal exchange of air masses in the atmosphere and by the asymmetry in surface distribution of continents and oceans. — A. J. S.

183-429. Kalashnikov, A. G., and Zybin, K. Yu. Nekotoryye rezul'taty nablyudeniya vektora variatsiy gorizontal'noy sostavlyayushchey geomagnitnogo polya [Some results of observations of the vector of variation of the horizontal component of the geomagnetic field]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 2, p. 236-242, 1960.

An analysis and interpretation of three-component fluxometric records of the earth's magnetic field variation at the geophysical station "Borok" (lat 58°02' N. and long 38°58' E.) are given. The purpose of the study is to determine the behavior of the KPK (short period variations) vector of the geomagnetic field in terms of the time of the day and to compare this vector's

behavior with that of the geoelectric field vector. It was found that both vectors rotate anticlockwise, their end points inscribing somewhat elongated ellipsoidal curves; the major axes of the magnetic and electrical ellipsoids tend to be at 90° to one another. It was found that the ratio E/H is a function of the variation period; it exhibits a sharp decrease within the range of 10-40 sec periods, a slight decrease within the range of 50 sec to 2 min, and remains almost constant in the range of the intermediate periods. The variations in the horizontal components of H and E are considered to be due to electric whirls in the ionosphere. — A. J. S.

- 183-430. Rochester, Michael G. Geomagnetic westward drift and irregularities in the earth's rotation: Royal Soc. [London] Philos. Trans., ser. A, v. 252, no. 1018, p. 531-555, 1960.

This is virtually the same paper as published by University of California, La Jolla, 53 p., 1959 (see Geophys. Abs. 179-286). — D. B. V.

- 183-431. Heisler, L. H., and Whitehead, J. D. Longitude effect in temperate zone sporadic E and the earth's magnetic field: Nature, v. 187, no. 4738, p. 676-677, 1960.

It is pointed out that the variation of the horizontal component of the geomagnetic field shows a longitude effect similar to that observed in the occurrence of sporadic E. There is some correlation between magnetic dip and sporadic E, due to the horizontal component of dip, but there is no correlation between total geomagnetic intensity and sporadic E. Theories accounting for sporadic E are evaluated in terms of these observations; movement of existing ionization by winds or electric fields seems to be the most likely source and is being studied further. — D. B. V.

- 183-432. Parker, E. N. Geomagnetic fluctuations and the form of the outer zone of the Van Allen radiation belt: Jour. Geophys. Research, v. 65, no. 10, p. 3117-3130, 1960.

It is demonstrated by formal calculation that the large-scale geomagnetic fluctuations observed at ground stations result in a rapid and somewhat remarkable kind of diffusion of the electrons in the outer zone of the Van Allen radiation belt. An initial thin ring of electrons will give an immediate finite particle flux at infinity, at the same time that the group of the particles remaining moves radially inward as a "wave." We predict a decline of particle counting rate beyond about 4 earth radii of the order of $1/r\beta$, where $\beta \approx 12$ to 16, depending upon the kind of counter, in agreement with the many observations. — Author's abstract

- 183-433. Beard, David B. The interaction of the terrestrial magnetic field with the solar corpuscular radiation: Jour. Geophys. Research, v. 65, no. 11, p. 3559-3568, 1960.

In this investigation the terrestrial magnetic dipole field is assumed to exist in an intense stream of protons and electrons emanating from the sun which behaves as a diamagnetic medium terminating the earth's magnetic field at about 7 earth radii on the daylit side and up to perhaps 100 earth radii on the night side of the earth. By detailed examination of particle trajectories the interaction between plasma and magnetic field is shown to occur within a negligibly thin current sheath enveloping the earth. Numerical solutions of the differential equation for the sheath surface reveal an approximately spherical surface on the daylit side giving rise to a more complicated

expanding surface on the night side, including a prominent bump of reversed current sheath near the magnetic poles. — Author's abstract

- 183-434. Sonett, C. P. Coupling of the solar wind and the exosphere: *Phys. Rev. Letters*, v. 5, no. 2, p. 46-48, 1960.

It is generally assumed that a solar wind consisting of a cool neutral plasma, primarily of hydrogen, is transported past the earth, and causes termination of the geomagnetic field. This termination occurs where the pressure of the wind normal to the dipolar field lines is equal and opposite to the magnetostatic pressure. This letter points to additional evidence for a solar wind, obtained by two rocket magnetometer experiments at altitudes greater than 14 earth radii.

The indication from the rocket data of subsolar boundary at about 13-14 earth radii can be made consistent with data based on comet observations (which yield a value for the momentum flux that is two orders of magnitude larger) by invoking a two-step process at the boundary. It is suggested that low-frequency magnetoacoustic waves are generated in a double-stream process between the incoming wind and inelastically stopped gas, that in the lab system (geocentric) only inward propagating waves are of significance, and that these waves carry a considerable fraction of both the momentum and the energy of the incident solar wind deeply into the geomagnetic field without convecting the incident gas body inward. — D. B. V.

- 183-435. Akasofu, Syun-Ichi. On the ionospheric heating by hydromagnetic waves connected with geomagnetic micropulsations: *Jour. Atmos. Terrest. Physics*, v. 18, no. 2/3, p. 160-173, 1960.

The energy dissipation process of the hydrodynamic waves in the ionosphere is studied in detail. It is shown that their heat production and the resulting increase of temperature are negligible. — Author's abstract

- 183-436. Jacobs, J. A., and Sinno, K. Some characteristics of geomagnetic micropulsations (Pc): *Nature*, v. 188, no. 4747, p. 285-287, 1960.

A detailed investigation has been made of geomagnetic micropulsations (Pc) recorded in 1957-58 at 17 widely distributed observatories. If the evidence of all investigators over a wide area is considered, Pc micropulsations correspond to two wavebands, a shorter-period micropulsation of about 15-30 sec and a longer-period micropulsation of about 30-90 sec. Equiamplitude contours can be drawn by combining the results of previous investigations with the latitude distribution of Pc amplitude found in this study. Differences in latitude distribution of the amplitude of the two wavebands and the geographic variation of period of the shorter micropulsations lead to the conclusion that the longer- and shorter-period micropulsations are probably caused by hydromagnetic waves in the upper and lower parts of the outer atmosphere, respectively.

Sometimes the beating oscillation type of Pc micropulsations, which appears mainly in middle latitudes, occurs simultaneously with long-period linear pulsations (LPc) in polar regions; the periods of both are about the same, 3-7 min, and their ideal overhead current systems are strikingly similar. The close relation between them suggests a common source, probably outer atmospheric oscillations. — D. B. V.

- 183-437. Matsushita, S. Seasonal and day-to-day changes of the central position of the S_q overhead current system: *Jour. Geophys. Research*, v. 65, no. 11, p. 3835-3839, 1960.

International Geophysical Year geomagnetic data for three permanent stations (Fredericksburg, Va., Tucson, Ariz., and San Juan, Puerto Rico) were studied in order to find the central position of the overhead current system responsible for S_q variations for the North American zone. It was found that the latitudinal location of the center is higher in summer than in winter, and that the local time at which minimum daily variation of H occurs at Fredericksburg is different in summer, at equinox, and in winter. A similar seasonal latitudinal shift can be seen in the European and Far Eastern zones. This shift is the reverse of that obtained by Bartels (1928). The present result is believed to be more reasonable; Bartels did not take into account the longitudinal inequality.

The pattern of the S_q current system is apparently regulated by local time and H_z (vertical intensity of the main geomagnetic field). The boundary between the daytime S_q current systems in the northern and southern hemispheres is at a line of equal H_z , where $H_z=0$, which is the magnetic equator in all seasons. The equatorial electrojet flows at this boundary. These considerations indicate that in the dynamo theory the common assumption that $|H_z|=2/3 \cos \theta$ gauss (where θ is colatitude) is oversimplified.

The average day-to-day shift of the S_q current center was found to be several degrees of latitude. An unusually high or low central position in one zone did not necessarily have a corresponding high or low in other zones. A complete paper is in preparation. — D. B. V.

- 183-438. Shapiro, Ralph, and Ward, Frederick W., Jr. Daily normals of the international magnetic character figure C_1 : *Jour. Geophys. Research*, v. 65, no. 1, p. 115-117, 1960.

Daily normals (averages) of C_1 have been computed for each day of the year, using the "final" C_1 figures for the 72-year period 1884-1955. It is concluded that departures of the long-term daily averages from a smooth semiannual variation are due to statistical sampling fluctuations. — D. B. V.

- 183-439. Pohrte, T., Warwick, C., and Macdonald, N. A search for geomagnetic singular days: *Jour. Geophys. Research*, v. 65, no. 9, p. 3013-3015, 1960.

Analysis of various indices of geomagnetic disturbance confirms the conclusion of Shapiro and Ward (see *Geophys. Abs.* 183-438) that there are no significant deviations in geomagnetic activity for a given calendar date, nor are there "singular days" in geomagnetic activity. — D. B. V.

- 183-440. Dessler, A. J., Francis, W. E., and Parker, E. N. Geomagnetic storm sudden-commencement rise times: *Jour. Geophys. Research*, v. 65, no. 9, p. 2715-2719, 1960.

Adopting the view that the sudden commencement of a geomagnetic storm (SC) is the result of the impact on the geomagnetic field of an abrupt solar-plasma front, the form of the SC observed on the surface of the earth is investigated. A model is constructed to represent the shape of the geomagnetic field boundary as perturbed by the solar plasma. Calculations (carried out in the equatorial plane for simplicity) show that, regardless of how abrupt may be the impact of a solar-plasma front on the geomagnetic field, the variation in hydromagnetic transit times from different positions on the boundary, down to a point on the surface of the earth, yields SC rise times of several minutes at ground level. These times are in agreement with the observed SC rise times. — Authors' abstract

- 183-441. Sugiura, Masahisa. A note on the harmonic analysis of geophysical data with special reference to the analysis of geomagnetic storms: *Jour. Geophys. Research*, v. 65, no. 9, p. 2721-2725, 1960.

At any given station on the earth, geophysical characteristics that tend to have a fixed distribution relative to the sun undergo a daily variation that depends only on local time (latitude and season). This simple daily variation pattern may be modified by intrinsic changes in the solar influences on the earth. The harmonic components of the daily variation at any station then undergo phase changes causing frequency shifts, analogous to Doppler shifts in optical or sonic phenomena, that must be taken into account in interpreting the results of harmonic analysis.

Such interpretation is discussed with respect to the Dst and DS parts of magnetic storm variations. It is concluded that the Doppler effect appears when the variation simultaneously involves time and space coordinates as variables. — D. B. V.

- 183-442. Hill, G. E. Ionospheric disturbances following a solar flare: *Jour. Geophys. Research*, v. 65, no. 10, p. 3183-3207, 1960.

The time variation and geographic distribution of f_{\min} , f_oE_s , and f_oF_2 during the geomagnetic storm of September 13, 1927, are analyzed. On the basis of f_{\min} and f_oE_s patterns it is concluded that prior to the SC, solar corpuscles impinge on the lower ionosphere directly from outside the earth's "magnetosphere." The post-SC f_{\min} and f_oE_s disturbances are attributed to trapped radiation drifting at relatively low altitudes (below 2,000 km). The southward expansion of the disturbances is a result of strengthening of the solar stream. — D. B. V.

- 183-443. Duncan, R. A. The cause of magnetic storms and bays: *Jour. Geophys. Research*, v. 65, no. 11, p. 3589-3592, 1960.

Because of the Hall effect, electric current will circulate anticlockwise around an area of proton precipitation and clockwise around an area of electron precipitation (in the northern hemisphere). This is suggested as the cause of the current systems of magnetic bays and storms. The observed geographical distribution of auroral hydrogen emission, polar blackout, and auroral E ionization is used to suggest that the required pattern of proton and electron precipitation occurs. — Author's abstract

- 183-444. Chapman, Sydney. Geomagnetic storms and the space around the earth: *Nature*, v. 187, no. 4740, p. 825-827, 1960.

This is the substance of three University of London Special Lectures delivered at Queen Mary College during June 1-3, 1960. The historical development of theories accounting for geomagnetic storms is traced, and currently favored concepts and recent trends are reviewed. — D. B. V.

- 183-445. Ellison, M. A., McKenna, Susan M. P., and Reid, J. H. The solar flare of June 1, 1960: *Nature*, v. 187, no. 4741, p. 926, 1960.

A class 3⁺ solar flare of exceptionally large extension was observed on June 1, 1960, at the Royal Greenwich Observatory at Herstmonceux, England, and at a number of other solar stations in Europe. A sudden commencement was recorded in the geomagnetic field at 1800 hours on June 3, followed by a minor magnetic storm ($K_p \text{ max}=7$) that lasted for 2 days. The distance of the June 1 flare from the sun's central meridian, however, reduced the probab-

ity that a magnetic storm would follow, and the longtime interval between the flare and the SC (57 hr) suggests that this storm was caused by particles emitted from a subsequent flare. — D. B. V.

- 183-446. Wilcox, J. B., and Maple, Elwood. Audio-frequency fluctuations in the geomagnetic field: *Jour. Geophys. Research*, v. 65, no. 10, p. 3261-3271, 1960.

Audiofrequency geomagnetic fluctuations recorded at three North American stations covering a latitude range of 41° (Panama City, Fla.; White Oak, Md., and Point Barrow, Alaska) are analyzed and interpreted. It is concluded that thunderstorm activity is the major source of fluctuations throughout the audiofrequency range, with the magnetic atmospherics being generated chiefly in the lower latitudes and propagated poleward. — D. B. V.

- 183-447. Martin, L. H. Observations of "whistlers" and "chorus" at the South Pole: *Nature*, v. 187, no. 4742, p. 1018-1019, 1960.

Seasonal and diurnal variations in the occurrence of whistlers at the South Pole maybe due to seasonal and diurnal variation in D-region absorption over the path of propagation. The diurnal peak at 0600 u. t. at Pole Station suggests that the whistlers penetrate the ionosphere somewhere along the 70° meridian, probably in the vicinity of Graham Land (about 55° south geomagnetic latitude).

The origin of chorus is not fully understood. The seasonal variation at the South Pole, with maximum activity in midsummer, suggests a dependence on solar radiation, perhaps in the form of solar corpuscular radiation impinging on the outer ionosphere. — D. B. V.

- 183-448. Mariani, F., and Molina, F. Perturbazioni geomagnetiche, auro-rali, ionosferiche e dei raggi cosmici: interdipendenze e relazioni con l'attività solare. 3: Perturbazioni ionosferiche [Geomagnetic, auroral, ionospheric, and cosmic ray disturbances; interdependences and relations with solar activity, pt. 3. Ionospheric disturbances (with English abstract)]: *Annali Geofisica*, v. 13, no. 1, p. 85-128, 1960.

Ionospheric disturbances in low to mean ($\pm 60^\circ$) and in polar latitudes are analyzed in this third part of the study of solar-terrestrial relationships (see also *Geophys. Abs.* 182-393, -394). The time variations of foF2 and h'F2 are described. The most recent results concerning the distribution and seasonal variations of D_{st} and S_D , particularly in foF2, are described. Knowledge of the behavior of the F1 and E layers during the disturbances is also summarized.

The main features of polar ionospheric disturbances are analyzed in more detail, and the causes of blackouts that are not strictly correlated with geomagnetic activity are discussed. — D. B. V.

- 183-449. Vassy, Arlette, and Rasool, Ishtiaq. Relations entre l'ozone atmosphérique et le magnétisme terrestre [Relations between atmospheric ozone and terrestrial magnetism]: *Acad. Sci. [Paris] Comptes Rendus*, v. 250, no. 23, p. 3865-3866, 1960.

The International Geophysical Year has provided data on the ozone content of the atmosphere for a period of maximum solar activity and intense geomagnetic activity. Comparison of ozone measurements at different stations with geomagnetic records at the same stations shows a number of coincidences that do not appear to be fortuitous. Minimums in ozone content precede magnetic storms by 1 or 2 days. — D. B. V.

- 183-450. Ose, Masami, and Wakai, Noboru. Report on results of ionospheric sounding on M/S Soya, 1958-59 [in Japanese with English abstract]: Antarctic Rec., no. 10, p. 19-22, 1960.

Ionospheric soundings were carried out on the Soya during the trip from Japan to the Antarctic in 1958 using a portable ionospheric sounding apparatus having an output peak power of 2.5kw and covering the frequency range of 1.0-20 megacycles per second. The latitude dependence of foF2 was almost the same as that found during the expedition of 1956-57; it showed two peaks, one at about 10° N. and the other at about 20° S. in geomagnetic latitude.

Comparison of diurnal variations of foF2 for the two expeditions shows the same interesting feature just south of Madagascar Island where foF2 was much lower than usual for two succeeding days. Scattering echoes at sea were not as strong as those observed in 1956-57, but the results of observation of the vertical distribution of the refractive index should give a clearer explanation for the scattering mechanism. — V. S. N.

MAGNETIC PROPERTIES AND PALEOMAGNETISM

- 183-451. Akimoto, Syun-iti, and Kushiro, Ikuo. Natural occurrence of titanomaghemite and its relevance to the unstable magnetization of rocks: Jour. Geomagnetism and Geoelectricity [Kyoto], v. 11, no. 3, p. 94-110, 1960.

The physical mechanism causing scattered polarization or unstable magnetization of some dolerite sheets was investigated by means of various magnetic measurements and microscopic examination. X-ray and chemical analyses showed that titanomaghemite is found only in rocks having unstable magnetization. This suggests that the scattered polarization or unstable magnetization of rocks may be caused by destruction of the thermoremanent magnetization by the natural oxidation of titanomagnetite into titanomaghemite, leaving only the isothermal remanent magnetization produced by the magnetic after-effect under the geomagnetic field. This explains why magnetic instability varies systematically with degree of alteration or weathering. — D. B. V.

- 183-452. Yasukawa, Katsumi. Remanent magnetism of dynamo-metamorphic rocks: Kyoto Univ. Coll. Sci. Mem., ser. B, v. 26, no. 2, p. 225-227, 1959.

Measurements were made of the remanent magnetization on more than 100 samples of crystalline schists from the Sambagawa metamorphic zone in Japan. More than 90 samples exhibit no remanent magnetization, and only 16 possess marked remanent magnetization. In 8 of the 16 the ferromagnetic minerals are nearly pure magnetite, and in the remaining 8 nearly pure hematite; in both cases the direction of magnetism lies in the plane of schistosity. Because crystalline schists develop their schistosity under pressure from one direction, it is likely that the origin of magnetism in the schists is a combined effect of piezoremanent magnetism and chemical remanent magnetism (see Geophys. Abs. 174-272, 176-266, 182-409), and that the direction of magnetization coincides with that of the component of the geomagnetic field in the schistosity plane. It is concluded that magnetism of a dynamometamorphic rock such as a crystalline schist cannot be used for paleomagnetic determinations not only because the component of the geomagnetic field perpendicular to the schistosity plane cannot be fossilized at the time of recrystallization but also because relative rotational movements of the schistosity plane might take place after recrystallization. — V. S. N.

- 183-453. Powell, D[avid] W[illiamson]. Stress-dependent magnetization in some quartz-dolerites: *Nature*, v. 187, no. 4733, p. 225, 1960.

When nonaxially magnetized cylindrical specimens of a quartz dolerite were axially compressed in an axial magnetic field of the order of the earth's field, their natural remanent magnetism vectors changed towards the ambient field direction. The empirical functions

$$K = \frac{P_{\phi} - P_{90}}{\tan 90 - \phi} \pm 7 \text{ percent and } I_T = \frac{I_A}{\tan 90 - \phi} \pm 10 \text{ percent}$$

fit the measured changes, where P_{ϕ} is the pressure applied to produce a vector making an angle ϕ with the field and compression direction, K is a parameter dependent on the magnetic minerals and ambient field strength, I_A and I_T are the axial and transverse components of the natural remanent magnetism intensity.

The K parameters are a measure of stability under conditions of geologic significance. An experiment on one specimen shows that K_{TRM} is 3 or 4 times greater than its K_{NRM} in the earth's field; this suggests that the stress dependence is due to unmixing of higher temperature magnetic phases. — D. B. V.

- Girdler, R. W., and Peter, G. An example of the importance of natural remanent magnetization in the interpretation of magnetic anomalies. See *Geophys. Abs.* 183-469.

- 183-454. Stacey, F. D. Stress-induced magnetic anisotropy in rocks: *Nature*, v. 187, no. 4745, p. 134-135, 1960.

An experiment is described which shows that the saturation magnetostrictions of rocks are easily measured in terms of stress-induced anisotropy. Two cylindrical samples of Tasmanian dolerite, 2 of basalt from Kiama, New South Wales, and 1 of monchiquite from Kiama, in all of which the natural anisotropies are small, were subjected to axial stress; the torque curves $T_S(\theta)$ in the stressed state and $T_0(\theta)$ in the unstressed state were measured, and values of saturation magnetostriction λ_S were calculated from $(T_S - T_0)$. The saturation magnetic moments I_S were also measured.

For the three rock types examined the magnetostriction has the sign and approximate magnitude expected for magnetite-bearing rocks, and it is reasonable to take as general the rule that the magnetostriction of a rock may be simply calculated as a weighted sum of the magnetostrictions of its constituent magnetic minerals.

In view of this result, the experiments reported by Stoot and Stacey (see *Geophys. Abs.* 176-268, 182-407) show that when an intrinsically isotropic rock is subjected to stress while cooling in a field it acquires thermoremanent magnetization in a direction deflected away from the field by an angle such that it returns precisely to the field direction when unloaded.

The method described could be used without modification down to $\lambda_S = 10^{-8}$, and appears capable of even further development. — D. B. V.

- 183-455. Keen, M. J. Magnetization of sediment cores from the eastern Atlantic Ocean: *Nature*, v. 187, no. 4733, p. 220-222, 1960.

The results of investigations of the remanent magnetization of two sediment cores from the eastern Atlantic Ocean are described. Details of the investigations will be given elsewhere. The cores were collected during the cruise of the *Discovery II* in May-July 1958; the first core was taken from the lower slopes of a group of abyssal hills on the west edge of the Iberian abyssal plain (station 3738, lat $41^{\circ}00'$ N., long $15^{\circ}08'$ W., corrected depth 5,267 m) and the

second was from the bottom of a bank about 3 m above the abyssal plain (station 3780, lat 41°26' N., long 14°43' W., corrected depth 5,333 m).

Variations in declination D , inclination I , intensity of remanent magnetization J , and magnetic susceptibility χ down the core are shown in graphs. At least 90 percent of the magnetic moment is due to magnetite. The results suggest that the magnetization of the sediments of the type found in core 3738 (brown clay and foraminiferal ooze and mixtures of the two, with some disturbance by burrowing animals) is due to the geomagnetic field during or soon after deposition while the clay was still wet and being reworked by burrowing animals. Core 3780 consists largely of material deposited by turbidity currents, in which sediment of the order of 100 cm in thickness may be laid down at any one time. In this core the changes in D and I are much greater than in core 3738.

Studies are being made of longer cores and of cores taken within 200 m of each other to see whether reversals of polarity occur and whether correlation can be found between adjacent cores. — D. B. V.

183-456. Arutyunyan, E. A. O magnitnykh svoystvakh porod i rud zhelezorudnykh mestorozhdeniy severnoy Armenii [Magnetic properties of rocks and ores of the iron deposits of northern Armenia]: Akad. Nauk Armyan. SSR Izv., v. 11, no. 5, p. 23-27, 1958.

The magnetic susceptibility and remanent magnetization of 146 specimens of rocks and ores from the iron fields of northern Armenia were measured; the results are presented in a table. It is concluded that the large anomalies in these iron fields are related either to magnetite and magnetite-hematite ore bodies or to rocks with abundant inclusions of ore minerals. Barren host rocks on the whole possess a relatively low magnetic susceptibility and remanent magnetization; therefore, they cannot cause anomalies. — J. W. C.

183-457. Doell, Richard R., and Cox, Allan V. Paleomagnetism, polar wandering and continental drift, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-426-B-427, 1960.

In an attempt critically to evaluate current interpretations of paleomagnetic evidence, available paleomagnetic data have been reviewed with special attention to evidence for stability and paleomagnetic applicability of the observed remanent magnetizations. Statistical analyses have been made of original data when possible. It is concluded that the earth's magnetic field had vastly different characteristics during post-Early Pleistocene, Oligocene to Early Pleistocene, Mesozoic to Early Tertiary, Late Paleozoic, Early Paleozoic, and Precambrian, but for only a few of these temporal subdivisions has the configuration of the geomagnetic field been established with sufficient certainty to justify application to the problem of continental drift. A summary of paleomagnetic data is given for each of the specified periods. — V. S. N.

183-458. Brodskaya, S. Yu., and Grabovskiy, M. A. Ob odnoy iz prichin nesovpadeniya vektora ostatochnoy namagnichennosti gornoy porodys napravleniyem namagnichivayushchego polya [On one of the causes of deviation of the vector of remanent magnetization in rocks from the direction of magnetizing field]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 490-494, 1960.

The influence of rock foliation on the vector of remanent magnetization (I_n) is studied. Measurements of anisotropic samples of hematite-magnetite quartzite of the Kursk magnetic anomaly showed that both the induced and the remanent magnetization parallel to the foliation are tens of times stronger than

that in the transverse direction, when the samples are magnetized isothermally. Similarly, the stability of magnetization parallel to the foliation is also higher than the stability in the transverse direction. Both direction and intensity of magnetization of layered rocks by the earth's magnetic field depend also on the angle of dip of the rocks. Independently of the original and the present magnetization fields, I_n tends to align parallel to the plane of the laminar anisotropy of the rock, since the longitudinal remanent magnetization component is much stronger than the transverse component. In cases when the magnetizing field is directed perpendicularly to the plane of the layering of the rocks, the vectors I_n of different samples may have opposite directions. The divergence of I_n and H vectors, due to the anisotropy of the rock, remains stable even when the rock is magnetized at a low temperature. — A. J. S.

- 183-459. Collinson, D. W., and Runcorn, S. K[ieith]. Polar wandering and continental drift. Evidence from paleomagnetic observations in the United States: *Geol. Soc. America Bull.*, v. 71, no. 7, p. 915-958, 1960.

Further studies of paleomagnetic directions in red sandstones and siltstones of various geologic ages in the United States are described. Usually the directions of magnetization of samples from a formation at one site are grouped symmetrically about a mean direction, from which the pole position for that time can be calculated. In some magnetically unstable formations, however, the directions of magnetization are distributed approximately in the plane containing the present dipole field at the site and the original direction of the magnetic field. This distribution is the result of superposition of a secondary magnetization, thought to be a viscous or chemical magnetization acquired in the last 1,000-1,000,000 yr, on the original magnetization.

Pole positions calculated for different sites are consistent for the same formation and for different formations of the same age. The general trend of the polar wandering curve for North America obtained by Runcorn (see *Geophys. Abs.* 165-273) is confirmed. The data also show that this curve for North America is displaced relative to that for Europe; the amount of drift between the two continents since Mesozoic time is of the order of 30° in longitude. — D. B. V.

- 183-460. Opdyke, N. D., and Runcorn, S. K[ieith]. Wind direction in the western United States in the Late Paleozoic: *Geol. Soc. America Bull.*, v. 71, no. 7, p. 959-972, 1960.

The latitude and orientation of Great Britain and the United States relative to the axis of rotation have been inferred for successive periods from paleomagnetic data. Ancient wind directions deduced from a study of eolian sandstones in the Permo-Pennsylvanian Tensleep, Casper, and Weber formations in the Western United States confirm the paleomagnetic results. — D. B. V.

- 183-461. Howell, Lynn G., Martinez, Joseph D., Frosch, Alex, and Statham, E. H. A note on chemical magnetization of rocks: *Geophysics*, v. 25, no. 5, p. 1094-1099, 1960.

Previously obtained magnetic data for Silurian samples from Alabama are presented. Both the remanent vector and the plane of maximum susceptibility lie close to the bedding plane for this ore containing chemically formed hematite. Now, X-ray measurements show preferred crystal orientation of the hematite in agreement with the susceptibility anisotropy. On the other hand, samples from the Tertiary in Texas containing hematite resulting from chemical alteration show no appreciable preferred crystal orientation or susceptibility anisotropy. Thus, in this case there is no obvious relationship between

the crystal growth of the hematite and the direction of the earth's magnetic field. It is suggested that stresses probably played a role in the crystal orientation in the Silurian iron ore. An interesting chemical magnetization took place in the Weches of Tertiary age in Texas. The unaltered glauconite in the Weches is reversely magnetized whereas the limonite derived from the glauconite by weathering is normally magnetized. — Authors' abstract

- 183-462. Du Bois, P. M. Correlation of Keweenaw rocks of Lake Superior district by palaeomagnetic methods: Geol. Assoc. Canada Proc., v. 11, p. 115-128, 1959.

An attempt to use paleomagnetism to show the contemporaneity or noncontemporaneity of certain Keweenaw rocks in the Lake Superior district is reported. In general, the paleomagnetic results are in accord with the geological evidence. In some places in the Lake Superior district, however, paleomagnetism suggests that some of the geological inferences are incorrect or that modifications should be made. For example, the Alona Bay lavas, generally thought to be the same age as the Keweenaw lavas, give a pole position very different from that of the Keweenaw lavas. Moreover, as the Baraga County dikes give a pole position close to that of the Alona Bay lavas, it is possible that there may have been a period of both intrusive and extrusive activity distinct from the main period of volcanism. The few determinations on the pole position of the Sault Freda sandstone suggest that it should be classified as Middle rather than as Upper Keweenaw.

It is felt that the conclusions reached in the Lake Superior district demonstrate great possibilities for the paleomagnetic method in the field of geologic correlation. — V. S. N.

- 183-463. Rutten, M. G., and Wensink, H. Paleomagnetic dating, glaciations, and the chronology of the Plio-Pleistocene in Iceland: Internat. Geol. Cong., 21st., Copenhagen 1960, Proc., pt. 4, p. 62-70, 1960.

Paleomagnetic dating is a valuable tool for the mapping of Pleistocene volcanics in Iceland. Within the youngest series of plateau basalts, two units of normally magnetized beds (N_1 and N_2) are separated by an inversely magnetized unit (R_1). N_2 is correlated with part of the Pliocene (Plaisancian-Astian) and R_1 with the Villafranchian. The Tertiary-Quaternary boundary can be defined as the limit between R_1 and N_2 , but its exact position has not yet been determined stratigraphically. Tillites are interbedded in all three sequences. The existence of pre-Quaternary glaciation in Iceland is thus demonstrated. — D. B. V.

- 183-464. Lin'kova, T. I. Paleomagnitnyye issledovaniya osadochnykh tolshch devona Severo-Zapada Russkoy platformy [Paleomagnetic investigations of Devonian sedimentary deposits of the northwest of the Russian platform]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 868-870, 1960.

The magnetic properties of 650 samples of Devonian sedimentary rocks taken from 64 outcrops in the northwest part of the Russian platform were studied. The remanent magnetization is found to be $0.3-17.3 \times 10^{-6}$ cgs units, and the magnetic susceptibility is of the order of 10^{-5} cgs units. These rocks exhibit direct and reverse magnetization; the coordinates of the north magnetic pole are nearly the same for both types. — A. J. S.

MAGNETIC SURVEYS

- 183-465. Andreasen, Gordon E., and Zietz, Isidore. Magnetic evidence for the attitude of a buried magnetic mass, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-114-B-116, 1960.

A method is presented for determining the dip of a dikelike mass at known depth, irrespective of the thickness of the mass, from magnetic data obtained at the surface. A two-dimensional anomaly extending from Fayette County across Wayne County and into Randolph County, Ind. was chosen to illustrate the procedure. — V. S. N.

- 183-466. Paarma, H., and Levanto, A. [E.]. On the use of magnetic measurements in ore prospecting: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 2, p. 98-110, 1960.

The proper selection of magnetic methods of prospecting for ores is particularly important in a financially poor country. Three case histories are described to illustrate the use of different magnetic methods in Finland. The cases examined are those of the Honkamäki (Otanmäki) and the Kärvasvaara and Raajärvi ore bodies in the Misi district. Airborne, surface, and bore-hole magnetic, magnetic difference, and absolute measurements were used in different combinations.

The methods of interpretation preferred are those which do not require complex calculations, such as the magnetic derivative and magnetic vector methods. — D. B. V.

- 183-467. Stam, J. C. Geological reconnaissance mapping with the help of aeromagnetic surveys: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 2, p. 111-120, 1960.

Examples are given to show that a structural interpretation map of an airborne magnetometer survey can be made and a tentative classification of the formations can be obtained without resorting to a complete quantitative analysis of the magnetic data in areas where the bedrock is covered with little or no overburden. Where crystalline rocks are overlain by thick sedimentary formations, the geological interpretation becomes more difficult. Airborne magnetic surveys are most useful as an aid in geologic mapping in Precambrian shield areas and have been used extensively in this way in Canada. The method can also be used in areas where formations are strongly disturbed and where regional metamorphism and (or) magmatic activity have played an important role, as in large parts of the Cordilleran region.

The method has the great advantage over photogeology that it can be used in areas covered by overburden, swamps, or jungle. It can easily be combined with electromagnetic surveying to improve the quality of interpretation at relatively little extra cost. — D. B. V.

- 183-468. Wahl, W. G[eorge]. An interpretive technique for delimiting mineral potential areas based on the magnetic susceptibility of source rocks: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 2, p. 200-215, 1960.

The magnetic susceptibility of syenites, quartz syenites, and granites is an index to their content of copper, lead, and zinc. Deposits of these metals are apt to occur around these rocks if their magnetic susceptibility is low but not if it is high.

A technique that is useful where sampling difficulties are great has been developed whereby the magnetic susceptibility is deduced from the distribution of isogams on aeromagnetic maps. Use of the technique is illustrated by examples of three Canadian stocks of similar composition, size, and occurrence but with different magnetic susceptibilities. — D. B. V.

183-469. Girdler, R. W., and Peter, G. An example of the importance of natural remanent magnetization in the interpretation of magnetic anomalies: *Geophys. Prosp.*, v. 8, no. 3, p. 474-483, 1960.

An example is given from the Gulf of Aden of a total intensity magnetic anomaly which cannot be explained by a body assumed to be magnetized in the direction of the earth's present magnetic field. It is inferred that the natural remanent magnetization is much greater than the induced magnetization and computations have been made which suggest the presence of igneous rocks with a reverse magnetization. The example illustrates that it is important to know the ratio of remanent to induced magnetization and the direction of remanent magnetization for the correct interpretation of magnetic anomalies. — Authors' abstract

183-470. Strakhov, V. N. Integral'nyye metody interpretatsii anomalii ΔZ odinakovogo znaka [Integral methods of interpretation of ΔZ anomalies of the same sign]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 4, p. 520-529, 1960.

The two-dimensional case of magnetic anomalies the profile of which can be represented by an open curve L in the vertical plane of the profile, and when the anomalies ΔZ are of the same sign, mostly positive, is discussed. The most important parameter, characteristic of the curve L from the point of view of exploration geophysics, is considered to be its distance between the Ox axis and the center of the curve's mass which, in the first approximation, should coincide with the center of the disturbing magnetic masses. Three integral methods are discussed and their mathematical analysis given for a determination of these characteristic distances. The proposed methods are applied to the Kursk magnetic anomaly (KMA) in central Russia where data on ΔZ of 5 anomalistic regions (Shchigry, Panki, Saltykovo, Smorodino, and Yakovlevo) are available. The values for the horizontal component were calculated with the aid of the formulas derived, and the value of the sought distance $h = -y_c$ was determined by the three integral methods suggested. The analysis conducted showed that the best agreement between the values H and h_u (the depth of the disturbing body according to the interpretation data) was $h \approx (100 \pm 5 \text{ per cent})H$ obtained by the third method. The integral methods described for the known vertical and horizontal components of the anomalistic field can be adjusted for the case when gradients of the field or certain other parameters of the field are available. — A. J. S.

183-471. Lapina, M. I. O nekotorykh rezul'tatakh issledovaniya vertikal'nykh gradiyentov magnitnogo polya v rayone Kurskoy magnitnoy anomalii [On some results of investigation of vertical gradients of the magnetic field in the region of the Kursk magnetic anomaly]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 4, p. 594-600, 1960.

Measurements of the magnetic field Z and its vertical gradient $\partial Z / \partial h$ carried out in 1954-57 at the Kursk magnetic anomaly are described and discussed. The depth of occurrence of the iron-bearing quartzite ranges from 150 to 600 m. At each station measurements of Z were made at 11 levels at vertical intervals of 0.5 m. A linear relationship was established between Z and h , and the value of $\partial Z / \partial h$ was determined from a graph constructed from the

data provided by the measurements. Errors of Z measurements reached 200-700 gammas for anomalies of 0.3-1.2 oersted, and the errors in the measured gradient were between 5 and 10 gammas per m for $\partial Z/\partial h$ anomalies of 50-700 gammas per m. The results of the survey were used in a study of comparative accuracy of the 8 methods available for calculating values of $\partial Z/\partial h$, assuming a two-dimensional magnetic field. It was found that the method of $\partial Z/\partial h$ measurement at several levels gives values of h accurate to 2-5 percent in the regions where the maximum values of the gradient are less than 30-40 gammas per m. This method cannot give satisfactory results when the maximum of $\partial Z/\partial h$ is greater than 40 gammas per m because of field variations and changes in temperature during measurements at different levels. — A. J. S.

- 183-472. Berkman, R. Ya., and Mikhaylovskiy, V. N. Izmereniye napryazhennosti slabykh peremennykh magnitnykh poley nizkoy chastoty pri geofizicheskoy razvedke [Measurement of the intensity of weak alternating magnetic fields of low frequency in geophysical prospecting]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 865-871, 1959.

Self induction coils are used at the present time as the sensing elements for measuring the intensity of an oscillating magnetic field in various forms of geophysical exploration. In order to increase the sensitivity of this method, the operating frequency of the instrument must be increased. The sensitivity in magnetic logging is limited, however, because of an increase in error associated with the effect of electrical conductivity, and the sensitivity in electrical prospecting because of a decrease in the depth of penetration of the waves. The question of the use of methods that do not depend directly on electromagnetic induction thus arises.

A method based on the principle of magnetic modulation of the field under investigation by an auxiliary field of higher frequency is described. This method has basic advantages with respect to sensitivity, natural noise level, noise proof qualities, and portability of the apparatus. The main advantages of the method are noted in the low frequencies of the acoustic band and in the subsonic frequencies. — J. W. C.

- 183-473. Strakhov, V. N. Nekotoryye voprosy metodiki interpretatsii magnitnykh anomalii [Certain problems in the method of interpretation of magnetic anomalies]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1389-1399, 1956.

The method of solution of the plane problem of magnetic prospecting with the aid of specially constructed master charts is discussed. The geometric meaning of the solution of direct and inverse problems is explained, and the solution of the inverse problem of magnetic prospecting is analyzed. Indicatrices of symmetrical bodies and logarithmic indicatrices are derived, and their applications are analyzed mathematically. It is concluded that the master charts of logarithmic indicatrices yield a better interpretation of anomalies than do other methods. — A. J. S.

- 183-474. Lozinskaya, A. M., and Mindlin, L. E. Opyt radiogeodezicheskoy privyazki detal'noy aeromagnitnoy s"emki [Experiment in radio-geodetic adjustment of a detailed airborne magnetic survey]: Prikladnaya Geofizika, no. 24, p. 213-221, 1960.

A radio arrangement consisting of 3 grounded transmitting radio stations outside of an airborne magnetic survey area, a retransmitting station within the area, and a radio receiving station equipped with phase meters on the air-

craft is described. It is used for continuous radiogeodetic adjustment of the traverse routes. The phase differences phototaped by the aircraft depend on the difference in distances between the three base stations and the receiving station on the aircraft. The tape shows any deviation from a predetermined traverse. — A. J. S.

183-475. D'yachkov, N. P. Sposob kasatel'nykh i yego teoreticheskoye oboznovaniye [The tangents method and its theoretical basis]: Prikladnaya Geofizika, no. 26, p. 90-98, 1960.

The empirical formula $h = \frac{1}{2}[\frac{1}{2}(x_2 - x_1) + \frac{1}{2}(x_4 - x_3)]$ of the tangents method is discussed, and its theoretical basis analyzed mathematically. The depth to the upper boundary of a magnetized rock is determined from the abscissa points x_1 , x_2 , x_3 , and x_4 at which the tangents to the anomaly curve are intersected. — A. J. S.

Karatayev, G. I. Determination of the ratio of intensity of magnetization to excess density according to gravity and weak magnetic ΔT anomalies. See Geophys. Abs. 183-359.

Tyapkin, K. F. On the relation between derivatives of gravity potential and derivatives of magnetic potential of a homogeneously magnetized body at an upper semispace. See Geophys. Abs. 183-360.

Roy, A., and Burman, S. D. Application of relaxation method of upward continuation of gravity and magnetic data. See Geophys. Abs. 183-354.

183-476. Garland, G. D., and Bower, Margaret E. Interpretation of aeromagnetic anomalies in northeastern Alberta (with French abstract): World Petroleum Cong. 5th, New York 1959, Proc., sec. 1, paper 42, p. 787-799, 1959.

This is the same as the paper published in Oilweek, v. 10, no. 18, p. 32-40, 1959 (see Geophys. Abs. 178-308). — V. S. N.

183-477. Allingham, John W. Use of aeromagnetic data to determine geologic structure in northern Maine, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-117-B-119, 1960.

The aeromagnetic method is used in Maine to trace magnetic units and thus to determine regional geologic structures in areas with a thin glacial cover. Aeromagnetic surveys in northern Maine cover about 12,000 sq mi. The magnetic susceptibility of the rocks, as determined in the laboratory, has been used to divide the rocks into three groups; it has thus been possible to trace units across areas of sparse outcrops. The data can also be used in areas of intrusive rocks to study the form and attitude of the intrusive bodies. — V. S. N.

183-478. Bromery, Randolph W., Zandle, Gerald L., and others. Aeromagnetic maps of Pennsylvania: U. S. Geol. Survey Geophys. Inv. Map GP-210, -222, -224, -226, -229, -232, -260, -262 to 265, 1960.

Aeromagnetic maps that show by contour lines the total intensity at about 500 feet above ground level have been published for the following: 210, Collegeville quadrangle, Montgomery County; 222, Pottstown quadrangle, Berks, Chester, and Montgomery Counties; 224, Downingtown quadrangle, Chester County; 226, part of the Unionville quadrangle, Chester County; 229, Manatawny quadrangle, Berks County; 232, Boyertown quadrangle, Berks and Montgomery Counties; 260, part of the Bedminster quadrangle, Bucks County; 262,

Telford quadrangle, Montgomery and Bucks Counties; 263, part of the Doylestown quadrangle, Bucks and Montgomery Counties; 264, Lansdale quadrangle, Montgomery County; and 265, part of the Ambler quadrangle, Montgomery and Bucks Counties. — W. L. G.

- 183-479. Bromery, Randolph W., Henderson, John R. Jr., Zandle, Gerald L., and others. Aeromagnetic maps of Pennsylvania: U. S. Geol. Survey Geophys. Inv. Map GP-223, -225, -227, -228, -230, -231, -233, -234, -237, and -238, 1960.

Aeromagnetic maps that show by contour lines the total intensity at about 500 feet above ground level have been published for the following: 223, Wagontown quadrangle, Chester County; 225, part of the Coatesville quadrangle, Chester County; 227, Temple quadrangle, Berks County; 228, Fleetwood quadrangle, Berks County; 230 Reading quadrangle, Berks County; 231, Birdsboro quadrangle, Berks County; 233, Honey Brook quadrangle, Chester and Lancaster Counties; 234, Parkesburg quadrangle, Chester and Lancaster Counties; 237, part of the Hatboro quadrangle, Bucks, Montgomery, and Philadelphia Counties; and 238, Langhorne quadrangle, Bucks County. — W. L. G.

- 183-480. Bromery, Randolph W., Henderson, John R. Jr., Zandle, Gerald L., and others. Aeromagnetic maps of Pennsylvania and New Jersey: U. S. Geol. Survey Geophys. Inv. Map GP-235 and -236, 1960.

Aeromagnetic maps that show by contour lines the total intensity at about 500 feet above ground level have been published for the following: 235, part of the Easton quadrangle, Northampton County, Pennsylvania, and Warren County, New Jersey; and 236, part of the Riegelsville quadrangle, Bucks and Northampton Counties, Pennsylvania, and Hunterdon and Warren Counties, New Jersey. — W. L. G.

- 183-481. Bromery, Randolph W., Zandle, Gerald L., and others. Aeromagnetic map of part of the Lumberville quadrangle, Bucks County, Pennsylvania, and Hunterdon County, New Jersey: U. S. Geol. Survey Geophys. Inv. Map GP-261, 1960.

This aeromagnetic map shows by contour lines the total intensity at about 500 feet above ground level for part of the Lumberville quadrangle, Bucks County, Pa., and Hunterdon County, N. J. — W. L. G.

- 183-482. Zietz, Isidore, and Gray, Carlyle. Geophysical and geological interpretation of a Triassic structure in eastern Pennsylvania, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-174-B-178, 1960.

The Triassic rocks of the Newark-Gettysburg basin are exposed extensively in Bucks County, eastern Pennsylvania. The configuration and structure of the Precambrian surface as deduced from aeromagnetic data differ in two important respects from those based on geology alone: (a) The displacement along the Furlong fault is less than 3,000 feet, whereas stratigraphic data indicate it to be about 10,000 feet; and (b) the Precambrian surface southeast of the Furlong fault dips southeastward, instead of northwestward as was expected from surface structure. An aeromagnetic map and several profiles are shown along with geologic sections deduced from them. — V. S. N.

- 183-483. Bromery, Randolph W. Preliminary interpretation of aeromagnetic data in the Allentown quadrangle, Pennsylvania, in Geological Sur-

vey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-178-B-180, 1960.

In the Allentown quadrangle a Precambrian metamorphic and igneous rock belt (the Reading Prong) trends northeast across the south-central part separating the Paleozoic sedimentary rocks on the north from the Triassic sedimentary and igneous rocks on the southeast. Aeromagnetic data indicate that some previously mapped faults are longer than supposed and that faulting may have occurred in some areas where it had hitherto not been recognized. — V. S. N.

183-484. King, Elizabeth R., and Zietz, Isidore. Determination of structure in the Appalachian basin by geophysical methods, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-199-B-202, 1960.

Geophysical data from the Appalachian Mountains and the plateau areas to the west, consisting mainly of long aeromagnetic profiles flown at various times over a period of more than 10 yr and a minor amount of gravity data, have been brought together in an attempt to delineate trends and major lithologic units in the crystalline basement and to estimate the thickness of the overlying sedimentary rocks. The region studied lies west of the Blue Ridge province and extends from Alabama to New York State.

Preliminary interpretations are based on nine aeromagnetic profiles extending from the Blue Ridge just north of Asheville, N. C., to the Ohio River at Louisville, Ky. The dominant feature is a group of exceptionally large magnetic anomalies delineating a block of strongly magnetic rock approximately 100 miles wide under the Appalachian Plateau. These probably reflect a large mass of predominantly mafic igneous rock. The thickness of the overlying sedimentary rocks is estimated to be 8,000-10,000 feet; recently drilled wells support this thickness. In the Valley and Ridge province, the thickness of the Paleozoic section is on an average 17,000 feet and increases southeastward. Over the Cincinnati arch depths to basement are about 15,000 feet; it is probable that this arch is underlain by Precambrian sediments or other nonmagnetic rocks. A much greater thickness of sedimentary rocks is also indicated in the northern part of the Appalachian Plateau province. — V. S. N.

Johnson, Robert W. Jr., and Bates, Robert G. Aeromagnetic and aeroradiactivity survey of the Concord Quadrangle, North Carolina. See Geophys. Abs. 183-530.

183-485. Allingham, John W. Interpretation of aeromagnetic anomalies in southeast Missouri, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-216-B-219, 1960.

Interpretation of aeromagnetic data from a survey of the Ozark uplift, the major structural feature in the Paleozoic rocks of southeastern Missouri, is presented. Aeromagnetic information in southeast Missouri is useful in distinguishing (a) areas having potential economic deposits of magnetite, (b) borders of basins having possible archipelago environments, (c) knobs and ridges having suitable sedimentary structures for localizing deposits of galena, (d) areas of faulting, and (e) the attitude of contacts. — V. S. N.

183-486. Andreasen, Gordon E., Kane, Martin F., and Zietz, Isidore. Regional geological interpretation of aeromagnetic and gravity data for the Rowe-Mora area, New Mexico, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-238-B-239, 1960.

A contour map of the Precambrian surface underlying the Rowe-Mora area of northeastern New Mexico based on 40 depths computed from aeromagnetic anomalies, 45 depths from drill holes, and exposures of Precambrian rocks along the east edge of the Sangre de Cristo Mountains is presented. The major feature of the map is the Sierra Grande arch, a basement highland trending northeast across the area. — V. S. N.

- 183-487. Joesting, H[enry] R., and Case, J[ames] E. Salt anticlines and deep-seated structures in the Paradox basin, Colorado and Utah, *in* Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-252-B-256, 1960.

The magnetic and gravity evidence bearing on the configuration and structure of the Precambrian basement in the salt anticline area of the Paradox basin, Colo. and Utah, and on the association of deep-seated structures with the salt anticlines are discussed. — V. S. N.

- 183-488. Zietz, Isidore. Configuration of the 10N pluton, Three Forks, Montana, *in* Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-E, p. B-229-B-230, 1960.

A detailed aeromagnetic survey was carried out in the Three Forks area, Montana, to determine the approximate shape of the 10N pluton and its relation to the Lombard thrust, which crops out about a mile to the east. Calculations strongly suggest that the pluton is bottomed at a depth of several thousand feet. This would imply that the thrusting may be younger than the intrusive and that the 10N pluton may be cut off by the Lombard thrust. — V. S. N.

- 183-489. Bromery, R[andolph] W., Emery, K. O., and Balsley, J[ames] R., Jr. Reconnaissance airborne magnetometer survey off southern California: U. S. Geol. Survey Geophys. Inv. Map GP-211, 1960.

Results of an aeromagnetic survey totaling 1,450 sq mi flown off the coast of southern California between lat 32° N. -34° N. and long 117° W. -121° W. are presented in a regional aeromagnetic contour map and 11 total intensity aeromagnetic profiles accompanied by a geologic map of the seafloor and adjacent land of southern California. A short text gives the field and compilation methods used, the general geology of the area, and the magnetic interpretation.

The most conspicuous features on the aeromagnetic contour map are two high-amplitude, linear magnetic trends, which are parallel to the northwest structural trend of the Peninsular Range of Baja California and southern California and correlate with the structural basins on the sea floor. These features suggest large masses of magnetic rock possibly intruded into rifts in the earth's crust. Calculated depths to the igneous masses are given; these may not agree with seismic or measured depths to basement because the intrusive rocks may not reach the basement surface. — V. S. N.

- 183-490. Grantz, Arthur, and Zietz, Isidore. Possible significance of broad magnetic highs over belts of moderately deformed sedimentary rocks in Alaska and California, *in* Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-342-B-347, 1960.

Regional aeromagnetic surveys over the Cook Inlet and Copper River Lowlands, Alaska, and the northern and central Great Valley, Calif., record broad total intensity magnetic highs over the belts of Jurassic and Cretaceous marine sedimentary rocks that underlie these areas. These highs are parallel

to the major geologic features in each area and are absent over parallel belts of more severely deformed sedimentary rocks of similar age.

There may be a causal relationship between the existence of the rocks that produce the broad magnetic highs and the structure and lithology of the sedimentary prisms that overlie them. This could be true if the magnetic rock masses are structurally more competent than the rocks under the severely deformed belts where such broad highs are not observed. — V. S. N.

- 183-491. Balsley, J[ames] R., Jr., Bromery, R[andolph] W., Remington, E. W., and others. Aeromagnetic map of the Kerby and part of the Grants Pass quadrangles, Josephine and Curry Counties, Oregon: U. S. Geol. Survey Geophys. Inv. Map GP-197, 1960.

This aeromagnetic map shows by contour lines the total intensity at a barometric elevation of 4,500 feet for Kerby and part of the Grants Pass quadrangles, Josephine and Curry Counties, Oregon. — W. L. G.

Washington Division of Mines and Geology. Geological interpretation of airborne magnetometer and scintillometer survey Mt. Bonaparte, Bodie Mountain, Curlew, Aeneas, and Republic Quadrangles, Okanogan and Ferry Counties, Washington. See Geophys. Abs. 183-531.

- 183-492. Zietz, Isidore, Andreassen, G[ordon] E., and Grantz, Arthur. Regional aeromagnetic surveys of possible petroleum provinces in Alaska, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-75-B-76, 1960.

Evaluation of geologic and aeromagnetic data from numerous regional aeromagnetic surveys of possible petroleum provinces in Alaska indicates that significant thicknesses of sedimentary rocks occur in several areas. For example, Cook Inlet and the Kenai lowland, and the Kvichak Bay and Kandik areas are underlain by thick sedimentary sections; much of the southern Copper River basin is underlain by a thick section of nonmagnetic, possibly sedimentary rock; the thick sediments in the Yukon-Kuskokwim delta are overlain in places by late Cenozoic lavas; and a sedimentary basin has been outlined in the Koyukuk area east of Seward Peninsula and west of Koyukuk Flats.

In the Arctic slope area, the magnetic basement subsides to the south from Point Barrow to about the Colville River. Magnetic basement is relatively shallow to the east near the Anaktuvuk and Kuparuk Rivers between lat 69° N. and 70° N. — V. S. N.

- 183-493. Canada Geological Survey. Aeromagnetic maps of New Brunswick: Dept. Mines and Tech. Surveys, Geophysics Papers 592G, 596G, 764G-769G, 773G, 775G-778G, 803G-817G, and 824G, 1960.

Aeromagnetic maps that show by contour lines the total magnetic intensity at about 1,000 feet above ground level have been published for the following quadrangles: 592G, Musquash; 596G, St. George; 764G, Harcourt; 765G, Grand Manan; 766G, Bay of Fundy; 767G, Salisbury; 768G, Rogersville; 769G, Petitcodiac; 773G, Campobello; 775G, Cape Spencer; 776G, Loch Lomond; 777G, Salmon River; 778G, Waterford; 803G, Hillsborough; 804G, Kouchibouguac; 805G, Chatham; 806G, Tabusintac River; 807G, Burnsville; 808G, Grande-Anse; 809G, Moncton; 810G, Buctouche; 811G, Richibucto; 812G, Point Sapin; 813G, Point Escuminac; 814G, Wishart Point; 815G, Tracadie; 816G, Caraquet; 817G, Port Elgin; and 824G, Miscou Island. — W. L. G.

- 183-494. Canada Geological Survey. Aeromagnetic maps of Nova Scotia: Dept. Mines and Tech. Surveys, Geophysics Papers 759G, 762G,

763G, 770G-772G, 774G, 779G-802G, 825G, 830G, 840G, 846G, 1010G, 1011G, 1013G, 1014G, 1025G, and 1026G, 1960.

Aeromagnetic maps that show by contour lines the total magnetic intensity at about 1,000 feet above ground level have been published for the following quadrangles: 759G, Ecum Secum; 762G, Hopewell; 763G, New Glasgow; 770G, Granville Ferry; 771G, Digby; 772G, Centreville; 774G, Sambro; 779G, Owls Head; 780G, Tangier; 781G, Upper Musquodoboit; 782G, Bridgetown; 783G, Margaretsville; 784G, Chezzetcook; 785G, Musquodoboit; 786G, Shubenacadie; 787G, Truro; 788G, Tatamagouche; 789G, Halifax; 790G, Uniacke; 791G, Kennetcook; 792G, Bass River; 793G, Oxford; 794G, Wolfville; 795G, Parrsboro; 796G, Springhill; 797G, Amherst; 798G, New Germany; 799G, Gaspereau Lake; 800G, Berwick; 801G, Cape Chignecto; 802G, Alma; 825G, Pugwash; 830G, Malagash; 840G, Merigomish; 846G, Port Hood; 1010G, Margaree; 1011G, Cheticamp; 1013G, Pleasant Bay; 1014G, Dingwall; 1025G, Cheticamp River; and 1026G, Lake Ainslie. — W. L. G.

183-495. Canada Geological Survey. Aeromagnetic maps of Prince Edward Island: Dept. Mines and Tech. Survey, Geophysics Papers 818G-821G, 827G-829G, 831G-833G, 836G, 837G, 842G, 843G, and 847G, 1960.

Aeromagnetic maps that show by contour lines the total magnetic intensity have been published for the following quadrangles: 818G, Cape Egmont; 819G, O'Leary; 820G, Tignish; 821G, North Point; 827G, Summerside; 828G, Malpeque; 829G, 833G, and 847G, Gulf of St. Lawrence; 831G, Charlottetown; 832G, Rustico; 836G, Montague; 837G, Mount Stewart; 842G, Boughton Island; and 843G, Souris. — W. L. G.

183-496. Canada Geological Survey. Aeromagnetic maps of Prince Edward Island and Nova Scotia: Dept. Mines and Tech. Surveys, Geophysics Papers 835G and 841G, 1960.

Aeromagnetic maps that show by contour lines the total magnetic intensity have been published for the following quadrangles: 835G, Pictou Island, Queens, Kings, and Pictou Counties; and 841G Malignant Cove, Antigonish and Kings Counties. — W. L. G.

183-497. Canada Geological Survey. Aeromagnetic maps of Ontario: Dept. Mines and Tech. Surveys, Geophysics Papers 850G-859G, and 880G-959G, 1960.

Aeromagnetic maps that show by contour lines the total magnetic intensity at about 500 feet above ground level have been published for the following quadrangles: 850G, Wegg Lake; 851G, Gullrock Lake; 852G, Red Lake; 853G, Nungesser and Coli Lakes; 854G, Kirkness Lake; 855G, Berens Lake; 856G, McInnes Lake; 857G, Critchell Lake; 858G, Kennedy Lake; 859G, Favourable Lake; 880G, Wapesi Lake; 881G, Papaongo Lake; 882G, Jeanette Lake; 883G, Birch Lake; 884G, Carillon Lake; 885G, Wigwasikak Lake; 886G, Nabimina Lake; 887G, Loughton Lake; 888G, McCoy Lake; 889G, Petownikip Lake; 890G, Anenimus River; 891G, Otatakan Lake; 892G, Wesleyan Lake; 893G, Zionz Lake; 894G, Cat Lake; 895G, Whitestone Lake; 896G, McCauley Lake; 897G, Shinbone Lake; 898G, Windigo Lake; 899G, Nikip Lake; 900G, St. Raphael Lake; 901G, Lindbergh Lake; 902G, Blackstone Lake; 903G, Obaskaka Lake; 904G, Gitche River; 905G, Upturnedroot Lake; 906G, Hinton Lake; 907G, Stirland Lake; 908G, Yoyoy Lake; 909G, Weagamow Lake; 910G, De Lesseps Lake; 911G, Miniss Lake; 912G, Lake St. Joseph West; 913G, Kawinogans Lake; 914G, Dobie River; 915G, Obabika Lake; 916G, Kecheokagan Lake; 917G,

Mawley Lake; 918G, Donnelly River; 919G, North Caribou Lake; 920G, Never-freeze Lake; 921G, McCrea Lake; 922G, Osnaburgh House; 923G, Ochig Lake; 924G, Tarp Lake; 925G, Mamiegowish Lake; 926G, Menako Lakes; 927G, Forester Lake; 928G, Opapimiskan Lake; 929G, Wachusk Lake; 930G, Wabakimi Lake; 931G, Burntrock Lake; 932G, Achapi Lake; 933G, Seach Lake; 934G, Collishaw Lake; 935G, Lysander Lake; 936G, Dillen Lake; 937G, Neawagank Lake; 938G, Obabigan Lake; 939G, Big Beaver House; 940G, Goldsborough Lake; 941G, Whitewater Lake; 942G, Greenmantle Lake; 943G, Pruner Lake; 944G, Crerar Lake; 945G, Jervis Bay Lake; 946G, Totogan Lake; 947G, Wig-wascence Lake; 948G, Michikenis Lake; 949G, Wunnammin Lake; 950G, Link-later Lake; 951G, Whiteclay Lake; 952G, Kilbarry Lake; 953G, Grace Lake; 954G, Miminiska Lake; 955G, Ozhiski Lake; 956G, Pattle Lake; 957G, Eyes Lake; 958G, Sheridan Lake; and 959G, Sennett Lake. — W. L. G.

183-498. Bower, Margaret E. Aeromagnetic surveys across Hudson Bay from Churchill to Coral Harbour and Churchill to Great Whale River: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Paper 59-13, 32 p., 1960.

Aeromagnetic and geomagnetic profiles are presented for two aeromagnetic flights across Hudson Bay made by the Geological Survey of Canada. The first flight was flown in 1955 from Churchill, Manitoba, to Coral Harbour, Southampton Island, a distance of 510 miles; the second flight was flown in 1957 from Churchill to Great Whale River, Quebec, a distance of 660 miles.

For flight 1, flown at 2,500 feet above sea level, the average magnetic gradient is -3.2 gammas per mile with a rate of decrease from 0.45 gammas per mile near Churchill to 3.75 gammas per mile at Coral Harbour. For flight 2, flown at 1,000 feet above sea level, the average magnetic gradient is -1.9 gammas per mile with a rate of decrease from 1.75 gammas per mile at Great Whale River. About 100 miles east of Churchill a region of increasing magnetic intensity was found.

Calculations were made to determine depth to the Precambrian basement. Results indicate that there is no great thickening of the sedimentary rock in the areas traversed. — V. S. N.

183-499. Agocs, W[illiam] B. Trans-European igneous structure determination from aeromagnetic profile: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 2, p. 91-97, 1960.

The igneous basement depths and structures have been determined along the course of an aeromagnetic profile about 2,400 miles (3,860 km) long extending from Beirut, Lebanon to Farnborough, England, via Cyprus, the southwest coast of Turkey, Athens, Brindisi, Rome, Nice, Valence, Lyon, Rouen, and Dieppe. The variations of the earth's total magnetic field and the igneous structure determined therefrom are correlated with the Bouguer gravity anomaly and the general geology and structure along the course of the profile. — Author's abstract

Hohl, Rudolf. Trend and character of a basement fault in the North German Plain according to geological and geophysical (gravimetric and geomagnetic) evidence. See Geophys. Abs. 183-379.

183-500. Andreyeva, R. I. K voprosu o geologicheskom istolkovanii Chernigovskoy magnitnoy anomalii [On the problem of a geologic interpretation of the Chernigov magnetic anomaly: Prikladnaya Geofizika, no. 21, p. 74-83, 1958.

A geologic interpretation of the Chernigov magnetic anomaly in the northwestern part of the Dnieper-Donets depression is presented. The basis for the interpretation was an analysis of the magnetic properties of sedimentary-ef-fusive strata recovered from the Chernigov basement borehole and a quantitative estimate of the anomaly which these rocks should produce in the localities studied. It was concluded that the Chernigov magnetic anomaly is caused by a sedimentary-effusive stratum, the top of which is 1.5-1.7 km deep. — A. J. S.

- 183-501. Yarosh, A. Ya. Stroyeniye kristallicheskogo fundamenta basseyna rek Vyatki i Kamy po materialam magnitnoy s"emki [The structure of the crystalline basement of the basin of Vyatka and Kama Rivers from the data of a magnetic survey]: Sverdlovsk. Gornyy Inst. Trudy, no. 34, Voprosy Razvedochnoy Geofiz., p. 108-124, 1959.

A schematic map of the crystalline basement constructed according to a magnetic survey of the Vyatka and Kama river basins has now been verified by drilling. The depth and relief of the magnetic basement were calculated from magnetic anomalies by the method of the ratio of derivatives of magnetic potential developed by Yarosh. The characteristics of the map and their relation to the geological structure of the territory are given. The magnetic susceptibility of the basement rocks ranges from 0.0 to $6,600 \times 10^{-6}$ cgs units and the remanent magnetism from 0.0 to $15,000 \times 10^{-6}$ cgs units. The density of these rocks ranges from 2.42 to 2.96. — A. J. S.

Boronin, V. P. Fundamental features of the internal structure of the Precambrian crystalline basement of the Tatar ASSR according to the data of gravity and magnetic surveys. See Geophys. Abs. 183-381.

MICROSEISMS

- 183-502. Zátópek, A[lois], and Zikmunda, O. Die harmonische Bodenunruhe in Mitteleuropa im Internationalen Geophysikalischen Jahr 1957/58 [Harmonic ground agitation in central Europe in the International Geophysical Year 1957-58]: Freiburger Forschungshefte C81 Geophysik, p. 171-186, 1960.

This is an analysis of microseisms registered in central Europe, particularly at Prague, during the International Geophysical Year. Their relationship to synoptic factors in the frontal zone between the east coast of North America and the west coast of Europe is marked.

Amplitudes and periods during several microseismic storms are shown in graphs. The relation of microseisms to zonal circulation at the 500-millibar level was studied with the aid of an index number, proportional to the east-west component, that could be read as the number of 40-m isohypse intervals on the map of the 500-millibar surface.

The source of these microseisms is cyclonic activity in the vicinity of Iceland and Jan Mayen Land, on the west and north coasts of Norway, and in the northern Baltic Sea. Both surf action on the coast and the effect of barometric lows are assumed to be factors in the generation of the microseisms recorded in central Europe. — D. B. V.

- 183-503. Tabulevich, V. N. O nekotorykh sluchayakh vozbuzhdeniya mikro-seysm v Atlanticheskom i Tikhom okeanakh [On some cases of microseism generation in the Atlantic and Pacific Oceans]: Akad. Nauk SSSR Doklady, v. 132, no. 4, p. 814-817, 1960.

The method developed for correlating microseismic with meteorologic conditions in the Caspian Sea area (see Geophys. Abs. 180-322) is here applied to other areas, using records from a number of International Geophysical Year seismic stations. The location of the source of microseismic storms originating in the Atlantic Ocean in December 1957 and January 1958 is illustrated by sketch maps and graphs of microseism periods and amplitudes, using records from Pulkovo and Apatity in the U.S.S.R.; Resolute Bay, Canada; Nord, Greenland; Uppsala and Kiruna, Sweden; Debilt, Netherlands; Durham, England; Halle, Germany; and Akureyri and Reykjavik, Iceland. — D. B. V.

- 183-504. Saha, B. P. Microseismic evidence for the existence of cold fronts, in association with the Nor'westers: *Indian Jour. Meteorology and Geophysics*, v. 11, no. 2, p. 137-144, 1960.

Group or storm type microseisms recorded at Alipore observatory at Calcutta during the passage of "nor'westers" over the head of the Bay of Bengal are shown to be of frontal type and are attributed to the passage of cold fronts. In the absence of direct meteorologic evidence the microseismic records are considered to be indirect proof of the existence of cold fronts in nor'westers during the premonsoon season. — D. B. V.

- 183-505. Iyer, H. M., and Kartha, T. D. K. Microseisms associated with the intense cyclone in the Bay of Bengal during September 1959: *Indian Jour. Meteorology and Geophysics*, v. 11, no. 3, p. 298-300, 1960.

The east-west component microseisms recorded at Cochin, India, during the cyclone of September 1959 in the Bay of Bengal have been analyzed, using a new band-pass filter technique of analysis that makes it possible to separate local short-period microseisms from distant storm microseisms. The intensity of microseisms of 2-5-sec period shows good correlation with the formation, intensification, and movement of the storm. — D. B. V.

RADIOACTIVITY

- 183-506. Eckelmann, W[alter] R., Broecker, W[allace] S., and Kulp, J. L[aurance]. Half-life of Pb^{210} : *Phys. Rev.*, v. 118, no. 3, p. 698-701, 1960.

A new determination of the half life of Pb^{210} has been made by the geological method. $PbCl_2$ extracted from uranium minerals in secular equilibrium was used to calibrate the thick-source scintillation counter for Pb^{210} alpha particles. Using this calibration the absolute activity of Po^{210} in partial equilibrium with a known number of Pb^{210} atoms prepared from the decay of a measured quantity of radon was determined. From these data a half life of 21.4 ± 0.5 yr was obtained for Pb^{210} . — D. B. V.

- 183-507. Gorshkov, G. V., and Lyatkovskaya, N. M. O neytronnom izluchenii gornyykh porod [On the neutron emission of rocks]: *Akad. Nauk SSSR Doklady*, v. 133, no. 1, p. 92-94, 1960.

Thermal neutrons are formed near the surface of the earth by retardation of fast neutrons that result from cosmic ray reactions in the atmosphere or in the materials enclosing the detector, or from nuclear processes in the ground, in the atmosphere, or in the materials enclosing the detector. The rate of formation of neutrons by nuclear processes in rocks of the earth's crust is considered here.

The emission of neutrons from granite due to bombardment by alpha particles from radon and its disintegration products is calculated as 2.4×10^{-7} neutrons per sec per g, and from the thorium family as 5×10^{-7} neutrons per sec per g. Spontaneous fission of uranium-238 produces 1.5×10^{-8} neutrons per sec per g. The neutron flux from granite thus is about 5 neutrons per cm per day. The number of neutrons formed by nuclear reactions in the earth is therefore about 50 times smaller than the number formed in paraffin by cosmic radiation at sea level; this is below the limit of sensitivity of modern apparatus. However, neutron flux from rocks should be measurable in mine workings where the concentration of radioactive elements is high, or where there is a high content of light elements such as beryllium and lithium. Cosmic-ray-produced neutrons present a rather great obstacle to measurement of neutron flux from rocks. — D. B. V.

- 183-508. Kashkarov, L. L., and Cherdyntsev, V. V. Neytronnoye izlucheniye mineralov i proiskhozhdeniye Ne^{21} v zemnoy atmosfere [Neutron emission from minerals and the origin of Ne^{21} in the earth's atmosphere]: *Geokhimiya*, no. 7, p. 632-641, 1958.

Neutron emission of radioactive minerals has been examined. For ferri-thorites the average yield is 0.9 ± 0.2 neutrons per 10^6 α -particles, and for uranium minerals it is 0.39 ± 0.03 neutrons per 10^6 α -particles. It has been shown previously that about 40 percent of the neutrons emitted from uranium minerals is due to spontaneous fission.

The chief reaction of the artificial transformation leading to neutron formation is the $^{18}\text{O}(\alpha, n)\text{Ne}^{21}$ -reaction; it yields about 0.2 neutrons per 10^6 α -particles for both the thorium and uranium families. At least one-fourth of the Ne^{21} of the earth's atmosphere is due to this reaction in the earth's crust. — D. B. V.

- 183-509. Roubault, Marcel, and Coppens, René. Étude radiogéologique d'une partie du massif granitique de Mortagne (Vendée)—France [Radiogeologic study of a part of the Mortagne granitic massif, Vendée, France]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 15, p. 78-97, 1960.

The radioactivity of the Mortagne granite batholith in France was measured in three different ways. Direct field measurements with a Geiger-Müller counter showed that gamma activity ranges from 25 to 50 counts per second. Alpha activity was measured by means of autoradiographs of powdered samples; it ranges from 0.6×10^{-3} to 5.3×10^{-3} α per cm^2 per second and can be regarded as an approximate indication of uranium plus thorium content. Autoradiographs of thin sections (three months exposure) showed the distribution of uranium within the rocks. The precise uranium content was determined by fluorimetry, and the proportions of mobile and fixed uranium by chemical methods.

The distributions of gamma and alpha activity and of uranium, shown in sketch maps, are more or less parallel. The radioactivity is distinctly stronger in the southwestern part of the area. The LaChappelle Largeau uraniumiferous deposit lies in the northeastern part, surrounded by an aureole in which activity is slightly higher but still not as high as that of the southwestern part.

An investigation of the effect of alteration on radioactivity showed that in fresh rock samples 75 percent of the radioactivity is in the inclusions, whereas in the altered rock there are fewer inclusions and most of the uranium is in the essential minerals or in fracture fillings. In the altered rock the uranium occurs in autunite of very recent formation, in which the percentage of daughter products of uranium, and therefore the intensity of gamma activity, is very small. — D. B. V.

- 183-510. Kirchheimer, Franz. Über radioaktive und uranhaltige Thermal-sedimente, insbesondere von Baden-Baden [Concerning radioactive and uranium-bearing thermal-spring deposits, particularly of Baden-Baden]: Geol. Landesamt Baden-Württemberg, Abh., v. 3, 67 p., 1959.

Measurements were made of the radioactivity and uranium-content of thermal-spring deposits at Baden-Baden, one of the most ancient and famous balneotherapy centers of the world. The Carboniferous and Devonian country rock in this area is not unusually radioactive. Secondary materials, however, exhibit higher radioactivity. Notable among these is a black manganese-iron hydroxide deposited on the walls of a Roman ruin. None of the radioactive deposits of the area have any economic importance. — J. W. C.

- 183-511. Martin, W. R. B., and Long, Anwyn M. Heavy mineral content and radioactivity count of beach sands west of Oreti River mouth to Blue Cliffs, Southland, New Zealand: New Zealand Jour. Geology and Geophysics, v. 3, no. 3, p. 400-409, 1960.

Beach and dune sands on the south coast of Southland, New Zealand, were sampled, and the heavy minerals were extracted, magnetically separated, and measured for radioactivity. The predominant heavy mineral is a green amphibole. Significant radioactivity (maximum 7 counts per minute) was found in two areas. The radioactivity is associated mainly with zircon, principally with the -100 mesh fraction. Monazite in minor amounts in the +100 mesh fraction may also contribute somewhat to the activity. — D. B. V.

- 183-512. Meigh, A. C., and Skipp, B. O. Gamma-ray and neutron methods of measuring soil density and moisture: Géotechnique, v. 10, no. 3, p. 110-126, 1960.

Nucleonic methods of measuring soil density and moisture are reviewed, the theory outlined, and the performance discussed. An instrument to measure bulk densities in boreholes is described, and an example of its use on a large airfield construction job given. The laboratory studies on a neutron scatter moisture-measuring system are presented, and a brief description is given of an improved transistorized unit in which a moisture and density measuring system are combined for use in the control of surface compaction. — Authors' abstract

- 183-513. Niino, Hiroshi. Study on the natural radioactivity of bottom deposits (II): Oceanog. Works in Japan Recs., Spec. no. 4, p. 165-170, 1960.

Samples of bottom deposits from the eastern Seto Inland Sea were taken at 25 stations between Takamatsu City and Tsuda Bay, Japan, for the purpose of determining the radioactivity of the deposits. The bedrock on the many islands around Takamatsu City is granite covered locally by younger volcanics. Because of the strong currents in the area, sampled deposits are mostly coarse grained. The samples were graded by size, and the natural radioactivity of 100 g of each fraction was counted by a Geiger counter for a period of 10 min. Values obtained were compared with those of the natural radioactivity in the hinterland. The natural radioactivity count at 8 stations is higher (10-30 percent) than that in the hinterland; the bottom deposits having this high radioactivity are poorly sorted coarse sand.

Bottom deposits have also been sampled at 13 stations off the coasts of Ogi and Raka north of Miyako Harbor, Iwate Prefecture, Japan. The results of this study are not yet available. — V. S. N.

- 183-514. Wilkening, Marvin H., and Hand, John E. Radon flux at the earth-air interface: *Jour. Geophys. Research*, v. 65, no. 10, p. 3367-3370, 1960.

The radon content of the atmosphere and of the soil gases escaping to the earth's surface has been measured in the vicinity of Socorro, N. Mex., by means of a radon condenser that uses a trap cooled by liquid oxygen. The average radon content of the atmosphere at ground level was found to be 0.24×10^{-12} curie per liter, and radon flux at the earth-air interface to be 90×10^{-18} curie per cm^2 per sec. The well-known diurnal variation of atmospheric radon was clearly evident; the radon content built up in the early evening, then rapidly decreased when the inversion was broken in the morning. The radon flux at the earth-air interface, on the other hand, appeared to be relatively constant over a diurnal period.

Diffusion theory is used to derive an expression for the radon flux in terms of the concentration of radium in the soil at depth. The measured value is consistent with a radon concentration produced by 1.1×10^{-12} g radium per g soil, assuming the local soil density to be 1.7 g per cm^3 . This value (accuracy about 50 percent) is within the range reported for rock types in the area. — D. B. V.

- 183-515. Jurain, G[eorges]. Moyens et résultats d'étude de la radioactivité due au radon dans les eaux naturelles [Means and results of study of the radioactivity due to radon in natural waters]: *Geochim. et Cosmochim. Acta*, v. 20, no. 1, p. 51-82, 1960.

A field method for determining the radon content of natural waters is described, and the results obtained in two surveys in different areas in France are analyzed statistically. Samples are introduced into Pyrex glass bubbles of 500 cm^3 capacity lined with zinc sulfide and coupled optically to a scintillometer with photomultiplier and preamplifier. The laboratory is carried on a truck.

From the results it appears that (1) the radon is distributed lognormally in a given geological formation, (2) the determination of radon in waters is capable of development into a geochemical prospecting technique, and (3) the radon content of waters is very often greater than that in biological systems. — D. B. V.

- 183-516. Alekseyev, F. A., Yermakov, V. I., and Filonov, V. A. K voprosu o soderzhanii radioelementov v vodakh neftyanykh mestorozhdeniy [Problem of the content of radioactive elements in the waters of oil fields]: *Geokhimiya*, no. 7, p. 642-649, 1958.

The distribution of uranium and radium in the waters of oilfields in platforms, folded areas, and reef and salt dome structures has been studied. For all types of fields the radium concentrations are similar ($n \times 10^{-10}$ g per l), and the uranium content is low (rarely exceeding 1.0×10^{-7} g per l). The maximum amount of radium is accumulated in waters of the calcium chloride type; the radium content correlates with the (Cl-Na)/Mg ratio (coefficient of metamorphism) but not always with the salt content. Maximum uranium is accumulated in waters of the sodium chloride type; the uranium content correlates with the Na/Cl ratio.

The radium content increases with proximity to an oil pool. As a rule maximum radioactivity is observed at the level of an oil pool and in the basal water-bearing horizons. In some cases the surface waters show an increase in radium content within the productive crests of structures and a decrease beyond the petroliferous area; the reverse is observed in the case of uranium content. — D. B. V.

- 183-517. Nelepo, B. A. Issledovaniye radioaktivnosti vod Atlanticheskogo okeana [Investigation of the radioactivity of Atlantic Ocean waters]: Akad. Nauk SSSR Doklady, v. 134, no. 4, p. 810-811, 1960.

The radioactivity of Atlantic Ocean waters was measured during a voyage from lat 22°45' N., long 63°06' W. to lat 15°22' N., long 20°56' W. Observations were made to a depth of 120 m, thus including the mixed layer above the thermocline, the thermocline layer, and the layer below it. The radioactive elements K^{40} , Cs^{137} , Kr^{85} , and Eu^{155} were identified.

The uniform distribution of radioactivity in the investigated area indicates that the atmosphere is the source of contamination. Three distinct layers could be distinguished at each observation point: In the upper layer the specific activity is very high and practically constant throughout its depth; in the intermediate layer specific activity drops sharply; and in the lower layer activity is low. — D. B. V.

Rama. Investigations of the radioisotopes Be^7 , P^{32} , and S^{35} in rain water. See Geophys. Abs. 183-408.

- 183-518. El Nadi, Abdel Fattah, and Omar, Hassan M. Radon and thoron content in atmospheric air at Giza, Egypt: Geofisica Pura e Appl., v. 45, p. 261-266, 1960.

The radon and thoron content of the air at Giza, Egypt, during the period January 1958 to July 1959 was determined by the emanometric technique. The concentration of radon and its decay products was $(88 \pm 4) \times 10^{-18}$ curies per cm^3 and that of thoron and its decay products was $(51 \pm 11) \times 10^{-18}$ curies per cm^3 . — D. B. V.

- 183-519. Hess, Wilmot H. The radiation belt produced by neutrons leaking out of the atmosphere of the earth: Jour. Geophys. Research, v. 65, no. 10, p. 3107-3115, 1960.

The present state of experimental knowledge about radiation belts is reviewed, and calculations of the radiation belt spectrums and fluxes based on the neutron decay source are compared with the experiments. It is concluded that the inner zone of the radiation belt is quite likely supplied by neutron decay alone, and that the e_2 region of the outer zone may well be due to neutrons alone, but that there may be an additional source of particles that supplies electrons of less than 100 Kev to the e_3 region of the outer zone. — D. B. V.

RADIOACTIVITY SURVEYING AND LOGGING

- 183-520. Tanner, Allen B. Usefulness of the emanation method in geologic exploration, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-111-B-112, 1960.

Exploration for radioactive materials or geologic features by measurement of one or more of the emanation isotopes, radon, thoron, and actinon, contained in soil gas near the surface of the earth, is called the emanation method. Because techniques for emanation measurement are more sensitive and more specific than field gamma-ray measurements, emanation surveying, particularly that using Rn^{222} , has been practiced for about 40 yr. However, it has become apparent that most "radon" anomalies described in the literature probably are not caused by the short-lived radon but by radium and other intermediate decay products of uranium in solution. This type of anomaly tends to be displaced in the direction of ground-water movement; therefore, it is in-

accurate in locating geologic features unless the features are large compared with the thickness of overburden. — V. S. N.

- 183-521. Guillou, Robert B., and Schmidt, Robert G. Correlation of aeroradioactivity data and areal geology, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-119-B-121, 1960.

Study of aeroradioactivity profiles, obtained using equipment and surveying techniques developed in the search for deposits of radioactive materials, indicates that aeroradioactivity surveying can be an important adjunct to a geological mapping program. Correlation of aeroradioactivity data and areal geology is similar to subsurface correlation using gamma-ray logs of drill holes.

Survey techniques are described briefly and examples of interpretation of magnetic features in several areas discussed. The technique is of most value in areas of low to moderate topographic relief, residual soil, and poor outcrop, such as the Appalachian Piedmont. — V. S. N.

- 183-522. Flanagan, F[rancis] J., Smith, W[illiam] L., and Sherwood, A. M. A comparison of two estimates of the thorium content of the Conway granite, New Hampshire, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-168-B-169, 1960.

An indirect, physical method of estimating the amount of thorium present in a sample is described. The technique is none too accurate for individual determinations, but its short counting time and the use of an average potassium content of the rock under study recommend its use in reconnaissance work where duplicate samples are available.

Four samples from each of the four groups of the Conway granite were chosen to test the validity of the technique. The amount of thorium was determined by both the chemical method and the indirect method of subtracting the uranium content of the ore from the radioactivity expressed as equivalent uranium, then multiplying the remaining radioactivity by the specific counting rate ratio for U/Th. It was found that it was not necessary to use individual determinations if an average potassium content is available. — V. S. N.

- 183-523. Tanner, A[llen] B. Increasing the efficiency of exploration drilling for uranium by measurement of radon in drill holes, in United Nations, Processing of raw materials: Internat. Conf. Peaceful Uses Atomic Energy 2d, Geneva 1958, Proc., v. 3, p. 42-45, 1958.

Through the influence of atmospheric pressure changes, Rn-222 tends to migrate from uranium ore into drill holes. Under appropriate geologic conditions advantage may be taken of this tendency by increasing the distance between exploration drill holes without increasing the likelihood of missing bodies of ore. Where there is sufficient fracturing or permeability of the rock constituting the ore horizon, anomalous concentrations of radon may be observed tens of feet from uranium ore, in contrast to the extremely local information derived from gamma-ray logs or from analysis of drill cuttings or cores. If there are errors, caused by excess radon, in gamma-ray evaluation of many drill holes in an area, there is reason to believe that this method is applicable. Radon measurement may be accomplished either upon samples of drill-hole air taken at the ore horizon or by direct measurement of alpha radiation in the hole.

Samples of air from the ore horizon in 11 drill holes on a line traversing a uranium ore body in limestone near Grants, N. Mex., were analyzed for ra-

don with field equipment. Anomalous concentrations of radon were observed not only in samples from holes that penetrated ore but also in samples from holes located from 100 to 200 feet from the nearest ore. — A. B. T.

- 183-524. Wiles, D. R. The effect of radioactive fallout on instrumental prospecting: *Canadian Mining Jour.*, v. 81, no. 5, p. 61-63, 1960.

The nature of the nuclear fission process is discussed in its relation to atomic explosives, and the origin of radioactive atmospheric contaminants is clearly set forth. Sedimentation and subsequent dissemination of radioactive fallout in plants are described, and the question is raised as to whether these radioactive materials—notable Cs^{137} —may interfere with prospecting for uranium and thorium. The equipment carried by prospectors or available in mine offices is not capable of distinguishing between Cs^{137} and those nuclides in uranium ores which emit gamma-rays. It may be necessary for assay offices to equip themselves with gamma-ray spectrometers in order to distinguish between the 0.662 Mev gamma rays of Cs^{137} and the higher energy gamma rays from Radium C'' and other decay products of uranium. — V. S. N.

- 183-525. Alekseyev, F. A. Radiometricheskii metod poiskov nefti i gaz (o prirode radiometricheskikh i radiogeokhimicheskikh anomalii v rayone neftyanykh i gazovykh mestorozhdenii) [Radiometric method of oil and gas exploration (nature of radiometric and radiogeochemical anomalies in the region of oil and gas fields)] in *Yadernaya Geofizika* [Nuclear Geophysics]: Moscow, Gostoptekhizdat, p. 3-26, 1959.

The possibilities of using radioactivity methods for oil and gas exploration at the surface and for study of cores from shallow boreholes are examined. The radiogeochemical method of direct oil and gas exploration is based on the anomalous distribution of radioactive and stable elements in the section above the deposits. This anomalous distribution is determined by air and ground survey with high precision apparatus, which records total gamma radiation. The anomalies in the natural gamma field of the earth are governed by changes in the clark concentration of the radioactive elements. Experiments in the laboratory have demonstrated that hydrocarbons occupying the adsorption surface within the rock decrease the capacity for adsorption; this leads to the anomalous distribution of the elements in question. Anomalously low values of gamma radiation were recorded above most of the oil fields investigated; this includes platform, geosynclinal, and salt dome types. The anomalous effect is 10-25 percent of the background. — J. W. C.

- 183-526. Jones, A. R. Uses of semiconductor detectors in health-physics monitoring: *Nucleonics*, v. 18, no. 10, p. 86-91, 1960.

Semiconductor junctions of high-purity n- and p-type silicon can be used for detection of nuclear radiations. In contrast to scintillation and Geiger-Müller counters, the semiconductor detectors are rugged and compact, require simple, low-voltage power supplies, and have short response times. Schematic diagrams are given for a detector circuit having a risetime of about 10^{-9} sec, for a transistorized input circuit to amplify alpha pulses of 10μ sec duration from 200μ v to 5 mv, and for a hybrid input circuit to amplify and invert beta and gamma pulses of 5μ sec duration from +4 to -25 mv. Alpha and neutron monitors using the semiconductor detector are satisfactory at present; beta- and gamma-ray monitors need further development. A coating of B^{10} over the detector is considered superior to a coating of U^{235} as the means of adapting the device to neutron detection. — A. B. T.

- 183-527. Mero, John L. Uses of the gamma-ray spectrometer in mineral exploration: *Geophysics*, v. 25, no. 5, p. 1054-1076, 1960.

Gamma-ray spectroscopy offers a rapid and reliable radiometric method of analysis of uranium and (or) thorium ores. Methods of ore analysis are described and experimental results are presented. The uranium-thorium ratios of rocks, which are important in strata recognition and correlation studies, can be determined directly by gamma-ray spectroscopy without the necessity of making individual uranium or thorium assays. Analysis of potash ores is facilitated with a gamma-ray spectrometer. Erratic behavior of gamma-ray well logs can often be resolved by studying the gamma-ray spectra of these logs. Neutron-activation, followed by gamma-ray spectral analysis, of common earth materials offers a method of borehole rock analysis for elements such as calcium, hydrogen, chlorine, sulphur, and magnesium. Data in studies employing radioactive tracers can often be enhanced through use of a gamma-ray spectrometer. Other present and potential applications of the gamma-ray spectrometer in mineral exploration are also discussed. — Author's abstract

- 183-528. Derksen, George. Beryllium detector developed by Winnipeg scientists: *Precambrian*, v. 33, no. 4, p. 14-16, 1960.

A gamma-ray neutron beryllium detector (Beryllometer) capable of identifying beryllium positively has been developed at the University of Manitoba. It has been field tested in both Canada and the United States and is now commercially available. The instrument is based on the principle that beryllium will emit neutrons when bombarded by high energy gamma rays. The radioactive source used to activate the beryllium is Sb^{124} . The Beryllometer contains the essential components of any scintillation counter, but is must be placed directly on the rock outcrop or sample to be tested in order that the strong gamma rays from the Sb^{124} can penetrate the rock. The strength of the neutron flux is proportional to the beryllium content of the rock; thus, quantitative assays are immediately provided in the field. — V. S. N.

- 183-529. Kobayashi, Hisanobu. Low background end-window Geiger-Müller counter: *Sci. Papers [Tokyo]*, v. 54, no. 1, p. 16-19, 1960.

A Geiger-Müller counter devised for exact measurement of weak beta-ray activities is described. In this instrument, the natural background count is reduced to 2-4 counts per minute without lowering the accuracy. The center wire of the counter is provided with a mica disc guard as a beta-ray absorber dividing the counter into two separate compartments, each serving as an independent counter. The counter is equipped with a mica end-window 2 cm in diameter and is shielded by lead blocks 5 cm in thickness. — V. S. N.

- 183-530. Johnson, Robert W. Jr., and Bates, Robert G. Aeromagnetic and aeroradioactivity survey of the Concord Quadrangle, North Carolina, in Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-192-B-195, 1960.

An airborne magnetic and radioactivity survey has been made of the Concord quadrangle in the Piedmont of central North Carolina to help guide geologic work now in progress. The complex geologic patterns are obscured here by extensive development of saprolite.

Results show that the radioactivity data are in excellent agreement with the mapped boundary of the porphyritic granite across the north edge of the quadrangle, and in general agreement with mapped outlines of the syenite bodies of the central ring structure. Both magnetism and radioactivity indicate possible

interfingering of syenite and gabbro at the north end of the west syenite body. Most of the magnetic highs associated with the ring structure lie within the gabbro adjacent to the syenite-gabbro contact. Areas of high radioactivity along the east edge of the quadrangle maybe related to shear zones or to base-metal and heavy-mineral concentrations along those zones, or to both. — V. S. N.

- 183-531. Washington Division Mines and Geology. Geological interpretation of airborne magnetometer and scintillometer survey Mt. Bonaparte, Bodie Mountain, Curlew, Aeneas, and Republic Quadrangles, Okanogan and Ferry Counties, Washington: Washington Div. Mines and Geology Inv. Rept., no. 20, 34 p., 25 maps and overlays, 1960.

A combined airborne magnetic and radiometric survey was made of five 15-minute quadrangles in northern Washington. The flight direction was east-west, flight lines were spaced at 1,320 feet, and the average ground clearance was 500 feet. A total of 3,945 line miles was surveyed.

The radiometric survey was made with a Measurement Engineering Limited Model 1903R scintillation instrument. The location of anomalies is shown by dots along the flight lines on the accompanying maps.

The magnetic data were recorded by a Varian (12-volt model) nuclear precession magnetometer using a 512 gate. During the survey a magnetic monitoring device was operated on the ground to detect any excessive magnetic disturbance. The data are presented on contoured magnetic maps and overlays. Geologic interpretations are given for each quadrangle. — J. W. C.

Roubault, Marcel, and Coppens, René. Radiogeologic study of a part of the Montagne granitic massif, Vendée, France. See Geophys. Abs. 183-509.

Jurain, G[eorges]. Means and results of study of the radioactivity due to radon in natural waters. See Geophys. Abs. 183-515.

- 183-532. Filippov, Ye. M. Issledovaniye raspredeleniya gamma-izlucheniya v gornyykh porodakh [Study of gamma-radiation distribution in rocks]: Prikladnaya Geofizika, no. 24, p. 100-120, 1960.

The problems of gamma-gamma and gamma logging are analyzed theoretically, and an attempt is made to obtain theoretical data that are in agreement with observations. A study was made of the distribution of diffused gamma radiation in a homogeneous medium, in two mediums having a cylindrical boundary, and for the case of a dry borehole. It was found that in rocks of the same concentration of radioactivity, the intensity of radiation on the axis of the borehole is independent of the density of the medium. In the case of an equal volume of radioactive substance in the rocks, the intensity of radiation at the center of the hole decreases with an increase in the density of the rock. — A. J. S.

- 183-533. Korzhev, A. A. K voprosu otsenki poristosti pronitsayemykh porod pri pomoshchi radioaktivnykh izotopov [On the problem of estimation of the porosity of permeable rocks with the aid of radioactive isotopes]: Prikladnaya Geofizika, no. 26, p. 137-148, 1960.

Adsorption of radioactive isotopes by various rocks, particularly by clays and sands, is studied with respect to the method of labeled atoms in the oil industry. It was found that adsorption by clay and sand is strongly correlated with the acidity of the solvents. On the basis of adsorption experiments with the radioactive isotope iron-59, it was possible to produce a radioactive source

in permeable layers; the amount of radioactivity introduced into the rock was a function of its porosity. — A. J. S.

- 183-534. Armstrong, F. E. Transistorized logging probe: *Nucleonics*, v. 15, no. 10, p. 100, 102, 104, 106, 1957.

A transistorized logging probe suitable for modern "slim-hole" drilling techniques, which require logging probes with outside diameter not greater than 1 inch, is described. It is designed for operation in water-flooded petroleum reservoirs to measure radioactive-tracer materials used in field studies. It will withstand bottom hole pressures exceeding 2,000 psig and temperatures to 135°F; and where pressures make it necessary, it may be run through a packing gland.

The probe consists of a cluster of 5 small G-M tubes, a transistor high-voltage supply, a transistor pulse-shaping and amplifying stage, and a mercury-cell battery pack housed in a stainless-steel tube. A schematic diagram of the probe circuit and pictures of the four subassemblies making up the complete probe circuit are given. The probe has been used in wells where the temperatures ranged from 70°F-123°F under hydrostatic pressures as high as 750 psig without observable error. Good correlation has been obtained with gamma-ray logs made with larger, ionization-chamber type instruments. The instrument has almost no sensitivity to shock. — V. S. N.

- 183-535. Tal'yanskiy, I. I. Osnovy teorii impul'snogo neytronnogo karotazha [Fundamentals of the theory of impulse neutron logging]: *Prikladnaya Geofizika*, no. 26, p. 113-136, 1960.

This is a theoretical analysis of the pulse neutron logging method and its efficiency. A miniature pulse neutron generator and a neutron detector are placed in a borehole. A pulse of neutrons is sent through the drilling mud and casing into the surrounding rock. Neutrons in the rock are activated, penetrate back through the casing, and are recorded by the detector. A time τ after each impulse is so selected that the neutrons coming directly to the detector from the generator are absorbed in the mud and are not recorded; the neutrons of the rock arrive at the detector after the τ period. The optimum time τ as a function of the borehole radius and the percentage of petroleum in the strata is derived. It was calculated, for example, that for a borehole radius of 10 cm and 10 percent petroleum in the rock, the value of τ should be 2×10^{-4} sec. — A. J. S.

- Pomerants, L. I., and Kaplunov, A. I. Laboratory of the automatic single-cable well logger OKS-56. See *Geophys. Abs.* 183-264.

SEISMIC EXPLORATION

- 183-536. Kisslinger, Carl. Motion at an explosive source as deduced from surface waves: *Earthquake Notes*, v. 31, no. 1-2, p. 5-17, 1960.

The history of events occurring near the source following a small explosion has been deduced from the Rayleigh waves recorded at two distances. The Fourier analysis method developed by Sato, and Lamb's solution for the displacement on a half space have been employed in two distinct approaches to this problem. The displacement history from the first approach shows an essentially rectilinear vibration of the earth particle following the initial compression. The second technique yields the vertical point force equivalent to the explosion. The vertical acceleration at the source from the first method agrees fairly well in general form with the force found in the second. Infor-

mation about the phase velocities and the initial phases of the constituent frequency components is a valuable byproduct of the Fourier analysis technique. — Author's abstract

183-537. Dennison, A. T. An introduction to synthetic seismogram techniques: *Geophys. Prosp.*, v. 8, no. 2, p. 231-241, 1960.

This paper is the introduction to a symposium on synthetic seismograms, comprising five papers and discussion (see *Geophys. Abs.* 183-541, -539, -538, -540). The principles, uses, and limitations of synthetic seismogram techniques are discussed, and the relative advantages of the different methods are compared. — D. B. V.

183-538. Anstey, N. A. Attacking the problems of the synthetic seismogram: *Geophys. Prosp.*, v. 8, no. 2, p. 242-259, 1960.

The four problems considered are the definition and simulation of the filtering effects which occur in the earth between the explosive and the case of the geophone, the problem of errors in the time scale of the synthetic record, the simulation of multiple reflection effects, and the difficulty of finding a representative comparison trace on the field record. A partial solution to the first of these is offered by SIRAN, examples of whose operation are presented. A method of assessing allowable errors in the time scale is discussed. Multiple reflections may be introduced by the preparation of multiple-corrected reflection-coefficient logs on a digital computer such as the IBM 709. The particular problems of multiple reflections from the base of the weathered layer (including "ghost" reflections) are discussed. The preparation of a "composite" trace is shown to be a partial solution to the problem of the comparison with the field record. — Author's abstract

183-539. Bois, P., Chauveau, J., Grau, G., and Lavergne, M. Sismogrammes synthétiques; possibilités, techniques de réalisation et limitations [Synthetic seismograms; possibilities, techniques of realization, and limitations (with English abstract)]: *Geophys. Prosp.*, v. 8, no. 2, p. 260-314, 1960.

Synthetic seismograms have been computed with and without multiples by exact and by approximate methods. By means of these seismograms, some studies have been made on the various multiple reflections, the character of the films, the effect of the surface in the formation of multiples, as well as on the shape of the pulse and the spectra of seismograms. Refraction synthetic seismograms have also been realized on schematic examples with fault and pinch-out. Various techniques for synthesizing seismograms are described which make use of analogue computing equipment such as a bar with variable diameter, or of digital computers. The orders of magnitude of the prices of these various methods are shown. Some of the limitations are described which are imposed on synthetic seismograms by the hypotheses and the inaccuracies of our knowledge of the conditions which prevail underground. — Authors' abstract

183-540. Baranov, V[ladimir][I.], and Kunetz, G[eza]. Film synthétique avec réflexions multiples—Théorie et calcul pratique [Synthetic seismograms with multiple reflections—Theory and practical calculation (with English abstract)]: *Geophys. Prosp.*, v. 8, no. 2, p. 315-325, 1960.

The theory of synthetic seismograms including all multiple reflections is summarized. Practical methods of calculation are discussed and illustrated

by specific examples. The purpose of the paper is to show that under the assumptions adopted (plane waves and parallel homogeneous layers), a rigorous solution of the problem can be obtained by an iterative algebraic procedure that is very well adapted to modern electronic calculators. — D. B. V.

- 183-541. Delaplanche, J., and Ledoux, Y. L'analyse des films réels et leur comparaison avec les films synthétiques [The analysis of real seismograms and their comparison with synthetic (with English abstract)]: *Geophys. Prosp.*, v. 8, no. 2, p. 326-346, 1960.

The practical use of synthetic records involves previous studies on field records from an original point of view; these studies consist essentially in analysing and cancelling noise, in bringing out the form of pulses and the character of seismic events, in detecting multiple arrivals. Various tools have been tested for this purpose: high multiplicity shooting, analysis of conventional well velocity surveys, mixing or selecting traces, varied filters; all these operations are facilitated by the use of magnetic recording. After several examples of these methods are given, it is shown how the results of such studies can help to make and discuss synthetic records with and without multiples. The share of multiple events and their effect on the efficiency of the later comparisons are especially treated. The authors finally present some specific examples of successful comparisons between synthetic records and field records treated beforehand. They insist on the discrepancies and on the importance of finding their origin, for the most tangible results in seismic interpretation generally appear during the analysis of such discrepancies. — Authors' abstract

- 183-542. *Geophysical Prospecting. Discussion on the symposium: Geophys. Prosp.*, v. 8, no. 2, p. 347-351, 1960.

This is a record of the discussion following the symposium on synthetic seismograms (see *Geophys. Abs.* 183-538, -539, -540, -541). Remarks by Schwaetzer, van Riel, Anstey, Van Nostrand, Rosenbach, Dennison, Endtz, Krey, Bortfeld, Kunetz, Tait, Ledoux, Lavergne, Baranov, and Millouet are quoted in French or English. — D. B. V.

- 183-543. Olhovich, V[ladimir] A. General method for construction of trajectories and wave-fronts diagram for any velocity distribution: *Geophys. Prosp.*, v. 8, no. 3, p. 445-458, 1960.

A graphical method is presented for construction of trajectories and wave-front diagrams for any velocity distribution. The analytical solution is given for the case when the time-depth curve shows a flexure, that is, when the velocity increases down to a certain depth and, after reaching a maximum, begins to decrease. A numerical example is considered for the computation of a trajectory. — Author's abstract

- 183-544. Weber, Max. Die Laufzeitfunktion in der Reflexionsseismik des quasi einachsigen inhomogenen Körpers [The travelttime function of a quasi-uniaxial inhomogeneous body, in seismic reflection surveying (with English summary)]: *Geofisica Pura e Appl.*, v. 45, p. 53-61, 1960.

The reflection travelttime function for a quasi-uniaxial inhomogeneous medium is calculated, and examples are given for two special cases. — D. B. V.

- Kasahara, Keichi. Wave generation by small explosions, (1). See *Geophys. Abs.* 183-210.

Duda, S. J. Elastic waves in the anisotropic medium according to a macroseismic measurement underground. See *Geophys. Abs.* 183-181.

183-545. Moody, Robert C. Discussion on "Photomechanical method of frequency analysis of seismic pulses": *Geophysics*, v. 25, no. 4, p. 948-950, 1960.

An example is cited of the use of the method described by Howell and others (see *Geophys. Abs.* 179-371, 180-365). This method was refined to provide automatic graphing, a high resolution, and an extended frequency range. The manner in which this is accomplished is described briefly and illustrated by figures showing different pulse spectrums. — D. B. V.

183-546. Thralls, H. M. Topography and its apparent effect on average velocity: *Tulsa Geophys. Soc. Proc.*, v. 5, p. 31-42, 1957-58.

The effect of changes in topographic overburden on velocity, one of the most commonly ignored factors in seismic interpretation, is discussed. The geophysical prospect discussed as an illustration is an area of low structural relief in Oklahoma. In this case records were time corrected to a "base-of-shot" datum, and a conversion velocity for each shotpoint was determined by an increment of increase or decrease in velocity of 1.0 ft per sec per ft of overburden as the surface elevation increased or decreased from that at the base point. It is concluded that topographic changes cannot be safely ignored if the magnitude of elevation change is equal to or greater than the order of magnitude of subsurface structural relief sought. The time increment factors associated with topographic changes are additive in the majority of instances resulting in an apparent topographic overburden effect that is greater than measured observations. — V. S. N.

183-547. Voyutskiy, V. S. Nulevaya korrelatsionnaya skhema izmereniya slablykh signalov [A zero correlation method of measurement of weak signals]: *Prikladnaya Geofizika*, no. 21, p. 37-43, 1958.

A zero-correlation method of measurements of weak, continuous spectrum signals whose amplitude is considerably lower than that of the background noise of the apparatus is described. The theory of the method and results of its experimental verification are discussed. — Author's abstract, A. J. S.

183-548. Kunz, Bruno F. J. Diffraction problems in fault interpretation: *Geophys. Prosp.*, v. 8, no. 3, p. 381-388, 1960.

Distinguishing between diffractions and true reflections is often difficult and may lead to misinterpretations. In the Molasse zone of Upper Austria, numerous faults were established by seismic surveying. Diffractions were observed at several antithetic faults but not at synthetic faults. As an example, a seismic record section of the Steindlberg structure is shown. The reflections from the base of Tertiary and from the Cretaceous-Jurassic contact run parallel over long distances, and so do the less important reflections lying above and between. If, contrary to the general trend, the reflection from the base of the Tertiary approaches the underlying reflection from the Cretaceous-Jurassic contact, or if the latter diverges from the former, this is considered a criterion for a diffraction. — Author's abstract

183-549. D'Hoeraene, J. Filtrage compensateur en sismique réflexion [Compensating filtering in reflection seismic surveying]: *Geophys. Prosp.*, v. 8, no. 3, p. 389-400, 1960.

In playing back seismic reflection records using the same filtering apparatus used in their recording, the films obtained can often be grouped into two or three categories that differ essentially in the predominant period of the reflections, corresponding to different outcrop zones of the area prospected. Interpretation can be facilitated if overlapping reflections can be rendered uniform by suppressing or sufficiently reducing the differences in frequency. This can be done in either of two ways. The first is to refer all other reflections to one of a chosen reference distribution; this avoids the necessity of filtering a part of the film but requires very drastic filtering of the rest, which may seriously affect the signal-to-noise ratio. The second method applies less severe filtering to the whole record.

Both methods are examined in detail. It is concluded that the first method can be used successfully when the noise level is low or when the narrowest spectrum is included entirely within the passing band of the other spectrum or spectrums. The other method, which reduces the spectrum of the filtered reflection to the product of the unfiltered spectrums, is especially useful when only two types of film are involved. — D. B. V.

- 183-550. Ma, En-tsze. *Primeneni kurgovogo gruppirovaniya zaryadov pri seysmorazvedke po metodu otrazheniy* [Application of circular grouping of charges in seismic exploration by the reflection method]: *Prikladnaya Geofizika*, no. 26, p. 3-13, 1960.

The method of circular grouping of charges is discussed. As used in the Chinese People's Republic in 1954 and 1955, equal charges are placed on the surface at the center of a circle and at 6 equidistant points along the circumference. The weight of individual charges ranges from 0.2 to 5 kg, and the radius of the circle from 5 to 25 m. A mathematical treatment is given for the seismic waves reflected from a plane discontinuity at depth. The method proposed increases the percentage of the effective energy of the explosion and permits checking by repeated seismic sounding at the same point. — A. J. S.

- 183-551. Ma, En-tsze. *Issledovaniye gruppovykh vzryvov v seysmorazvedke metodom otrazhennykh voln* [Investigation of group shots in seismic exploration by the method of reflected waves]: *Prikladnaya Geofizika*, no. 26, p. 14-29, 1960.

The arrangement of charges in pattern shooting used for seismic exploration is analyzed; linear, rectangular, and circular distributions, and their directional characteristics are considered. Surface grouping of unequal charges is shown to produce the needed directional characteristic. A method using a three-dimensional distribution of pattern charges is proposed. (See also Geophys. Abs. 183-550). — A. J. S.

- 183-552. Petkevich, G. I. *O vertical'nom godografe otrazhennoy volny* [On the vertical traveltime curve of reflected waves]: *Razvedochnaya i Promyslovaya Geofizika*, no. 19, p. 3-7, 1957.

An equation is derived for the vertical traveltime curve of reflected waves. It is found that for the case of a horizontal boundary and uniform thickness of the investigated layer, the curve is a flat hyperbola which in most cases can be represented by its asymptote $H = -v_1 t_{otr} + 2h_1$, where h_1 is thickness of layer, v_1 is its velocity, t_{otr} is reflected wave arrival time, and H is depth at which seismometer is placed in borehole. Comparison of the traveltime curves of the reflected and direct waves gives $H = -(v_1/2)t_{\Delta} + h_1$, from which the thickness h_1 of the layer can be found (t_{Δ} = difference between the arrival times of reflected and direct waves). — A. J. S.

- 183-553. Meidav, Tsvi. Nomograms to speed up seismic refraction computations: *Geophysics*, v. 25, no. 5, p. 1035-1053, 1960.

Nomographic solutions of a number of equations commonly employed in seismic refraction work are presented. The equations solved are: 1. Depth to a second layer, by means of the critical distance formula. 2. The critical angle and offset distance formulas. 3. True velocity of bedrock from the apparent up- and down-dip velocities. 4. Depth to a second layer by means of the intercept-time formula. This last solution is also applied to (a) finding the throw of a fault and (b) depth to an irregular second layer at each seismometer beyond the critical distance. Geometry of each of the nomograms is explained. Procedure for using each of the nomograms is described. — Author's abstract

- 183-554. O'Brien, P. N. S. The use of amplitudes in refraction shooting— a case history: *Geophys. Prosp.*, v. 8, no. 3, p. 417-428, 1960.

On a group of seismic refraction records there occurs a late arrival with the same apparent velocity as an earlier arrival. It was first thought that the late arrival travelled along the same refractor as the earlier one but had been delayed in the overburden either by multiple reflection or by P-S (dilatation to shear) conversion. Either of these two mechanisms could be made to fit the time-distance data. A study of the ratio of the amplitudes of the two events showed that the observed ratio was about ten times that to be expected on either of these hypotheses. Also, the rate of attenuation of the earlier arrival (3.7 ± 1.0 db/1,000 ft) was appropriate to a thin layer while the rate for the later arrival (0.74 ± 0.30 db/1,000 ft) was appropriate to a thick layer. Accordingly, the later arrival was identified as a refraction from a deeper layer. The subsequent depth section agreed very well with that found by drilling. — Author's abstract

- 183-555. Suyama, K., Muraoka, H., and Hada, S. Role of geological surveying in seismic prospecting—A guide to civil engineers planning geological surveying [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 1, p. 2-13, 1960.

The application of seismic prospecting and geological surveying to problems in civil engineering is discussed. It is emphasized that detailed geological surveying is necessary for the interpretation of seismic results. — V. S. N.

- 183-556. Hattori, Yasumasa. The refraction method of seismic prospecting for engineering purpose [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 1, p. 14-18, 1960.

The application and limitations of the seismic refraction method to engineering problems are discussed. — V. S. N.

- 183-557. Izaki, Akira. Seismic survey for tunnel-planning [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 1, p. 22-24, 1960.

A study of the results of seismic surveying in the vicinity of numerous tunnels shows that an indication of rock hardness may be derived from the longitudinal wave velocity. If enough of this type of data are accumulated, the seismic velocity can be a useful index of rock hardness in surveys of sites for proposed engineering structures. — V. S. N.

- 183-558. Widess, M. B. Recommended form for the acoustic (continuous velocity or sonic) log: *Geophysics*, v. 25, no. 5, p. 1119-1123, 1960.

Corrected acoustic logs at present are expressed in terms of linear velocity, although the field logs are obtained in "transit time." There would be considerable merit in having a corrected acoustic log in a form that can be easily compared with a field log to perceive and evaluate the nature of the corrections that were applied; therefore, it is highly desirable to have a corrected acoustic log in a linear "transit time" scale. The many advantages of such a scale are pointed out.

The need for a better term for reciprocal velocity is pointed out; perhaps "time modulus" (or its abbreviation "timemod") would be more appropriate than "transition time," although the unit is not in time alone. — D. B. V.

- 183-559. Gretener, P. E. F. An analysis of the observed time discrepancies between continuous and conventional well velocity surveys: Alberta Soc. Petroleum Geologists Jour., v. 8, no. 10, p. 272-286, 1960.

Discrepancies between conventionally obtained times and the integrated continuous velocity curves are analyzed. All results pertain to data from Western Canada measured with the Shell tool. These discrepancies may be ascribed to a random scatter and a systematic deviation, the integrated continuous curves being short. Possible causes of these discrepancies are discussed, but no final explanation can be offered. Check shots cannot be abandoned at the present time, although they may be spaced 2,000 feet apart without serious loss of accuracy provided the continuous velocity data are empirically corrected for the systematic deviation. — V. S. N.

- 183-560. Broding, R. A., and Poole, J[oseph] L. Collection and processing of digitized acoustic log data: Alberta Soc. Petroleum Geologists Jour., v. 8, no. 10, p. 287-294, 1960.

This is virtually the same paper as that published in Geophysics, v. 25, no. 4, p. 939-947, 1960 (see Geophys. Abs. 182-496). — V. S. N.

- 183-561. Rimmer, W. G. Seismic applications of the velocity log: Alberta Soc. Petroleum Geologists Jour., v. 8, no. 10, p. 295-302, 1960.

This paper deals with the use of the continuous acoustic tool as a velocity log and its uses in seismic interpretation. The origin and identification of a reflection event are discussed together with the possibility of studying this origin from synthetic seismograms. Analogue technique synthesis is compared with electronically computed types of synthesis, and some conclusions regarding the future approach to this problem are given. — Author's abstract

- 183-562. Carissimo, L., and D'Agostino, O. Development of new techniques applied to the search for stratigraphic traps: Geophys. Prosp., v. 8, no. 3, p. 401-416, 1960.

In this paper some examples are given of the use of the Summarizer (see Geophys. Abs. 180-364, 181-457) in geologic mapping. The device was tested in the Po Valley of Italy in three gas fields in which geologic features were known.

The Summarizer gives an output which is a function of the total energy detected by the geophone spread, and provides a means of energy correlation that is not obtainable with other seismic devices. These energy correlations have proved to be highly useful in detecting lateral facies variations. Used in conjunction with conventional seismic methods, the Summarizer gives a more accurate picture of subsurface stratigraphic conditions. — D. B. V.

- 183-563. Gregory, J. N. Portable timer offers new seismic applications: *Oilweek*, v. 11, no. 28, p. 28-30, 1960.

Recent developments in electronics have made possible the development of an inexpensive, easily-operated seismic timer for use in shallow exploration without drilling or blasting. One model of the seismic timer now available is a fully transistorized instrument that weighs 12 lbs and measures time to the nearest millisecond. Complete equipment includes the timer, a sledge hammer and striking plate, 300 feet of cable, and 2 geophones; it is all easily transportable by two men.

In operation, time is plotted against the distance between the point of shock and the geophone for a number of stations; a graphical representation of velocities through the various materials is thus obtained. Graphic representations of various types of subsurface structures are shown.

The timer can be used in geological surveys to determine dip and strike of shallow beds; to correlate rock densities; to trace strata over wide areas; and to locate faultlines, buried stream beds, gravel pits, and other features. In geophysical surveys, it may be used to determine near-surface velocities, depth to hard rock, and existence of large boulders. Areas for full-scale seismic work can also be delineated. In engineering work, it may be used to locate the best area for roads, wells, pipelines, and foundation sites. — V. S. N.

- 183-564. Banville, J. H., and Richard H[enri]. Experiments with static-resistant blasting caps: *Geophys. Prosp.*, v. 8, no. 3, p. 371-380, 1960.

Premature detonation of seismic blasting-caps may be caused by the accumulation of an electrostatic charge. This is especially true in desert areas where there are many sandstorms. Two makes of static resistant cap have been tested in the laboratory and the results compared with those for non-resistant caps made by the same manufacturers. The full results are given in the table, the breakdown voltage for the resistant caps is in the range 20-30,000 v as compared with the range 10-15,000 v for the ordinary cap. It is strongly recommended the static resistant caps should always be used and that experiments on premature detonation from this cause should be made in the field. In January 1960, 20 crews in the Sahara used a total of 146,150 static-resistant blasting caps. — Authors' abstract

- 183-565. Kimbell, Charles L. How oil hunters use the stomper as a seismic tool: *Oil and Gas Jour.*, v. 58, no. 38, p. 154-158, 1960.

Basic equipment for the stomper method is a self-propelled weight-dropping vehicle with weights of 3-5½ tons mounted between the wheels. Weights are dropped from heights of 8-9 feet, and location can be changed approximately once each 12 seconds. Seismic energy from a single drop normally is equal to that produced by 4-8 lb of dynamite. Drops are placed in patterns, and multiple geophone patterns are used. The magnetic field recorder is equipped to record sequentially the seismic signals.

The increasing use of weight-drop equipment has resulted from the improved record quality that may be obtained. In many cases the cost per mile profile is less than for the conventional shot hole method. — V. S. N.

- 183-566. Kuroda, Hidetaka, and Kimura, Shigemasa. On some problems for the use of floating cable [in Japanese with English abstract]: *Butsuri-Tanko*, v. 12, no. 4, p. 147-155, 1959.

Experiments with a new floating cable imported for marine seismic exploration show that the cable does not keep the geophones at a constant inter-

val or depth at the time of shooting; this makes it difficult to draw time-distance curves of reflections and to analyze the reflections by chart. This difficulty was corrected by reducing the number of lead-weights set on both sides of each geophone and by towing a small raft at the tail of the cable. Investigation of the time variation of the noise level shows that the best time for the shot as 1 min 30 sec after the boat engine stops. — V. S. N.

- 183-567. Kovalev, O. I., and Molotov, L. V. Udarnoye skvazhinnoye ustroystvo dlya vzbuzhdeniya uprugikh voln raznykh tipov [A shock borehole device for generation of elastic waves of various types]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 959-969, 1960.

The borehole shock generating device USU consists of a strong spring, a striking plunger, and a contact block enclosed in a casing. The device is lowered to the desired depth in the borehole, and the contact block pressed to the wall of the hole. The spring acts on the plunger with a maximum force of 20 kg, which is transmitted to the block and into the rock where elastic waves of desired direction are generated. The ratios v_P/v_S determined by this method were found to be comparable with v_P/v_S determined by other methods. — A. J. S.

- Riihimaa, J. Timing equipment for explosion seismology. See Geophys. Abs. 183-211.

- 183-568. Rudman, Albert J. A seismic reflection survey of the surface of the basement complex in Indiana: Indiana Dept. Conserv. Geol. Survey Prog. Rept., no. 18, 26 p., 1960.

The surface of the basement complex that underlies five counties in southwestern Indiana has been mapped by the reflection seismograph method. Seismic shot points were spaced 1 to 3 miles apart along six traverses in Gibson, Pike, Posey, Vanderburgh, and Warrick Counties. A structure map on the surface of the basement complex shows an elongate northwestward-trending depression that is as much as 22 miles in width and that has a maximum depth of 3,500 feet below the regional slope of the basement surface. Structure maps drawn on the surface of Devonian limestone, the Trenton limestone, and the St. Peter sandstone show a monocline over the northeast flank of this basement depression. The depression in the surface of the basement complex and the monocline shown on Paleozoic maps may be related structurally to the La-Salle anticline. — Author's abstract

- Ewing, John; Luskin, Bernard; Roberts, Archie; and Hirshman, Julius. Sub-bottom reflection measurements on the continental shelf, Bermuda banks, West Indies arc, and in the west Atlantic basins. See Geophys. Abs. 183-583.

- Diment, W[illiam] H., Healey, D. L., and Roller, J. C. Gravity and seismic exploration at the Nevada Test Site. See Geophys. Abs. 183-372.

- Moore, David G. Acoustic reflection studies of the continental shelf and slope off southern California. See Geophys. Abs. 183-584.

- Shor, George G., Jr. Crustal structure of the Hawaiian Ridge near Gardner Pinnacles. See Geophys. Abs. 183-396.

- 183-569. Macpherson, J. D. Anisotropy of the rock in the approaches to Halifax Harbour, Nova Scotia: Seismol. Soc. America Bull., v. 50, no. 4, p. 575-579, 1960.

During the summer of 1959 a series of high resolution acoustic refraction profiles were obtained for the Hartlen Point region of the Scotian Shelf. The profiles were taken across pairs of the three bottomed barium titanate hydrophones, connected by cables to a laboratory on the shore. The fixed positions of these hydrophones enabled the bottom properties to be measured considerably more accurately than is normally possible in water-covered areas. Marked anisotropic effects in the rock bottom were found by the surveys. This anisotropy may be associated with the tight folding of the rock in the Halifax area. Further work with a spark source is planned in order to clarify the exact location of the anticlines and synclines. — D. B. V.

183-570. Magrath, C. B. Multiple signals cause seismic problems at Taber: *Oilweek*, v. 11, no. 38, p. 38-39, 1960.

After completion of three seismic reflection curves in the Taber region of southeastern Alberta it was discovered that strong contact signals, thought to be from a certain subsurface formation, were actually composite signals with no structural significance as they failed to show two important geological features. On the other hand, the primary signals showed a fault with considerable throw at depth and the Madison "Channel." This discovery of the multiple interval signal has prompted oilmen to reinterpret their seismic records. — V. S. N.

183-571. *Oilweek*. Arctic seismic program is most northerly in Canada. *Oilweek*, v. 11, no. 28, p. 15, 1960.

During the summer of 1960 a seismic program was carried out in the coastal waters of the Arctic Ocean and in the rivers of the Northwest Territories, Canada. A continuous marine seismic profiler using the gas explosion method was used for the first time in Canada. The program included both seismic profiler and conventional seismic surveys of more than 600 miles along the McKenzie and Arctic Red Rivers, along the Arctic coast and coastal waters off Tuktoyaktuk Peninsula, and along the Anderson River and the coastline near its mouth. This coverage is equivalent to 12 crew months of coverage by land seismic survey. — V. S. N.

183-572. Crary, A. P. Seismic studies, in *Scientific studies at Fletcher's Ice Island, T-3, 1952-1955: U. S. Air Force Cambridge Research Center, Geophys. Research Papers*, no. 63, v. 3, p. 38-44, 1960.

This is virtually the same paper as previously published in *Am. Geophys. Union Trans.*, v. 35, no. 2, p. 293-300, 1954 (see *Geophys. Abs.* 157-118). — V. S. N.

183-573. Bouchon, R., Ortynski, H. I., de Lapparent, C., and Pommier, G[ilbert]. Le developpement de la sismique refraction dans l'interpretation geologique de Sahara nord—son role dans la decouverte et l'etude du champ d'Hassi Messaoud [The development of seismic refraction surveying in the geologic interpretation of the northern Sahara—Its role in the discovery and the study of the Hassi Messaoud field (with English abstract)]: *World Petroleum Cong.*, 5th, New York, Proc., sec. 1, paper 39, p. 729-744, 1959.

The refraction seismic method was chosen for surveying the northern Sahara because of difficulties in interpretation of the gravimetric map and because of the insufficient depth of investigation obtained by the reflection method. During the first stage, when no geologic information was available, the

refraction profiles indicated the shape of the basement and the limits of the various basins; a good reconnaissance map could thus be constructed.

More precise detail was obtained from drilling; standard and continuous velocity logs and anisotropy measurements made it possible to identify the seismic markers stratigraphically. The refraction method supplied information concerning the forms and the nature of the various markers.

The method was applied with particular success in the Hassi Messaoud area. Comparison of a structural map of this area made from seismic refraction information with a structural map made from borehole information contributed to the interpretation of the seismic data and led to the successful location of oil. — V. S. N.

- 183-574. Janoschek, R. H. Oil exploration in the molasse basin of western Austria (with French abstract): World Petroleum Cong., 5th, New York 1959, Proc., sec. 1, paper 47, p. 849-859, 1959.

Seismic reflection surveys together with surface geologic mapping and some data from earlier refraction seismic surveys have supplied information on the structural development of the molasse basin. The floor of the molasse basin in western Austria consists of granites and gneisses of the Bohemian massif generally overlain by Upper Jurassic and (or) Upper Cretaceous beds and 4,000-12,000 feet of Tertiary sediments. The basin is asymmetric; the sediments are the thickest in the immediate vicinity of the Alpine thrust front and diminish toward the north. In spite of the thick sedimentary section, the predominantly marine facies, and the varied structural development, only a few wells have encountered oil and no major fields have been indicated. — V. S. N.

- 183-575. Thomas, Erich. Strukturelemente im Norden der Deutschen Demokratischen Republik nach den Ergebnissen seismischer Refraktionsmessungen [Structural elements in the northern German Democratic Republic according to the results of seismic refraction measurements (with English abstract)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 2, p. 189-199, 1960.

A seismic refraction map of the northern part of East Germany is given, showing isochrones for 4 km. Short traveltimes usually correspond to areas where high-velocity sediments are near the surface, as in salt domes or anticlines, and high traveltimes usually correspond to synclines; however, interpretation is less simple in some cases. The depth reached by this kind of investigation is about 1,000-1,500 m.

The results are interpreted as follows: The Altmark depression in the southern part of the area is marked by long anticlines with Hercynian trend; west of Berlin there is an area with Rhenish or Erzgebirgian structures; the Prignitz district is underlain by thick Tertiary sediments with a few salt domes; and in the north, near the coast, there are few structures and no salt domes. — D. B. V.

- 183-576. Godin, Yu. N., Vol'vovskiy, B. S., and Vol'vovskiy, I. S. Seismicheskiye issledovaniya zemnoy kory v rayone Ferganskoy mezhgornoy vpadiny [Seismic investigations of the earth's crust in the region of the Fergana intermontane basin]: Akad. Nauk SSSR Doklady, v. 133, no. 6, p. 1398-1401, 1960.

Crustal structure in the Fergana valley in the Uzbek S. S. R. was investigated by deep seismic sounding in 1958-59. Seismograph groups (four per group) were spaced 100 m apart along profiles 15-20 km long. Shot points were located in streams, in artificial ponds, in shafts, and in boreholes. The maximum length of the travelttime curves was 200 km.

Velocity values of 6.0 km/s for the top of the Paleozoic, 6.5 km/s for the granite, 7.4 km/s for the top of the basalt, and 8.2 km/s for the M-discontinuity were used. An average crustal thickness of 50 km was found in the center of the basin. The thickness of the layer tentatively referred to the granite is 14-17 km, and that of the basalt is 15-19 km. — D. B. V.

183-577. Kozlov, E. A. Nekotoryye dannyye o skorostnom razreze Kubani [Some data on the velocity section of Kuban]: *Prikladnaya Geofizika*, no. 21, p. 44-55, 1958.

A quantitative evaluation of the relationship between seismic wave velocity in the upper Paleogene and Neogene of the Kuban-Azov depression of the Krasnodar district and age, depth, and composition of the strata is given on the basis of seismic logging of 39 deep boreholes (up to 3,000 m). It was found that the seismic velocities v are grouped close to a straight line that can be expressed by the formula $v = v_0 + \beta H$, where H is depth of the stratum, v_0 is velocity for $H=0$, and β is the vertical gradient of the velocity. — A. J. S.

183-578. Kaneko, Jun, and Imai, Shigeyoshi. An example of the seismic result obtained over fault zone [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 1, p. 19-21, 1960.

The results of a seismic survey across a fault zone at the site of a proposed tunnel are discussed. The seismic velocity associated with the crushed zone is 2.6-3.6 km/s, whereas in the undisturbed sandstone and shale zones it is 4.1-4.5 km/s and 3.7-4.3 km/s, respectively. — V. S. N.

STRENGTH AND PLASTICITY

183-579. Brace, W. F. An extension of the Griffith theory of fracture to rocks: *Jour. Geophys. Research*, v. 65, no. 10, p. 3477-3480, 1960.

The Griffith theory of fracture has recently been extended by McClintock and Walsh to include the closing of Griffith cracks during compression with the development of frictional forces along crack surfaces. This modified Griffith theory can be used to predict failure of any brittle material, such as rock, for a general stress state. The predicted failure condition is shown to be of the form $\tau = 2K - \mu\sigma$ in the Mohr diagram (in the region of compression), where K is the tensile or one-eighth of the compressive strength of the material and μ is the coefficient of sliding friction at crack surfaces. For a coefficient of friction of 0.8 to 1.0 this failure condition is nearly identical with the empirical Coulomb failure law observed for rocks (in the region of compression). This suggests that the Griffith mechanism of crack growth plays an important part in the fracture of rocks at low confining pressures. — Author's abstract

183-580. Gzovskij [Gzovskiy], M. V., Kuznecova [Kuznetsova], I. M., and Osokina, D. N. Die Charakterisierung tektonischer Spannungsfelder in Verbindung mit Problemen des Gebirgsdruck [The characterization of tectonic strain fields in connection with problems of rock pressure]: *Freiberger Forschungshefte C 81 Geophysik*, p. 209-230, 1960.

Present tectonic deformation in the earth's crust causes a state of nonuniform, as distinguished from hydrostatic, strains in rock. The distribution of strain in different types of deformation has been worked out on the basis of

field investigations, model studies, and theoretical treatment; results are shown in diagrams.

The effect of this inherent strain on subsequent mine workings in the rock is determinable, and the first steps in this direction have been taken. Further work is necessary to provide a complete understanding of problems of rock pressure in mines. — D. B. V.

Rizničenko, J. V. [Riznichenko, Yu. V.]. Some results of the application of seismoacoustic methods to the investigation of the state of strain in rocks. See Geophys. Abs. 183-193.

McKeown, F. A., and Dickey, D. D. Some relations between geology and effects of underground nuclear explosions at Nevada Test Site, Nye County, Nevada. See Geophys. Abs. 183-200.

Shoemaker, Eugene M. Brecciation and mixing of rock by strong shock. See Geophys. Abs. 183-202.

183-581. Hilty, Robert E. Measurements of ice tunnel deformation, Camp Red Rock, Greenland: U. S. Army Snow, Ice, and Permafrost Research Establishment, Spec. Rept. 28, 12 p., 1959.

A resurvey was made of the position of the pegs in the 1956-extension of the Red Rock Tunnel cut in the cliff terminus of the North Icecap parallel to the ice flow at Nunatarssuaq, 40 miles northeast of Thule Air Base, Greenland. Mapping of the ice stratigraphy and other deformation studies augmented the motion survey.

The deformation vector was directed principally forward, slightly downward, and inward to the void. The rate of forward motion increased rapidly upward from the base roughly following a parabolic curve tangent to the floor. Flow of the ice into the tunnel was essentially uniform over the span of the walls with a sharp decrease just above the floor; the downward component was relatively small but erratic and also decreased abruptly just above the floor. All evidence indicates that deformation proceeded at a uniform rate with no erratic or backward motions, discontinuities, or significant cracks in the ice. (See also Geophys. Abs. 180-211.) — V. S. N.

183-582. Jellinek, H. H. G. Plastic deformation of thick-walled snow-ice cylinders under hydrostatic pressure: U. S. Army Snow, Ice, and Permafrost Research Establishment, Research Rept. 63, 7 p., 1960.

Experiments have been carried out on the plastic deformation of thick-walled snow-ice cylinders under hydrostatic pressure as a function of pressure and temperature. At constant circumferential stress and temperature the natural strain rate of closure is a constant. This constant varies with the circumferential stress according to a sine function and is exponentially dependent on temperature with an energy of activation of 14.1 kcal per mole at an average circumferential stress of 3.1 kg per cm². The mechanism of the plastic flow is in agreement with a mechanism proposed previously, that is, flow between grain boundaries takes place. — Author's abstract

SUBMARINE GEOLOGY

183-583. Ewing, John; Luskin, Bernard; Roberts, Archie; and Hirshman, Julius. Sub-bottom reflection measurements on the continental

shelf, Bermuda banks, West Indies arc, and in the west Atlantic basins: *Jour. Geophys. Research*, v. 65, no. 9, p. 2849-2859, 1960.

A short survey was made with the subbottom depth recorder in the vicinity of the submarine canyon of the Hudson River between the 40- and 400-fathom contours. The results show that in this part of the continental shelf the upper layers are approximately horizontal whereas the deeper layers dip seaward at a slightly greater angle than the bottom. A number of reflecting horizons were observed at depths up to 400 feet below the bottom. Several of these reflectors crop out on the canyon walls, correlating in some places with benches or knees. Sediment cores were taken of some.

No subbottom reflections were found on Challenger and Plantagenet Banks near Bermuda. Shallow reflectors were observed in some areas on the West Indies arc near Puerto Rico and the Virgin Islands. On a run from New York to Bermuda and Puerto Rico, subbottom reflectors were seen at least 40 percent of the time; best results were obtained on the topographic rises, particularly on the outer rise north of the Puerto Rico trench. — D. B. V.

183-584. Moore, David G. Acoustic reflection studies of the continental shelf and slope off southern California: *Geol. Soc. America Bull.*, v. 71, no. 8, p. 1121-1136, 1960.

Acoustic reflection profiles showing the thickness of marine sediments and details of structure at shallow depth in bedrock have been made across the continental shelf and slope off southern California. The results, together with shear-strength tests of slope deposits, indicate that most theories of the origin of the continental terrace are overly generalized.

Recent shelf deposits occur on most of the shelves studied. Their thickness varies greatly. These deposits show that the modern drowned shelves are areas of real or potential deposition. The occurrence here of relatively thin but stable slope deposits indicates that much of the detritus introduced to the continental shelves does not find its way to the slope but may be carried diagonally across the shelf and trapped by canyons incised in the shelves and thence carried to the deep sea. — D. B. V.

183-585. Tikhonov, V. I., and Udintsev, G. B. K voprosu o svyazyakh mezhdú tektonikoy Kamchatki i rel'yefom yeye podvodnykh sklonov [On the problem of the relations between the tectonics of Kamchatka and the relief of its submarine slopes]: *Akad. Nauk SSSR Doklady*, v. 130, no. 3, p. 603-606, 1960.

Two structural plans of southern Kamchatka—one formed by early Quaternary and Recent movements and the other characteristic of the pre-Mesozoic but also inherited by Mesozoic and Tertiary folded rocks—are distinguishable in the submarine relief off the coast. The older trends are clearer in the submarine relief than in the subaerial landscape. This suggests that modification of primary structural relief by exogene processes takes place at a slower rate under submarine conditions. — D. B. V.

Bromery, R[andolph] W., Emery, K. O., and Balsley, J[ames] R., Jr. Reconnaissance airborne magnetometer survey off southern California. See *Geophys. Abs.* 183-489.

VOLCANOLOGY

- 183-586. Pakiser, L[ouis] C. Volcanism in eastern California—A proposed eruption mechanism, *in* Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-411-B-414, 1960.

This is an expansion of Pakiser's hypothesis initially applied to volcanic activity in Owens Valley, Calif. (see Geophys. Abs. 181-240), that the volcanic rocks along the eastern front of the Sierra Nevada were erupted from regions of relative tension or stress relief in offsets of a major left-lateral en echelon shear zone. This explanation is proposed for the Mono Basin, Long Valley, and Sierra Valley subsidence structures. It is also suggested that the zone of steep gravity gradients directly west of Lassen Peak may express a northward continuation under a volcanic cover into the southern Cascades of this en echelon shear zone with the Lassen volcanic field lying in an offset of this shear zone. — V. S. N.

- 183-587. Fraser, George D. Pahala ash—an unusual deposit from Kilauea Volcano, Hawaii, *in* Geological Survey research 1960: U. S. Geol. Survey Prof. Paper 400-B, p. B-354-B-355, 1960.

The older and younger volcanic series of the large volcanoes on Hawaii of Kilauea, Mauna Loa, and Mauna Kea are separated by the Pahala ash; this is the only ash bed in the Hawaiian Islands that is thick and extensive enough to be used for correlation on more than one volcano. This ash is explained by a series of coneless phreatomagmatic explosions at Kilauea Volcano in the form of many closely spaced explosions during a small part of Pleistocene time. The cause of these explosions at Kilauea was probably massive foundering in the summit and southwest rift areas, followed by ingress of the ground water abundantly available near sea level in the Ghyben-Herzberg lens. There appears to be no way to get large explosions in Hawaiian volcanoes except by extraneous water. — V. S. N.

- 183-588. Eaton, J[erry] P., and Murata, K. J. How volcanoes grow: *Science*, v. 132, no. 3432, p. 925-938, 1960.

The Hawaiian volcanoes offer an unmatched opportunity for studying the mechanism of eruptions and the differentiation of primitive tholeiitic basaltic magma. The enormous size, relatively simple structure, and frequent voluminous eruptions all permit the effective use of seismographs and tiltmeters in delineating their internal structure and in detecting the movement and accumulation of magma within them. Other more general geophysical investigations of the Pacific crust and mantle provide additional evidence on where Hawaiian magma originates and how it is driven to the surface. Geochemical studies show that the temperature, composition, and rate of ascent of the magma are closely interrelated.

The 1959-60 eruption of Kilauea is described as a case history, and the origin of the magma and the mechanism of eruption are discussed. — D. B. V.

- 183-589. Williams, Howel. Volcanic collapse-basins of Lakes Atitlan and Ayarza, Guatemala: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 21, p. 110-118, 1960.

The oval basin of Lake Atitlan, roughly 100 sq mi in extent, is surrounded by a ring fracture. The vent of the Quaternary volcano Atitlan lies on the ring fracture, and Toliman and San Pedro volcanoes lie within the basin. Growth of these three volcanoes dammed drainage to produce the lake. The basin is

neither a caldera nor a volcano-tectonic sink, but a cauldron subsidence caused principally by collapse resulting from withdrawal of magma from underground.

Lake Ayarza, however, is a caldera of Krakatoa type, caused by collapse after colossal pumice eruptions. The basin was formed by engulfment of the tops of two coalescing Quaternary cones and hence is shaped like the figure 8. — D. B. V.

183-590. Karapetyan, K. I. Vulkan Dalik [Dalik Volcano]: Akad. Nauk Arмян. SSR Izv., v. 12, no. 4, p. 23-37, 1959.

Dalik Volcano is located in the upper reaches of the Yerer River in the Armenian S. S. R. It is a truncated cone with a diameter at the base of 1.6 km and a height of 300-330 m. Its structure and the characteristics of its ejecta are described and illustrated. The active life of Dalik Volcano was marked by alternating explosive and effusive stages separated by short time intervals. Its age is set at 10,000-15,000 years. — J. W. C.

183-591. Sawata, Hideho, and Takahashi, Hiroshi, eds. Volcanoes of Japanese archipelago: Kawasaki City, Japan, Japan Geol. Survey, 24 p., 1960.

The volcanoes of the Kurile Islands, the main Japanese islands, the islands south of Tokyo, and the islands southwest of Kyushu are listed and located on a map according to whether active, dormant, or extinct. The major active volcanoes and Mounts Fuji and Hakone are illustrated. Each illustration includes a picture of the volcano, a geologic and topographic map, a statement of the height and area of the volcano, the dates of activity, the distance from Tokyo by train or plane, and the hotels in the vicinity. — V. S. N.

Yokoyama, Izumi, and Tajima, Hirokazu. A gravity survey on Volcano Huzi, Japan, by means of a Worden gravimeter. See Geophys. Abs. 183-385.

183-592. Shale Shaker. Geological Survey scientists study aftermath of volcanic disturbances: Shale Shaker, v. 10, no. 10, p. 23, 1960.

A crust thick enough and cool enough to walk across has formed over the 2,500-foot diameter, 365-foot deep lava pond in Kilauea Iki crater since the November-December 1959 activity according to U. S. Geological Survey scientists. A hole drilled into the crust showed solidification to a depth of about 10 feet by the end of April 1960. The temperature at a depth of 2 feet was 500°F, at 4 feet 940°F, at 6 feet 1,250°F, and at 7½ feet 1,400°F. Since April the hole has been deepened to 12¾ feet with a maximum temperature at the bottom of 1,685°F. A rain gauge installed at the hole showed that temperatures in the upper 3 feet of the hole are markedly affected by rainfall.

Tilt measurements throughout the vicinity showed that between January 21 and April 1, 1960, subsidence of the summit in the vicinity of Halemaumau had attained a total of 5 feet. During the month of April subsidence continued at a moderate rate. The filling and emptying of magma chambers beneath the summit are apparently reflected in gravity measurements. — V. S. N.

183-593. Bullard, F[red] M. Active volcanoes of Central America: Internat. Geol. Cong., 20th, Mexico 1956, Vulcanologia del Cenozoico, sec. 1, v. 2, p. 351-371, 1957.

Current volcanic activity in Costa Rica is limited to Irazú and Poás volcanoes, although some fumarolic activity is reported from Rincón de la Vieja. The activity of Irazú is entirely fumarolic but Poás, formerly exhibiting geyserlike eruptions from a hot crater lake, began a new eruptive phase in March,

1953, which is continuing with increasing vigor. Ash and cinders are being ejected, and a cinder cone has been formed in the bottom of the crater in the position formerly occupied by the crater lake.

The active volcanoes in Nicaragua are: (1) Concepción, which has been in a mild state of activity since 1943; (2) Santiago, which has been in a vigorous state of fumarolic activity since 1947; and (3) Las Pilas, which is showing a steady increase in volume of the fumarolic activity which began in 1952. Momotombo, Cerro Negro, and Telica volcanoes maintain about the same mild fumarolic activity as in previous years.

El Salvador has two volcanoes which are currently active, San Miguel and Izalco. San Miguel continues the mild fumarolic activity as in previous years. Izalco, one of the most active volcanoes of Central America, began a major eruption early in 1955 in which lava flows and cinders and scoria were ejected.

Guatemala has two volcanoes which are currently active, Fuego and Santiaguillo dome on the slope of Santa María volcano. Fuego, constantly in a state of fumarolic activity, has intermittent periods of more vigorous eruptions, throwing out ash, cinders, and incandescent scoria. One of these more active periods occurred during July 1955. Santiaguillo continues in the same state of activity as in past years, pushing out a dome of stiff, viscous material accompanied by abundant fumarolic activity. — Author's abstract

183-594. Miller, G., and Veyl, G. The birth of Nilahul, a new maar type volcano at Rininahue, Chile: *Internat. Geol. Cong.*, 20th, Mexico 1956, *Vulcanologia del Cenozoico*, sec. 1, v. 2, p. 375-396, 1957.

A new vent opened on July 17, 1955, along the western flanks of the Andes at lat 40°22' S. The eruptions were violent, and the ejecta was dispersed over such a large area that no distinct cone formed. The vent has been inactive since November 1955; it is now occupied by a lake and is similar to other maars in the district.

A total of approximately 520×10^6 tons of ejecta was emitted whereas the weight of the rock originally occupying the explosion pit is estimated to be 517.6×10^6 tons. This indicates that ejecta, 82.5 percent of which is fused pumice, was melted by the action of gases; little or no fused material was derived from greater depth.

Maars and stratovolcanoes are regarded as products of the same type of activity, the stratovolcano building up where an initial cone forms and the maar developing where no cone is built during the first activity. — J. W. C.

183-595. Morimoto, R[yohei]. The volcanic rock fragments embedded into the debris of No. 5 Kaiyo Maru, hit by a submarine explosion near the Bayonnaise Rocks off Japan: *Internat. Geol. Cong.*, 20th, Mexico 1956, *Vulcanologia del Cenozoico*, sec. 1, v. 1, p. 151-159, 1957.

This is virtually the same paper as published in Tokyo Univ. Education, *Geol.*, and *Mineralog. Inst. Studies (Kawada Memorial Volume)*, no. 3, p. 5-14, 1954 (see *Geophys. Abs.* 163-187). — J. W. C.

Kizawa, Takashi, and Yamaguchi, Rinzo. Some new phases observed in a study of earthquake swarms relating to volcanic activity, (2). See *Geophys. Abs.* 183-159.

183-596. Golovina, I. F., and Malov, N. N. K teorii geyzerov [On the theory of geysers]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 7, p. 922-929, 1960.

On the basis of data on the activity of Velikan geyser in Kamchatka obtained by Ustinova (see *Geophys. Abs.* 178-438) and Naboko (see *Geophys. Abs.* 173-366), and observations by the authors, a mechanism of geyser activity proposed by several investigators is analyzed and its modification proposed. It is concluded that very little if any cold ground water is supplied to the sub-surface cavities of the geyser. The authors consider that Velikan geyser is fed with hot water from the crust of the earth. — A. J. S.

183-597. de Anda, L. F. El campo de energia geotérmica en Pathé, estado de Hidalgo, México [Field of geothermal energy at Pathé, state of Hidalgo, Mexico]: *Internat. Geol. Cong.*, 20th, Mexico 1956, *Volcanologia del Cenozoico*, sec. 1, v. 2, p. 257-283, 1957.

The possibilities of commercial development of geothermal energy in Mexico are discussed. On the basis of geologic and economic considerations, the most favorable area is at Pathé in the state of Hidalgo. At this locality in the valley of the San Juan River there are thermal springs (60°C-90°C) and steam jets, particularly near the river bed. Large deposits of geysierite occur as far as three miles away. They are the type deposited by algae at temperatures above 80°C. This thermal deposit has been drilled and tested. — J. W. C.

183-598. McCall, G. J. H. Natural steam as a possible source of power in the Rift Valley of Kenya: *Internat. Geol. Cong.*, 20th, Mexico 1956, *Vulcanologia del Cenozoico*, sec. 1, v. 1, p. 47-54, 1957.

The occurrences of natural steam in Italy are first described and then compared with the steam vents of the Kenya Rift Valley. Although there are some similarities between the two areas, the contrasts are dominant. The most fundamental point of divergence is the lack of a thick, impermeable seal of covering sediments in Kenya to entrap the steam. It is, therefore, doubtful that the natural steam of Kenya has an economic potential. — J. W. C.

183-599. Tolstikhin, O. N. Termal'nyye vody Kamchatki i problema ikh osvoeniya [Thermal waters of Kamchatka and the problem of their utilization]: *Sovetskaya Geologiya*, no. 2, p. 109-133, 1958.

The distribution and composition of the thermal waters of Kamchatka are intimately related to structural features and to processes of effusive and intrusive magmatism. Three main types of hydrogeologic structures are recognized in Kamchatka: folded areas, artesian basins, and areas of Cenozoic effusives and volcanism.

The Precambrian folded areas are devoid of thermal springs, and the Mesozoic folded areas contain but a few, which are related to faults. The artesian basins contain waters with elevated temperature at depth, but none issues at the surface; this is due to the absence of deep faults.

Thermal springs are abundant in the areas of Cenozoic volcanic activity. These thermal waters have a great potential for obtaining electric power, for heating and hot water supply, and for medical purposes. Favorable areas are discussed. — J. W. C.

183-600. Healy, J[ames]. The hot springs and geothermal resources of Fiji: *New Zealand Dept. Sci. Indus. Research Bull.*, no. 136, 77 p., 1960.

Thirty-seven hot spring localities have been described in the Fiji Islands. Most of the springs emerge along streams or along the coast. Temperatures generally are below 60°C although 10 springs are known to have higher tem-

peratures and those at Savusavu are boiling. The hottest springs are on Vanua Levu. The Savusavu springs have an estimated heat discharge of approximately 2,000 kcal per sec.

The springs are fed for the most part by meteoric waters that penetrate to shallow depth, probably no more than 2,000 feet, become heated by contact with hot rock, and rise to the surface along faults. In some cases the waters are augmented by sea water and possibly connate water.

The heat gradient in some localities is higher than elsewhere. The origin of these localized hot spots is not known; some may mark the location of pockets of magma, and some may indicate generation of heat by seismic activity in an area dominated by major faults.

Although the heat discharges could be increased by drilling at the hot-spring localities, only Savusavu and the area south of Labasa are regarded as of possible economic importance. — V. S. N.

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