

# Geophysical Abstracts 182

## July-September 1960

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

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

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



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GEOPHYSICAL ABSTRACTS 182, JULY-SEPTEMBER 1960

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

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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 182 that have not been listed previously.

Acta Univ. Stockholm., Stockholm Contr. in Geology—Acta Universitatis Stockholmiensis, Stockholm Contributions in Geology. Stockholm Universitet. Stockholm, Sweden.

Alaska Univ. Geophys. Inst.—University of Alaska Geophysical Institute. College, Alaska.

Australian Meteorol. Mag.—Australian Meteorological Magazine. Australia Bureau of Meteorology. Melbourne, Australia.

Bol. Inf.—Boletín Informativo. Asociacion Venezolana de Geologia, Mineraia y Petroleo [Information Bulletin, Venezuelan Association of Geology, Minerals, and Petroleum]. Chacao, Venezuela.

Canadian Geophys. Bull.—Canadian Geophysical Bulletin. National Research Council of Canada. Ottawa, Ontario.

Chinese Assoc. Adv. Sci. Trans.—Transactions of the Chinese Association for the Advancement of Science. Taipei, Taiwan.

Colorado School Mines Quart.—Quarterly of the Colorado School of Mines. Golden, Colorado.

Geog. Tidsskr.—Geografisk Tidsskrift. Det Kongelige Danske Geografiske Selskab [Geographical Journal of the Royal Danish Geographical Society]. Copenhagen, Denmark.

Geonotes—Geonotes. Quarterly Journal of the Jamaica Group of the Geologists' Association (of London). Kingston, Jamaica.

- India Natl. Inst. Sci. Bull. — Bulletin of the National Institute of Sciences of India. New Delhi, India.
- India Natl. Inst. Sci. Proc. — Proceedings of the National Institute of Sciences of India. New Delhi, India.
- Indian Mineralogist — The Indian Mineralogist. Journal of the Mineralogical Society of India. Madras, India.
- Inst. Geologii Arktiki, Inf. Byull. — Instituta Geologii Arktiki, Informatsionnyy Byulleten [Institute of the Geology of the Arctic, Information Bulletin]. Leningrad, U.S.S.R.
- Jour. Petrology — Journal of Petrology. University Press. Oxford, England.
- Koninkl. Nederlandse Akad. Wetensch. Afd. Natuurk. — Koninklijke Nederlandse Akademie van Wetenschappen Afdeeling Natuurkunde [Royal Dutch Academy of Sciences, Section of Natural Science]. Amsterdam, Netherlands.
- Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki — Leningradskiy Ordena Lenina Gosudarstvennyy Universitet Uchenyye Zapiski, Voprosy Geofiziki [Leningrad Order of Lenin State University Scientific Notes, Problems of Geophysics]. Leningrad, U.S.S.R.
- L'Institut du Desert d'Egypte Pub. — Publications de l'Institut du Desert d'Egypte. Mataria, Egypt.
- Mississippi Water News — Mississippi Water News. Mississippi Board of Water Commissioners. Jackson, Mississippi.
- Petroleum Engineer — Petroleum Engineer. Petroleum Engineer Publishing Company. Dallas, Texas.
- Potsdam Geod. Inst. Veröffentl. — Veröffentlichungen des Geodätischen Instituts in Potsdam. Deutsche Akademie der Wissenschaften zu Berlin [Publications of the Geodetic Institute in Potsdam. German Academy of Sciences in Berlin]. Berlin, Germany.
- Queensland Govt. Mining Jour. — Queensland Government Mining Journal. Department of Mines. Brisbane, Queensland, Australia.
- Rept. Ionosphere Research [Japan] — Report of Ionosphere Research in Japan. Science Council of Japan. Tokyo, Japan.
- Schweizer. Mineralog. Petrog. Mitt. — Schweizerische Mineralogische und Petrographische Mitteilungen [Swiss Mineralogical and Petrographic Reports]. Verlag Leeman. Zürich, Switzerland.
- Smithsonian Contr. Astrophysics — Smithsonian Contributions to Astrophysics. Smithsonian Institution. Washington, D. C.
- South Africa Geol. Soc. Trans. and Proc. — Transactions and Proceedings of the Geological Society of South Africa. Johannesburg, South Africa.
- South African Mining and Eng. Jour. — The South African Mining and Engineering Journal. Johannesburg, South Africa.
- Southeastern Geology — Southeastern Geology. Department of Geology, Duke University. Durham, North Carolina.
- Vses. Neft. Nauchno-Issled. Geol.-Razved. Inst. Trudy — Trudy Vsesoyuznogo Neftyanoy Nauchno - Issledovatel'skogo Geologo - Razvedochnoy Instituta (VNIGRI) [Papers of the All-union Petroleum Scientific Research Geological Exploration Institute]. Moskva (Moscow), U. S. S. R.

#### 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 sys-

tem 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, H. Faul, A. J. Schneiderov, S. T. Vesselowsky, Anna Jespersen, I. Roman, H. C. Spicer, and J. H. Swartz, 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

- 182-1. Faul, Henry. Geologic time scale: Geol. Soc. America Bull., v. 71, no. 5, p. 637-644, 1960.

Evidence is gradually accumulating that the presently accepted (Holmes-Marble) geologic time scale should be lengthened, and that this extension should be greatest in the Paleozoic era. Age determinations on glauconites, however, contradict this evidence and generally support the present scale. A review of available data indicates many uncertainties. It still seems doubtful to attempt the construction of a new time scale until the key points can be established firmly enough to be useful. — Author's abstract

- 182-2. Kulp, J. Laurence. Absolute age determination of sedimentary rocks: World Petroleum Cong., 5th, New York, Proc., sec. 1, paper 37, p. 689-702, 1959.

The present status of the uranium-lead, potassium-argon, and rubidium-strontium methods of absolute age determination is reviewed. It is concluded that any of these methods can give dates that are accurate to at least 5 percent under suitable conditions. Relative ages to 1 percent are possible.

The most useful age method for sedimentary rock appears to be that based on the decay of potassium-40. The method is sufficiently sensitive so that, in principle, ages may be determined down to the range of the carbon-14 method, that is, 50,000 years ago.

Available quantitative age measurements on sedimentary rocks are presented and with other data used to infer a new geological time scale. Beginning with the Jurassic, the so-called Holmes time scale must be stretched by about 15 percent with the lengths of the Jurassic, Permian, and Carboniferous doubled. The Cambrian-Ordovician boundary appears to occur at about 490 million years.

The potential development of these methods is pointed out, and the types of problems in petroleum geology to which they may be most applicable are discussed. — V.S.N.

- 182-3. Semenenko, N. P. Dosyahnennaia absolyutnoi heokhronolohiyi ta holovni rubezhi heolohichnoi istoriyi [Progress of absolute geochronology and major boundaries of geologic history (with Russian summary)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 19, no. 5, p. 11-16, 1959.

In the U.S.S.R. absolute dating by the argon method has been applied widely to sediments by means of glauconites or interstratified effusives and to schists by means of micas. On the basis of glauconites in the Volyno-Podol'sk

grits in the Ukraine, the Cambrian-Precambrian boundary is set at  $536 \times 10^6$  yr ago; according to other investigators in other parts of the U.S.S.R. the age of this boundary is 505, 525, 540, or even  $600 \times 10^6$  yr.

The age of the boundary between Rifian and Proterozoic (Precambrian-IV and -III) is  $1,050-1,150 \times 10^6$  yr; glauconite from the Lower Baylin suite in the Pri-Urals is  $1,240 \times 10^6$  yr old, and this age is confirmed by the dating of a "gabbrodiabase" that intrudes it at  $1,120 \times 10^6$  yr.

A third major boundary is that between Proterozoic and Archean (Precambrian-III and -II). The best substantiated age for this boundary, established for the Karelian and for the Krivoy Rog groups, is  $1,850 \times 10^6$  yr; however, this figure requires verification, as  $2,000 \times 10^6$  yr has also been suggested.

The fourth major boundary is that between Archean and Catarchean, or Precambrian-II and -I. Its most reliable dating is  $2,650-2,700 \times 10^6$  yr. The lower limit of the oldest rocks of Precambrian I in the U.S.S.R., from the Kola Peninsula, has been set by Polkanov and Gerling at  $3,500 \times 10^6$  yr. (See also Geophys. Abs. 178-3.) — D.B.V.

Gilbert, C. Dirac's cosmology and the general theory of relativity. See Geophys. Abs. 182-281.

- 182-4. Catanzaro, E. J., and Gast, P[aul] W. Isotopic composition of lead in pegmatitic feldspars: *Geochim. et Cosmochim. Acta*, v. 19, no. 2, p. 113-126, 1960.

An ion-exchange method was developed for extracting microgram quantities of lead from pegmatitic feldspars. The isotopic composition of lead in 11 feldspars ranging in age from 350 to 2,750 million years was determined, and their model ages were calculated. The model ages were generally in good agreement with independent age determinations. The results are compatible with a lead model in which it is stipulated that the lead has been in a crustal environment for relatively short periods of time.

A large discrepancy between the model age and known age was resolved in one instance by acid leaching, which preferentially removed excess radiogenic lead.

The lead content of 25 feldspars was measured and found to range from <20 ppm to 500 ppm. — D.B.V.

- 182-5. Herzog, L[eonard] F., II. Age determination by X-ray fluorescence rubidium-strontium ratio measurement in lepidolite: *Science*, v. 132, no. 3422, p. 293-295, 1960.

X-ray fluorescence analysis of several lepidolites whose rubidium and strontium concentrations had already been determined by neutron activation and (or) by stable isotope dilution indicates that this technique provides an inexpensive, rapid, and reasonably precise method of reconnaissance determination of the Rb/Sr ratio and concentration. At present the threshold is 5 ppm, but it is possible that the technique can be developed sufficiently to permit determination of rubidium-strontium ages by X-ray fluorescence analysis alone (at least for Precambrian lepidolites) with an accuracy comparable to that of the stable isotope dilution technique. Besides being more rapid and cheaper, X-ray fluorescence analysis is nondestructive. — D.B.V.

- 182-6. Wänke, H., and König, H. Eine neue Methode zur Kalium-Argon-Alterbestimmung und ihre Anwendung auf Steinmeteorite [A new method of potassium-argon age determination and its application to stone meteorites]: Zeitschr. Naturforschung, v. 14a, no. 10, p. 860-866, 1959.

The potassium-argon ages of 5 chondrites and 2 achondrites were determined by a new neutron activation method. The principal, apparatus, and procedure are described. Argon-39 is formed from potassium-39 by ( $n, p$ ) reaction, and argon-41 from argon-40 by ( $n, \gamma$ ) reaction. As essentially only the  $\text{Ar}^{39}/\text{Ar}^{41}$  ratio is important in age determinations, this method appears to be particularly advantageous, especially because it requires little apparatus.

The ages of the meteorites investigated range from  $2.78 \times 10^9$  to  $4.25 \times 10^9$  yr. In addition, the calcium content of the samples was calculated from the argon-37 activities arising from ( $n, \gamma$ ) processes. — D. B. V.

- 182-7. Marmo, Vlad. On the potassium-argon-ages of the granitic rocks: Schweizer. Mineralog. Petrog. Mitt., v. 40, no. 1, p. 17-36, 1960.

The potassium-argon ages of microcline of the granitic rocks are generally much lower than the respective ages of the mica in the same rocks. The suggestion is made that these discrepancies are due to actual age differences between the microcline and the mica rather than to a difference in capacity to retain argon. An age difference should be expected for mica and microcline in synkinematic rocks because petrographic criteria indicate that microcline forms at a stage that is almost universally later than that of the formation of the associated mica. Such age differences do not exist in postkinematic granites.

There is an age group of 1,700-1,800 million years for the synkinematic rocks of Finland. It is not clear what sort of geological event this grouping represents. The  $\text{K}^{40}/\text{Ar}^{40}$  ages of microcline of the synkinematic rocks are close to the ages of late-kinematic granites. This may reflect a contemporaneity of the granitization of the synkinematic rocks and the formation of the late-kinematic granites. — J. W. C.

- 182-8. Firsov, L. V. O vybore konstant raspada  $\text{K}^{40}$  dlya opredeleniya vozrasta porod po otnosheniyu  $\text{Ar}^{40}$  k  $\text{K}^{40}$  [On the choice of decay constants of  $\text{K}^{40}$  for determination of the age of rocks according to the ratio of  $\text{Ar}^{40}$  to  $\text{K}^{40}$ ]: Akad. Nauk SSSR Izv. Ser. Geol., no. 3, p. 96-101, 1960.

Until 1959 Soviet potassium-argon dating laboratories used the value  $\lambda_k = 0.6 \times 10^{-10} \text{ yr}^{-1}$  for the K-capture constant,  $\lambda_\beta = 4.9 \times 10^{-10} \text{ yr}^{-1}$  for the beta-decay constant of potassium-40n, and  $\lambda_k/\lambda_\beta = 0.1225$  (1.13) for the branching ratio. In 1959 the values  $\lambda_k = 0.557 \times 10^{-10} \text{ yr}^{-1}$ ,  $\lambda_\beta = 4.72 \times 10^{-10} \text{ yr}^{-1}$ , and  $\lambda_k/\lambda_\beta = 0.118$  were recommended. As other laboratories in other countries use different constants, it is difficult to compare published results.

Measurements of the gamma and beta activity of potassium-40 made by various workers in different countries are compiled and evaluated. It is concluded that the most suitable values available at present are 3.40 gammas per sec per g K for the gamma activity and 27.2 betas per sec per g K for the beta activity. These are very close to the values used in American laboratories.

The decay constants derived from these values are as follows:  $\lambda_k = 0.585 \times 10^{-10} \text{ yr}^{-1}$ ;  $\lambda_\beta = 4.68 \times 10^{-10} \text{ yr}^{-1}$ ;  $\lambda_k/\lambda_\beta = 0.125$ ; half life  $T = 1.317 \times 10^9$  yr. Ages calculated using these constants are 2.65 percent higher than those calculated on the basis of the pre-1959 Soviet values. — D. B. V.

- 182-9. Sudovikov, N. G. Zamechaniya po ispol'zovaniyu argonovogo metoda dlya opredeleniya vozrasta porod Karelii i Aldana [Application of the argon method for the determination of the age of the rocks of Karelia and Aldan]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 9, p. 49-55, 1960.

The argon method permits determination of the age of rocks as well as the solution of various petrologic problems, particularly the degree of metamorphism of various minerals. It may even be possible to distinguish between the solid and fluid phases of migmatites. No data are given. — H. F.

- 182-10. Amirkhanov, Kh. I., Brandt, S. B., and Bartnitskiy, Ye. N. Radiogennyy argon u mineralakh i gornykh porodakh [Radiogenic argon in minerals and rocks]: Makhachkala Akad. Nauk SSSR Dagestan. Filial, 202 p., 1960.

This is a comprehensive report on the techniques of measurement and details of equipment used in the Dagestan Branch of the Academy of Sciences U.S.S.R., in Makhachkala. A theoretical study of diffusion of radiogenic gases in silicate minerals and the mechanism of their loss, especially from micas and feldspars, is presented. — H. F.

- 182-11. Gurvich, I. G., and Khanayev, Ye. I. Opredeleniye kaliya v gornykh porodakh i mineralakh metodom fotometrii plameni [Potassium determination in rocks and minerals by the method of flame photometry]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy, 5th sess., Trudy, p. 259-273, 1958.

Instead of the chemical method used generally for the determination of potassium-40 in rocks, Gurvich and Khanayev studied and experimented with the flame-photometry method proposed by Shillibeer and Russell (see Geophys. Abs. 160-152), and Amirkhanov, Gurvich, and Sardarov (see Geophys. Abs. 164-29). Instead of using Smith's coking method, the rock was dissolved in melted salts. The method and instrumentation of flame photometry are described in detail, and the proposed method is compared with the Smith's coking method. The results of the new methods were found to agree with chemical analysis within a few percent. — A. J. S.

- 182-12. Krylov, A. Ya., and Silin, Yu. O. Primeneniye argonogo metoda opredeleniya vozrasta k oblomochnym osadochnym porodam [The applications of the argon method of age determination to clastic sedimentary rocks]: Akad. Nauk SSSR Izv. Ser. Geol., no. 1, p. 56-66, 1960.

Study of the Ar<sup>40</sup>/K<sup>40</sup> ratio in granitic pebbles, arkosic sands, sandstones, and clastic clays shows that in most cases the original ratio has been preserved. Therefore, the argon dating method can be used for paleogeographic reconstructions and correlations of sedimentary rocks. In syngenetic minerals, such as kaolin, the argon-potassium ratio gives the time of crystallization and thus can be used for dating the sedimentary units themselves.

Conflicting processes are involved in the decomposition of granite. In the first stage of weathering, argon loss exceeds that of potassium, but by the end stage the original ratio is restored. Study of this phenomenon might throw light on the mechanism of decomposition of crystals during weathering. The fact that the Ar<sup>40</sup>/K<sup>40</sup> ratio is retained in the finest subcolloidal particles of

clays, silts, and local products of feldspar decomposition may be an argument in favor of the block theory of feldspar crystal structure, and also might lead to an understanding of the conditions of formation of hydromicas and other clay minerals. — D. B. V.

- 182-13. Rubinshteyn, M. M., Chikvaidze, B. G., Khutsaidze, A. L., and Gel'man, O. Ya. K ispol'zovaniyu glaukonita dlya opredeleniya absolyutnogo vozrasta osadochnykh porod argonovym metodom [On the use of glauconite for the determination of the absolute age of sedimentary rocks by the argon method]: Akad. Nauk SSSR Izv. Ser. Geol., no. 12, p. 77-83, 1959.

The problem of argon retention in glauconite has been investigated in order to check the suitability of that mineral for absolute dating purposes. The average argon-40 content of unheated glauconite from Tallinn, Estonia, was  $0.130 \pm 0.001 \times 10^{-9} \text{ mm}^3$  per g, corresponding to an age of about  $465 \pm 10 \times 10^6 \text{ yr}$ . Samples of the mineral were heated to temperatures of 150°C, 300°C, 400°C, 500°C, 600°C, and 700°C. Argon loss began at 300°C, reached a maximum at 400°C, and was almost complete at 600°C.

These results are not regarded as definitive. The effect of prolonged heating at lower temperatures should be investigated, and different glauconites from platform and geosynclinal areas should be studied. Results obtained on glauconites should be checked against those on synchronous micas from stratigraphically dated intrusions over a wide age range; in this way it might be possible to use glauconite in establishing an absolute chronology for sedimentary formations. — D. B. V.

- 182-14. Rubinshteyn, M. M., Grigor'yev, I. G., Gel'man, O. Ya., Khutsaidze, A. L., and Chikvaidze, B. G. K metodike polucheniya monomineral'nykh fraktsiy dlya opredeleniya absolyutnogo vozrasta gornikh porod argonovym metodom [On methods of obtaining monomineralic fractions for determination of the absolute age of rocks by the argon method]: Akad. Nauk SSSR Izv. Ser. Geol., no. 6, p. 95-100, 1958.

This paper describes two separators, one used for obtaining pure fractions of biotite or glauconite and the other for obtaining pure muscovite fractions. Photographs and diagrams are given. — D. B. V.

- 182-15. Tamers, Murry A. Carbon-14 dating with the liquid scintillation counter: total synthesis of the benzene solvent: Science, v. 132, no. 3428, p. 668-669, 1960.

Samples are analyzed for natural radiocarbon content by a total synthesis of benzene from their organic constituents. The benzene is employed as the solvent in a liquid scintillation counter. The instrument used permits 15 grams of carbon to be counted with an efficiency of 40 percent and a background of 13 counts per minute. — Author's abstract

- 182-16. Crevecoeur, E. H., Vander Stricht, A., and Capron, P. C. Precision of the dating method. Standardization of the calculation of errors and of the maximum age in the  $^{14}\text{C}$  method: Acad. Royale Belge Bull. Cl. Sci., ser. 5, v. 45, no. 9, p. 876-890, 1959.

The systematic and accidental errors that may affect carbon-14 age determinations are discussed and analyzed. The precision of results has been determined in many different ways by different authors; therefore, a standardized method of calculating precision is needed. It is suggested that the experimental error should always be taken into account first. It is further suggested that a reliable interval of 99.99 percent should be chosen for maximum age.

Background radiation, counting time, and amount of activity can be dealt with most simply by increasing the pressure. — D. B. V.

- 182-17. Willis, E. H., Tauber, H[enrik], and Münnich, K. O. Variations in the atmospheric radiocarbon concentration over the past 1300 years: Am. Jour. Sci., Radiocarbon Supp., v. 2, p. 1-4, 1960.

The results are reported of a joint project undertaken by the radiocarbon dating laboratories at Cambridge, England, Copenhagen, Denmark, and Heidelberg, Germany, designed to extend present knowledge of variations in atmospheric radiocarbon as demonstrated by de Vries (see Geophys. Abs. 175-333) and to serve as an exercise in interlaboratory cross-checking. A fully documented section of a sequoia tree was chosen for the experiment. Samples were taken at 50-year ring intervals, and each sample was subdivided into three parts, one going to each of the three laboratories. Since only one tree is involved, possible variation due to geographic position is eliminated, and isotopic fractionation effects from sample to sample reduced to a minimum.

Results are presented graphically and a general correspondence over the last 300 years with de Vries' concentration curve is noted. The results appear to confirm the existence of short-term oscillations in radiocarbon concentration, with a period of the order of 150 to 200 years superimposed upon an oscillation with a period of the order of 1,200 years. The underlying cause of the oscillations and their possible correlation with climatic phenomena remain obscure. In general, however, the experiment demonstrates that over the past 1,200 years the fundamental assumptions of the radiocarbon dating method are empirically correct to about 1.5 percent. This error may be disturbing for very recent samples but is of little significance for older samples. — V.S. N.

- 182-18. Zeller, Edward J. Preliminary report on thermoluminescence of limestones from Thule, Greenland, and Ward Hunt Island on Ellesmere Ice Shelf, in Proceedings of the Second Annual Arctic Planning Session, October 1959: U. S. Air Force Cambridge Research Center, Geophys. Research Directorate Research Notes no. 29, p. 164-165, 1959.

Two of five samples of limestone collected at Thule, Greenland, and three of seven collected on Ward Hunt Island showed low temperature thermoluminescence indicating that they have remained at reduced temperatures for an extended period of time. Study of the decay rate of the naturally occurring low temperature peak shows that at 25°C the half life of the peak is approximately 25 hours. Determinations of the actual age of refrigeration of the arctic areas from which the limestones were taken have not been completed. In view of the preliminary results, however, any assumption that climatic conditions were warm enough to melt the permafrost at Thule or Ward Hunt Island in the recent past would seem unwarranted. — V.S. N.

- Herr, W., Hoffmeister, W., and Langhoff, J. The determination of rhenium and osmium in iron meteorites by neutron activation. See Geophys. Abs. 182-70.

Wänke, H., and Vilczek, Else. Argon-39 as cosmic ray reaction product in iron meteorites. See *Geophys. Abs.*, 182-64.

Schaeffer, Oliver A., and Fisher, David E. Exposure ages for iron meteorites. See *Geophys. Abs.* 182-73.

- 182-19. Tauber, Henrik. Copenhagen natural radiocarbon measurements III, Corrections to radiocarbon dates made with the solid carbon technique: *Am. Jour. Sci. Radiocarbon Supp.*, v. 2, p. 5-11, 1960.

In order to check the magnitude of the Suess effect (dilution of atmosphere with inactive carbon by combustion of fossil fuels since the Industrial Revolution, see *Geophys. Abs.* 162-181) in the Copenhagen area and to determine the corrections to be applied to previous measurements by Anderson and others (*Geophys. Abs.* 155-14948) and by Tauber (*Geophys. Abs.* 167-8), the black-carbon materials of the former standards were combusted and measured with the carbon dioxide method. After normalization to a common  $C^{13}/C^{12}$  ratio these measurements showed an average depression of  $2.5 \pm 0.5$  percent in carbon-14 activity compared to 95 percent of the measured activity of the NBS oxalic-acid standard. It was calculated that  $200 \pm 40$  yr should be added to all dates in the Copenhagen I and II lists. The corrected dates, in years before 1950, are given for the pollen-zone boundary II/III and III/IV, and for the average ages of the Neolithic dwelling places Egolzwil-3 in Switzerland and Mul. I in Denmark. Measurements made up to June 1955 and not included in the Copenhagen I and II lists are also given; only dates from periods with no radioactive contamination of the atmosphere by fallout products are included. These include dates on samples from Alaska, Greenland, Iceland, Italy, and the Netherlands. — V.S.N.

- 182-20. Tauber, Henrik. Copenhagen radiocarbon dates IV: *Am. Jour. Sci. Radiocarbon Supp.*, v. 2, p. 12-25, 1960.

Radiocarbon ages, expressed in years before 1950 and measured at the National Museum in Copenhagen, Denmark, are reported for geologic- and pollen-dated samples from the Netherlands, Denmark (including Greenland), Poland, and Colombia; and for archeological samples from Greenland, Arctic Canada, Denmark, Iceland, Germany, Syria, and the United States of America. (See also Anderson and others, *Geophys. Abs.* 155-14948, and Tauber, *Geophys. Abs.* 167-8, 182-19.) — V.S.N.

- 182-21. Barker, H., and Mackey, C. J. British Museum natural radiocarbon measurements II: *Am. Jour. Sci. Radiocarbon Supp.*, v. 2, p. 26-30, 1960.

The second series of radiocarbon measurements made at the British Museum is presented with a brief description of modifications in procedures since the publication of the first series (*Geophys. Abs.* 178-7h). Radiocarbon dates are given for archeological samples from Somaliland, Southern Rhodesia, British Honduras, Egypt, Great Britain, India, Malaya, Thailand, and Turkey, and for one check sample from Nimrud, Iraq. — V.S.N.

- 182-22. Crane, H. R., and Griffin, James B. University of Michigan radiocarbon dates V: *Am. Jour. Sci. Radiocarbon Supp.*, v. 2, p. 31-48, 1960.

Radiocarbon dates are given for geologic samples from Michigan, Missouri, Colorado, Oregon, and Washington and for archeological samples from the Upper Mississippi Valley and Great Lakes, Lower Mississippi Valley and Southeastern United States, Northeastern United States and Canada, United States Plains, Western United States, Mexico, the Far East and Pacific islands, the Sudan, Spain, and Iran. (See also Geophys. Abs. 178-7n.)—V.S.N.

- 182-23. Stuiver, Minze, Deevey, Edward S., and Gralenski, L. J. Yale natural radiocarbon measurements V: Am. Jour. Sci. Radiocarbon Supp., v. 2, p. 49-61, 1960.

Radiocarbon dates, measured since the publication of the Yale IV list (see Geophys. Abs. 178-7m), are given for geologic samples from Quebec, Maine, Ontario, Massachusetts, Chile, Siberia, Japan, and Uganda; and for archeologic samples from Alaska, Mexico, Argentina, Kenya, and Southern Rhodesia. Revised measurements on wood samples from British Columbia, California, Mississippi, and Mexico are also presented. —V.S.N.

- 182-24. Godwin, H., and Willis, E. H. Cambridge natural radiocarbon measurements II: Am. Jour. Sci. Radiocarbon Supp., v. 2, p. 62-72, 1960.

Radiocarbon dates, obtained during 1959 at Cambridge University, are given for samples from England including a group from the Somerset Levels series in southwestern England; Full-glacial and Late-glacial woods from north London, Hertfordshire, and Cumberland; peat and pollen from Recurrence Surfaces series of Cardiganshire, the Lake District, and Cumberland; mud and wood representative of prehistoric agriculture in Kent and Huntingdonshire; and miscellaneous wood samples from Lancashire, Lincolnshire, Cumberland, North Ireland, and Cardiganshire. Dates for 1 sample from southwestern France and 2 from Gough Island in the South Atlantic are also given. The rise of atmospheric radiocarbon concentration during recent years is discussed and illustrated by measurements of radiocarbon in oat seeds from the harvests of each year from 1953 through 1959. The crops were grown in and around Cambridge, and measurements from year to year are directly comparable. (See also Geophys. Abs. 178-7f.)—V.S.N.

- 182-25. McCallum, K. J., and Dyck, W. University of Saskatchewan radiocarbon dates II: Am. Jour. Sci. Radiocarbon Supp., v. 2, p. 73-81, 1960.

Radiocarbon dates are given for geologic samples from Ontario, Washington, Alberta, Northwest Territories, and Saskatchewan; and for archeologic samples from British Columbia, Ontario, Vancouver Island, Alberta, Iceland, and Saskatchewan. (For Univ. Saskatchewan radiocarbon dates I, see McCallum, Royal Soc. Canada Trans., ser. 3, v. 49, sec. 4, p. 31-35, 1955.)—V.S.N.

- 182-26. Nydal, R. Trondheim natural radiocarbon measurements II: Am. Jour. Sci. Radiocarbon Supp., v. 2, p. 82-96, 1960.

Radiocarbon dates, obtained during the period September 1958 to December 1959, are given for geologic samples from the Tromsö glacial substage and from marine clay and shorelines in the Oslo region of Norway, and for archeologic samples from settlement sites, trackways, and graves of Norway. Laboratory equipment and dating methods are described. (See also Geophys. Abs. 178-7g.)—V.S.N.

- 182-27. Bray, E. E., and Burke, W. H., Jr. Socony Mobil radiocarbon dates I: Am. Jour. Sci. Radiocarbon Supp., v. 2, p. 97-111, 1960.

Radiocarbon dates are given for samples from cores of recent sediment taken in eight marine basins off the coast of southern California and from short cores of recent sediment obtained on the continental shelf in the Gulf of Mexico, and for samples of recent lake and bog deposits taken from the south-central part of Grassy Lake and Trout Lake, Vilas County, Wis., and from Searles Lake, Calif. — V.S.N.

- 182-28. Olsson, Ingrid. Uppsala natural radiocarbon measurements II: Am. Jour. Sci. Radiocarbon Supp., v. 2, p. 112-128, 1960.

Radiocarbon dates, measured at the Uppsala radiocarbon laboratory during 1959, are given for geologic samples from the Mediterranean area, Iceland, Spitsbergen, Norway, Sweden, and North America; and for archeologic samples from Argentina, Peru, Austria, and Sweden. Results give the excess in percent over reference samples corrected for atomic-bomb effect. (See also Geophys. Abs. 178-7i.) — V.S.N.

- 182-29. Rubin, Meyer, and Alexander, Corrinne. U.S. Geological Survey radiocarbon dates V: Am. Jour. Sci. Radiocarbon Supp., v. 2, p. 129-185, 1960.

Radiocarbon dates, determined at the U.S. Geological Survey radiocarbon laboratory at Washington since the U.S.G.S. IV list and up to the end of 1959, are given for geologic samples from the Eastern, Central, and Western United States, Alaska, Canada, and miscellaneous sites in Africa, Antarctica, Australia, Egypt, France, Germany, Greenland, Indonesia, Marshall Islands, Ryukyu Islands, and Colombia; and for archeologic samples from North America, Central America, South America, Iraq, and Portugal.

The radiocarbon activity of carbon dioxide, collected at 50,000 feet altitude from January 1956 through December 1957 at lat 32° in the United States, was compared with two standards used in the U.S. Geological Survey radiocarbon laboratory. It was found that the "stratosphere" is about 25 percent higher in activity than present wood or troposphere air when uncontaminated by nuclear explosions and burning of fossil fuels. — V.S.N.

- 182-30. Östlund, H. Göte, and Engstrand, Lars G. Stockholm natural radiocarbon measurements III: Am. Jour. Sci. Radiocarbon Supp., v. 2, p. 186-196, 1960.

This list of radiocarbon dates is a direct continuation of the second list released by the Radioactive Dating Laboratory of the Geological Survey of Sweden (see Geophys. Abs. 178-7c). Radiocarbon dates are given for geologic samples from Interglacial, Interstadial, Postglacial strandlines, and peat-bog deposits in Sweden; and for archeologic samples from Lappland and neighboring provinces, southern Sweden, and Cyprus. A few other samples dated include a tree ring series from an oak felled in 1953 in Stockholm, Sweden; soil humus samples from a spruce forest profile, 95 years old, Garpenberg, Sweden; and black sapropelitic mud from a core taken in the Adriatic Sea. — V.S.N.

- 182-31. Hubbs, Carl L., Bein, George S., and Suess, Hans E. La Jolla natural radiocarbon measurements: Am. Jour. Sci. Radiocarbon Supp., v. 2, p. 197-223, 1960.

Radiocarbon dates are given for samples measured at the radiation laboratory of Scripps Institution of Oceanography from August 1957 through December 1959. The counters and techniques used are described briefly. Samples to be measured were selected for paleoecologic significance only (physiography, oceanography, climatology, zoogeography, and archeology). Tests of strictly geochemical implication will be published later. Most of the samples are from California locations including offshore areas; others are from the Texas offshore, Baja California, Oregon, the northeast Pacific Ocean, Florida, Cape Cod, and Australia. — V.S.N.

- 182-32. Lyon, C., and Harrison, W. Rates of submergence of coastal New England and Acadia: *Science*, v. 132, no. 3422, p. 295-296, 1960.

Altitudinal and carbon-14 determinations of in-place pine stumps in drowned forests at Odiorne Point, N. H., and Grande Pré and Fort Lawrence, Nova Scotia, yield apparent average rates of submergence of 3.1, 14.5, and 20.3 feet per 1,000 years, respectively. These differences in rate are assessed in terms of eustasy, crustal movements, and tidal effects; however, conclusions are withheld pending dating of 6 more samples from intermediate altitudes at each of the 3 sites. — D.B.V.

- 182-33. Mason, Ronald J. Early man and the age of the Champlain Sea: *Jour. Geology*, v. 68, no. 4, p. 366-376, 1960.

Various dating techniques have yielded an approximately synchronous absolute chronology for fluted points characteristic of one phase of the Early Man or Paleo-Indian horizon in southern New England, the Upper Great Lakes, the high plains, and the southwestern United States. On the basis of these chronologies and on typology, some archeologists believe that closely similar artifacts elsewhere should be of nearly the same age. Recent geologic dating of fluted points in areas formerly occupied by Lake Iroquois and the Champlain Sea suggests that this archeological assumption is incorrect and that the northeastern Paleo-Indian artifacts are not nearly as old as their counterparts elsewhere. In this paper, a reinterpretation of the geologic sequence in the Ontario basin and St. Lawrence Valley is presented that seems to be supported by radiocarbon and by the most recent geologic investigations. It is suggested that available radiocarbon dates for the Champlain Sea are substantially correct and that Lake Iroquois is older than heretofore thought.

Acceptance of the Champlain Sea radiocarbon dates allows Paleo-Indian entry into the critical areas by 11,000 to 10,500 years ago. This age is consistent with typological considerations elsewhere and with radiocarbon dates for the Bull Brook site in Massachusetts (Byers, 1959). — V.S.N.

- 182-34. Rubin, Meyer. Changes in Wisconsin glacial stage chronology by  $C^{14}$  dating: *Am. Geophys. Union Trans.*, v. 41, no. 2, p. 288-289, 1960.

The flood of dated samples from radiocarbon dating laboratories has necessitated changes in previously accepted models of glacial advances and retreats in North America. The last advance in the Great Lakes area culminated about 11,000 years ago; the stage itself began some time between 70,000 and 100,000 years ago. Between its beginning and about 28,000 years ago there was either one very long substage or several shorter ones; the Iowan is included here. The Farmdale substage lasted from 28,000 to 22,000 years ago. Some workers believe that from 22,000 to 12,000 years ago only one substage

occurred, encompassing deposits known previously as the Iowan loess of Illinois, Tazewell drift, Cary drift, and Mankato drift. The Two Creeks substage was a short pause during the later advances of the Wisconsin stage, and was terminated by the Valders substage with the readvance of the ice approximately 11,000 years ago. The Valders substage ended with the retreat of ice into the Hudson Bay area and is arbitrarily terminated at about 8,500 years ago. — D. B. V.

- 182-35. Lowdon, J. A. Age determinations by the Geological Survey of Canada, Rept. 1. Isotopic ages: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Paper 60-17, 51 p., 1960.

This is the first in a proposed series of annual releases of geological age determinations carried out in the laboratories of the Geological Survey of Canada. It includes all potassium-argon age measurements completed as of December 31, 1959. The report is in two parts. Part 1 (geological age determinations) lists all pertinent experimental data, references to the geologic setting, and brief remarks by geologists responsible for collection and interpretation. Part 2 contains more detailed discussions of the significance and application of age measurements to specific geological problems such as notes on the interpretation of the uranium-lead, thorium-lead, and potassium-argon ages in the Bancroft, Ontario, region and potassium-argon dating in Keewatin and eastern Mackenzie districts, Northwest Territories.

The potassium-argon age determination program has developed through three phases. The first was a calibration phase during which potassium-argon measurements on micas were compared with lead-uranium and lead-thorium measurements on uranium minerals occurring in the same pegmatitic body. Thus, age measurements based on three separate elemental-decay systems could be compared. The second phase was a detailed investigation of a batholithic complex, its pegmatites, and the surrounding metamorphic rocks. Age results are included in this report but other details will be published later. As a result of the success of the second phase, a third phase for the reconnaissance dating of the Canadian Shield has been started, and first results are included in this compilation. — V. S. N.

- 182-36. Fairbairn, H[arold] W., Bullwinkel, H. J., Pinson, W. H., and Hurley, P[atrick] M. Age investigations of syenites from Coldwell, Ontario: Geol. Assoc. Canada Proc., v. 11, p. 141-144, 1959.

A major Precambrian thermal event about 1.1 billion years ago is well established in North America. The syenite pluton at Coldwell on the north shore of Lake Superior has recently been discovered to be an isolated example of this event. The age of the pluton has been determined by Ar/K and Sr/Rb mass spectrometric analysis of biotite in nepheline syenite and potassium feldspar in augite syenite. For biotite the preferred estimate of the Ar/K age is 1,065 million years, and of the Sr/Rb age is 1,070 million years; for potassium feldspar the preferred estimate of the Sr/Rb age is 1,225 million years. The slightly older age for the peripheral augite syenite could be evidence for either an intrusive or for a metasomatic origin for the syenite pluton. In either case, the investigation demonstrates the Late Precambrian origin of the syenite in an environment of granites and gneisses which preliminary work indicates are not less than 2 billion years old. — V. S. N.

- 182-37. Wetherill, G[eorge] W., Davis, G. L., and Tilton, G[eorge] R. Age measurements on minerals from the Cutler batholith, Cutler, Ontario: Jour. Geophys. Research, v. 65, no. 8, p. 2461-2466, 1960.

Mineral ages have been measured by the potassium-argon, rubidium-strontium, uranium-lead, and thorium-lead methods on samples of granite from the Cutler batholith, Ontario, as well as on samples of pegmatite that cut this granite. The age of pegmatitic muscovite and feldspar determined by the rubidium-strontium method is about  $1,750 \times 10^6$  yr whereas the age of the granitic biotites determined by the rubidium-strontium and potassium-argon methods is about  $1,300 \times 10^6$  yr. Most other ages are intermediate.

These apparent discrepancies are attributed to an event that took place 1,300 million years ago, 400 million years after the original crystallization of the batholith. There is no clear petrographic evidence for such an event. These data show that consistent results by one method on different minerals, or by several methods on one mineral, do not necessarily indicate the time of original crystallization of a granitic body. Nevertheless, it is clear that the Cutler granite was formed before the Grenville metamorphism and intrusion and therefore is not of very late Precambrian age. — D. B. V.

- 182-38. de Vries, Hessel, and Dreimanis, Aleksi. Finite radiocarbon dates of the Port Talbot interstadial deposits in southern Ontario: Science, v. 131, no. 3415, p. 1738-1739, 1960.

Three new finite radiocarbon dates determined at the Groningen laboratory (unenriched sample of gyttja,  $47,000 \pm 2,500$  yr; enriched sample of gyttja,  $47,500 \pm 2,500$  yr; wood in overlying till,  $44,200 \pm 1,500$  yr) suggest that the thermal maximum of the Port Talbot interstadial occurred prior to 47,000 years ago and that the interstadial deposits were overridden by a glacial advance approximately 44,000 years ago. New stratigraphic names are proposed for the Port Talbot type section to facilitate correlation with other areas. — D. B. V.

- 182-39. Blackadar, R. G. The age of the metamorphic complex of northernmost Ellesmere Island: Arctic, v. 13, no. 1, p. 51-52, 1960.

Recent study of the metamorphic rocks of northern Ellesmere Island suggests that these rocks are merely highly metamorphosed Paleozoic strata rather than Precambrian strata. Support for this comes from north Greenland where Paleozoic beds apparently can be traced into regions of metamorphic strata. Geological evidence from mapping of the Cape Columbia group by Blackadar and others, however, points to a pre-Ordovician age for this group. A specimen of biotite-rich gneiss from the Cape Columbia group has been dated by the potassium-argon method at 545 million years. Whether or not this age represents Cambrian or Precambrian depends upon whether the Holmes' time scale or that of various other investigating groups is used. If the consensus of current opinion is accepted, it appears that the last metamorphism to which the Cape Columbia group was subjected occurred in Early Paleozoic time; the rocks themselves may be much older. — V. S. N.

- 182-40. Crary, A. P. Arctic ice island and ice shelf studies, pt. 2: Arctic, v. 13, no. 1, p. 41-46, 1960.

The possible conditions at high latitudes under which thick floating ice can form and the possible history of two thick remnants of arctic ice, the Ellesmere ice shelf and the floating ice island T-3, are discussed. As a part of the latter, carbon-14 studies on dirt layers containing minute amounts of carbon material from T-3 and on driftwood and marine shells from Ellesmere Island are reported.

From carbon-14 dates of the dirt from T-3 and the driftwood on the landward side of the Ellesmere ice shelf, it can be concluded that these features are definitely later than the end of the Wisconsin ice age some 11,000 years ago. Thick growths of ice, of which T-3 is a remnant, probably began in Yelverton Bay, Ellesmere Island, about 5,500 years ago, and in the vicinity of Ward Hunt Island about 3,000 years ago. As part of the inner ice in Yelverton Bay, T-3 was protected from the movement of arctic pack ice. The deposits of marine shells along the shores of northern Ellesmere Island indicate no general advance of the glaciers in the area for at least 7,200 years and also indicate that the land has risen 38-60 m with respect to sea level in this time. Evidence from T-3 dirt layers and from material that worked up through the ice shows that the present ablation period has been going on for about 400 years and that it was preceded by an accumulation period about three times as long. — V. S. N.

- 182-41. Andersen, S. T., de Vries, H[essel], and Zagwijn, W. H. Climatic change and radiocarbon dating in the Weichselian glacial of Denmark and the Netherlands: *Geologie en Mijnbouw*, v. 39, no. 2, p. 38-40, 1960.

The results of pollen-analytical studies on the early Pleistocene Weichselian glacial stage in Denmark and the Netherlands show good consistency. As pollen-zone boundaries are not necessarily synchronous over a large area, radiocarbon determinations were made to help define chronostratigraphic units.

The Amersfoort Interstadial was found to be  $64,000 \pm 1,100$  yr old. Two dates were obtained for the Brörup Interstadial:  $59,430 \pm 1,000$  yr for pollen zone W 4 and  $58,740 \pm 1,000$  yr for pollen zone W 3c. Dates from Pleniglacial A of the Netherlands range from 32,000 to 50,000 yr. Humus from the still uncertain interstadial between Pleniglacial A and B at Breda in the southern Netherlands is  $29,930 \pm 300$  yr old, and organic matter remaining after thorough treatment of the sample gave an age of  $31,750 \pm 400$  yr. No good radiocarbon dates have yet been obtained for the Pleniglacial B of the Netherlands (28,000 to 14,000 yr ago). More details on these radiocarbon dates will be published later. — D. B. V.

- 182-42. Deutsch, Sarah, and Chauris, Louis. Mesure de l'âge absolu du granite du Huelgoat (Finistère) [Measurement of the absolute age of the Huelgoat granite (Finistère)]: *Acad. Sci. [Paris] Comptes Rendus*, v. 250, no. 7, p. 1298-1300, 1960.

The age of the two facies of the Huelgoat granite of Finistère, France, has been determined by potassium-argon and rubidium-strontium measurements on biotite. The Huelgoat facies is  $290 \times 10^6$  yr old by the argon method and  $310 \times 10^6$  yr old by the strontium method, and the La Feuillée facies is  $280 \times 10^6$  yr old by the argon method and  $317 \times 10^6$  yr old by the strontium method. The average age of  $300 \times 10^6$  yr (Middle Carboniferous) confirms the stratigraphic dating of this granite as Hercynian; the equivalent Quintin granite farther to the east is therefore also Middle Carboniferous. — D. B. V.

- 182-43. Jäger, Emilie, and Faul, H[enry]. Alterbestimmungen an einigen Schweizer Gesteinen und dem Granit von Baveno [Age determinations of several Swiss rocks and the Baveno granite]: *Schweizer. Mineralog. Petrog. Mitt.*, v. 40, no. 1, p. 10-12, 1960.

This is an abridged version of an article published in *Geol. Soc. America Bull.*, v. 70, no. 12, pt. 1, p. 1553-1558, 1959 (see *Geophys. Abs.* 180-13). — J. W. C.

- 182-44. Winogradow [Vinogradov] A. P., Tugarinow, A. J. [Tugarinov, A. I.]. Zhirowa [Zhirova], V. V., Sykow [Zykov], S. I., Knorre, K. G., and Lebedew [Lebedev] V. I. Über das Alter der Granite und Erzvorkommen in Sachsen [On the age of the granite and ore occurrences in Saxony]: Freiberger Forschungshefte C 57 Geologie, p. 73-85, 1959.

The ages of 15 metamorphic rocks and granites from Saxony and Bohemia were determined by the potassium-argon method, and the ages of 5 pitchblendes of different epochs of mineralization by the uranium-lead method. The lead isotopic ratios of lead ores from Saxony and Thuringia are also given. Results of these and of many other absolute age determinations from other countries, particularly the U.S.S.R., are analyzed in this discussion of methods of absolute dating and their application to the problem of the magmatic cycles of Saxony.

It is concluded that at least three intrusive cycles took place in Saxony, occurring successively 360-380, 300-320, and about 200 million years ago. The Lower Paleozoic deposits were intensively metamorphosed in the second of these cycles (Early Variscan). The most important ore deposits are related to the third cycle (Late Variscan). Regeneration of the ores as a result of hydrothermal activity occurred at least twice, during Cretaceous (100 million years ago) and Late Tertiary times (5 million years ago).

The existence of a Precambrian magmatic cycle and of an old Precambrian sedimentary complex in this region is extremely doubtful. Certain boundaries on the present international geochronologic scale should be checked. The Devonian-Carboniferous boundary should be moved downward and the Permian-Triassic boundary upward. — D. B. V.

- 182-45. Ledent, Dolly. Âge absolu d'une brannérite de Bou-Azzer (Sud-Morocain) [Absolute age of a brannerite from Bou-Azzer (south Morocco)]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 7, p. 1309-1311, 1960.

A brannerite from the Bou-Azzer deposit in the Anti-Atlas of Morocco has been dated by the lead method. The value of the lead-uranium ratio was controlled by the lead-210 (RaD) method, which is not affected by loss of lead during the analysis.

The ages obtained from the different ratios are as follows:  $Pb^{207}/Pb^{206} = 335 \times 10^6$  yr;  $Pb^{206}/U^{238} = 230 \times 10^6$  (direct Pb/U) and  $240 \times 10^6$  yr (lead-210);  $Pb^{207}/U^{235} = 240 \times 10^6$  yr (direct Pb/U) and  $250 \times 10^6$  yr (lead-210); and  $Pb^{208}/Th^{232} = 320 \times 10^6$  yr. The value  $(240 \pm 10) \times 10^6$  yr is considered to be the most reliable; therefore, the mineralization is probably Permian. — D. B. V.

- 182-46. Schürmann, H. M. E., Aten, A. H. W., Boerboom, A. J. H., Bot, A. C. W. C., Couwenberg, G., Dance, D. F., Hurley, P[atrick] M., Ledent, D[olly], Stauffer, H., Steensma, J. J. S., and Suringa, R. Fourth preliminary note on age determinations of magmatic rocks by means of radioactivity: Geologie en Mijnbouw, v. 39, no. 4, p. 93-104, 1960.

Provisional results of age determinations made partly for checking purposes at Amsterdam and cooperating laboratories are presented. The minerals and methods used are described, and the results are discussed and tabulated. The minerals investigated were from the Precambrian of Egypt, from Miocene deposits on the Egyptian Red Sea coast (galena), from the Late Precambrian of Nigeria, from the Mesozoic tin province of Indonesia, and from the Lausitz granite of East Germany. — D. B. V.

- 182-47. Nesteroff, Wladimir D. Âge des derniers mouvements du graben de la mer Rouge déterminé par la méthode du C<sup>14</sup> appliquée aux récifs fossiles [Age of the last movements of the Red Sea graben determined by the carbon-<sup>14</sup> method applied to fossil reefs]: Soc. Géol. France Bull., ser. 7, v. 1, no. 4, p. 415-418, 1959.

Carbon-14 dating shows that the fossil reef of Abulat Island in the Red Sea is at least 35,500 years old. Rather abrupt uplift, probably a small compensatory movement, occurred at about that time and affected the entire Arabian coastal segment of the Red Sea graben. — D.B.V.

- 182-48. Kratts, K. O. K obsuzhdeniyu voprosa ob absolyutnom vozraste karelid karelii [Discussion of the problem of the absolute age of the Karelian Kareliids]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 9, p. 42-47, 1960.

The potassium-argon ages of the Proterozoic igneous and metamorphic rocks of Karelia range from 1,650 to 1,880 million years. A total of 23 determinations are reported, of which one half fall between 1,730-1,770 million years using Gerling's "new constants". — H.F.

- 182-49. Shurkin, K. A. Obsuzhdenie rezul'tatov opredeleniya absolyutnogo vozrasta porod belomorskogo kompleksa [Discussion of the results of determination of absolute age of rocks of the Belomorye complex]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 9, p. 56-60, 1960.

Potassium-argon ages of the Belomorye complex show no particular grouping, but a majority range from 1,720 to 1,970 million years with a clearly anomalous group from 2,000 to 2,670 million years. The chronology established by Gerling (1956, 1957) is considered to be premature; additional data must be obtained. No data are given. — H.F.

- 182-50. Sudovikov, N. G., Krylova, M. D., and Neelov, A. N. K voprosu ob absolyutnom vozraste Arkheya Aldanskogo shchita [Problem of the absolute age of the Archean of the Aldan shield]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 9, p. 61-67, 1960.

Potassium-argon age measurements on 34 samples ranging in age from 1,700 to 2,120 million years are plotted on a geologic sketch map of the northern part of the Aldan shield. The iron-magnesium-calcium metasomatism of the region may have been weaker in those parts where older ages appear. The postmetasomatic granites are the youngest geologically and give the lowest ages. — H.F.

- 182-51. Bykovskaya, E. V., Polevaya, N. I., and Podgornaya, N. S. Absolyutnyy vozrast Mezo-kaynozoyskikh vulkanogennykh i intruzivnykh obrazovaniy Ol'ga-Tetyukhinskogo rayona [Absolute age of Meso-Cenozoic volcanic and intrusive formations of the Ol'ga-Tetyukhin region]: Sovetskaya Geologiya, no. 5, p. 107-114, 1960.

Age determinations of the igneous rocks of the Ol'ga-Tetyukhin region are facilitated by the relatively high potassium content of the rocks. Further, there are reliable biostratigraphic ages for many of the volcanic rocks, and clear age relationships are commonly observed between the intrusives and the ex-

trusives. Therefore, the geologic conditions are favorable for dating the igneous activity for a period of 30-40 million years from the second half of the Late Cretaceous to the Late Paleogene. A geologic column is presented, and the data of the potassium-argon determinations are tabulated. This study indicates the potential of the argon method for use in age determinations of relatively young rocks. — J. W. C.

- 182-52. Polevaya, N. I., and Izokh, E. P. *Absolyutnyy vozrast verkhne-melovykh i tretichnykh effuzivnykh i intruzivnykh porod Severnogo Sikhote-Alinya i khrebeta Myao-Chan* [Absolute age of the Upper Cretaceous and Tertiary extrusive and intrusive rocks of the northern Sikhote-Alin and of the Myao-Chan range]: Akad. Nauk SSSR Izv. Ser. Geol., no. 7, p. 46-50, 1960.

The results of potassium-argon age determinations on 8 specimens of igneous rocks from the northern part of the Sikhote-Alin range and on 8 specimens from the Myao-Chan range are tabulated. Two different intrusive series are distinguished, one about 58-63 million years old (Tertiary) and the other 75-113 million years old (Upper Cretaceous). The potassium-argon ages agree with geologically determined ages based on fossil flora and intrusive relationships. These ages are considered reliable enough to be very useful in working out the complicated successions within each series (including post-magmatic mineralization) and their relationships to each other where they occur together. — D. B. V.

- 182-53. Firsov, L. V. *Absolyutnyy vozrast izvershennykh porod magadan-skogo batolita* [Absolute age of the igneous rocks of the Magadan batholith]: Akad. Nauk SSSR Izv. Ser. Geol., no. 2, p. 28-38, 1960.

The absolute ages have been determined by the argon method for several facies of the Magadan batholith, which crops out on the shores of the Tauysk Gulf of the Sea of Okhotsk near the city of Magadan. The results not only confirm the geologically deduced age, but also illustrate the applicability of the argon method to Late Mesozoic igneous rocks.

The results of 28 analyses of 11 rock facies, given in a table, indicate that there have been six intrusive phases: (1) small intrusions of gabbro and gabbro-diorite,  $134 \times 10^6$  yr ago; (2) small intrusions of trondjemitic granite,  $130 \times 10^6$  yr ago; (3) quartz diorite intrusions, contemporaneous with the Lower Cretaceous lavas of intermediate composition,  $122-125 \times 10^6$  yr ago; (4) widespread intrusions of granodiorite (main phase of batholith formation),  $115 \times 10^6$  yr ago; (5) intrusions of various other granites,  $90-105 \times 10^6$  yr ago; and (6) formation of feldspar and feldspar-quartz veins and small intrusions of alkali-line and subalkaline molybdenum-bearing rocks,  $70-78 \times 10^6$  yr ago. — D. B. V.

- 182-54. Sivaramakrishnan, [M.] V., and Venkatasubramaniam, V. S. Ages of some detrital monazites by the lead-alpha method of geochronology: India Natl. Inst. Sci. Proc., v. 25, pt. A, no. 5, p. 278-280, 1959.

The lead-alpha ages of some monazites and cheralites from the states of Yediyur and Kerala, India, were determined. The age of  $2,200 \pm 100$  million years, obtained for a monazite crystal from Yediyur, agrees well with the age suggested by Holmes from isotopic lead studies and places this pegmatitic cycle in possibly the oldest of Archean structural provinces of India, the Dhawars. The monazites of Kerala State yielded an age of 750 million years, which is higher than that of Holmes' (630 million years); this may be a result of the fact that the samples here investigated were from beach sands and may

represent a mixture from different pegmatites. The age of the cheralites, 450 million years, agrees well with that of Holmes and suggests that the Balangoda group of pegmatites of late Precambrian to early Cambrian age is represented in Kerala State. — V. S. N.

- 182-55. Compston, W., Jeffery, P. M., and Riley, G. H. Age of emplacement of granites: *Nature*, v. 186, no. 4726, p. 702-703, 1960.

Rubidium-strontium age determinations were made on total-rock samples of a metamorphosed granite and associated pegmatites from Mundaring, Western Australia, in which pegmatitic muscovite and microcline were the only minerals to retain an old rubidium-strontium age. Although each total-rock sample was found to have a different rubidium-strontium ratio, they all gave the same age ( $2,700 \times 10^6$  yr) for a unique value of the initial  $\text{Sr}^{87}/\text{Sr}^{86}$  ratio; this was also the age given by the muscovite. It is concluded that this value represents the age of emplacement of the granite, and that the total-rock analysis method is the simplest and least ambiguous method of detecting this age. If so, the widely held premise that pegmatites can form immediately on solidification of a granite is confirmed.

None of the potassium feldspars from these granitic rocks exhibits complete preservation of the  $2,700 \times 10^6$  yr event; pegmatitic microcline comes closest at  $2,300 \times 10^6$  yr, whereas granitic microclines show any "age" down to about  $650 \times 10^6$  yr; this is also the age registered by all biotites. Pegmatitic muscovite and micromuscovite formed in the granite during saussuritization of plagioclase show complete retention; the latter indicates that saussuritization was definitely a late-stage magmatic process in this case. — D. B. V.

- 182-56. Cameron, R. L., Goldich, S. S., and Hoffman, J[ohn] H. Radioactivity age of rocks from the Windmill Islands, Budd Coast, Antarctica: *Acta Univ. Stockholm.*, Stockholm Contr. in Geology
- v. 6, no. 1, p. 1-6, 1960.

Two samples of gneiss and one of quartz diorite from the Windmill Islands, Budd Coast, Antarctica have been dated at 950-1,120 million years by the  $\text{Ar}^{40}/\text{K}^{40}$  method. An age determination by the  $\text{Sr}^{87}/\text{Rb}^{87}$  method for one of the gneiss samples agrees with the potassium-argon age. A period of orogeny and high grade metamorphism contemporaneous with the Grenville orogeny of eastern North America is indicated. — Authors' abstract

- 182-57. Zeller, E[dward] J., and Pearn, W. C. Determination of past Antarctic climates by thermoluminescence of rocks: *Internat. Geophys. Year Bull.*, no. 33, in *Am. Geophys. Union Trans.*, v. 41, no. 1, p. 118-121, 1960.

A total of 46 carbonate rock samples were collected in the McMurdo Sound region of Antarctica for thermoluminescence study. Four important values were measured by techniques that are described briefly: the natural low-temperature thermoluminescence of the sample, the gamma-radiation dosage necessary to duplicate the natural thermoluminescence, the equivalent alpha dosage, and the natural alpha activity. From these values it was possible to calculate the length of time required for the natural alpha bombardment rate to have produced the observed low-temperature luminescence; this is 170,000 years for the most thermoluminescent sample. Because of certain implicit assumptions and sources of error in the calculations, this value must be considered a minimum for the time that has elapsed since the Antarctic became cold. — D. B. V.

## COSMOGONY

- 182-58. Egyed, L[ászló]. The expansion of the earth in connection with its origin and evolution: *Geophysica* [Helsinki], v. 7, no. 1, p. 13-22, 1959.

Egyed summarizes his theory of an expanding earth (see *Geophys. Abs.* 177-178, 178-215) and uses this same idea of expansion to suggest a new theory for the origin of the solar system. As a starting point, a pre-solar system sun having an enormous density and a small volume, an initial angular velocity many times the present one, and very great gravity acceleration within and on the surface is assumed. Since the gravity coefficient varies with time, the phase boundaries of the ultra high-pressure phases shifted into increasing depth and part of the sun's mass was transferred into a lower density state, resulting in a volume increase of the sun and a decrease in both centrifugal force and gravity acceleration on the solar surface. Gravity acceleration diminished still further because of the change in the gravity coefficient. At a certain time when the weight and centrifugal acceleration of a given mass became equal on the solar equator, part of the solar mass escaped and began independent revolution as a planet. The play of forces repeated itself, but as the time intervals necessary for an escape became gradually longer the process ceased to repeat. The planets increased in density in order of formation because as each escaped from the sun the average density and the surface density of the sun increased.

The gravity field in the interior of the initial earth was very strong as compared to the present one; this strong field produced intense gravity differentiation in the ancient mantle resulting in a quartz-rich granodioritic mass of smaller density above a shell of more basic material. The continued steady decay of matter in the core with time has yielded a continuous trickle of material to be further differentiated. The differentiation pattern which developed can explain the low velocity channel of Gutenberg by material differences rather than by thermal effects. Taking into account the theory of earth expansion, the depth of the channel is found to vary in different areas. Seismological observations are in good agreement with this. — V. S. N.

- 182-59. Egyed, L[ászló]. Dirac's cosmology and the origin of the solar system: *Nature*, v. 186, no. 4725, p. 621-622, 1960.

This is virtually the same as the paper published in *Geophysica* [Helsinki], v. 7, no. 1, p. 13-22, 1959 (see *Geophys. Abs.* 182-58). — W. L. G.

Gilbert, C. Dirac's cosmology and the general theory of relativity. See *Geophys. Abs.* 182-281.

- 182-60. Omori, Keiichi. A consideration of the origin of some saline minerals (A concept of astronomical geology—pt. 1): *Tohoku Univ. Sci. Repts., ser. 3*, v. 6, no. 3, p. 405-407, 1960.

Large concentrations of saline minerals were deposited at definite times in geologic history, but the cause of the conditions favoring their deposition has not been satisfactorily explained. It is suggested that the passage of a large star near the earth would disturb the revolution and rotation of the earth and produce sudden changes in temperature and other physical conditions. Changes in sea-water concentration would result in deposition of saline minerals, and many kinds of animals and plants would become extinct. This might be an explanation for the gaps in the geologic sequence.

To support this theory Omori tabulates data on 62 stars that passed near the earth, including distances and the time of passing. In addition to a general correspondence with periods of saline deposition, the dates of passing of the seven nearest stars fit in with the stages of Pleistocene glaciation. — D. B. V.

- 182-61. Brown, Harrison. The density and mass distribution of meteoritic bodies in the neighborhood of the earth's orbit: *Jour. Geophys. Research*, v. 65, no. 6, p. 1679-1683, 1960.

A study of the frequency of meteorite falls throughout the last century indicates that the average rate of fall of meteorites on the earth probably lies between 0.32 and 1.0 falls per yr per  $10^6$  sq km. The frequency of fall as a function of type and mass has been studied, and it is shown that the distribution curves for stones and irons have similar shapes. The curves are also remarkably similar to those observed for asteroids.

The observed relationships are used to calculate the impact frequency of meteoritic particles upon the earth and moon as a function of their size; results are tabulated. Two sets of values are given. The first set is uncorrected and the second corrected for seasonal and diurnal variations in recovery efficiency. The results in turn have been translated into collision frequencies with the moon. It is assumed that, because of the higher gravitational field of the earth, the frequency of impact upon the earth is increased by about 30 percent above that calculated from geometry. — D. B. V.

- 182-62. Gallagher, P. B., and Eshelman, V. R. "Sporadic shower" properties of very small meteors: *Jour. Geophys. Research*, v. 65, no. 6, p. 1846-1847, 1960.

The number-mass, number-speed, and number-time distributions of very small meteors have been investigated since early 1957 by means of daily radar measurements of ionized trails produced by meteors as small as the 15th visual magnitude. The results show that most meteoritic particles which normally would be classified as sporadic are in fact distributed in a vast number of relatively small groupings (having characteristic dimensions less than about  $10^9$  m), and that on the average the earth is immersed in about 11 of these groupings at a time. As most meteoritic material in the solar system is believed to be associated with present or past comets, the observed particle groupings in the meteor population may indicate the presence of a large number of very small, subvisual comets. If so, it may be necessary to alter present theories of the origin, dynamics, and lifetime of interplanetary matter. — D. B. V.

- 182-63. Nier, Alfred O. Cosmic-ray effects in meteorites: *Am. Geophys. Union Trans.*, v. 41, no. 2, p. 289-291, 1960.

Studies of the effects of cosmic-ray bombardment of meteorites in the past few years have included measurement of the radioactive and stable isotopes produced as well as attempts to understand the phenomena in terms of reactions produced in the laboratory by the bombardment of targets by high-energy proton beams. The work of investigators in different laboratories is summarized briefly. — D. B. V.

- 182-64. Wänke, H., and Vilczek, Else. Argon 39 als Reaktionsprodukt der Höhenstrahlung in Eisenmeteoriten [Argon-39 as cosmic ray reaction product in iron meteorites]: Zeitschr. Naturforschung, v. 14a, no. 11, p. 929-934, 1959.

Argon-39, produced in meteorites by cosmic ray action on iron nuclei, has been investigated in three iron meteorites (Treysa, Carbo, and Clark County). An argon-39 decay rate of  $0.36 \pm 0.02$  disintegrations per kg per sec was obtained for Treysa at the time of its fall. The other two did not have measurable amounts of argon-39, which shows that they must have fallen more than 1,000 years ago.

From these measurements an age of  $6.0 \times 10^8$  yr can be calculated for Treysa, and a value of  $I_0 = 0.25 \pm 0.07$  particles per  $\text{cm}^{-2}$  per sec $^{-1}$  per sterad $^{-1}$  is obtained for the intensity of cosmic radiation for particles with energies of more than 1 Gev. — D. B. V.

- 182-65. Levskiy, L. K. Pogloshcheniye kosmicheskoy radiatsii v zheleznykh meteoritakh [Absorption of cosmic radiation in iron meteorites]: Geokhimiya, no. 3, p. 274-277, 1960.

The cosmic ray absorption of individual samples from the Sikhote-Alin meteorite shower has been calculated on the basis of measurements of their helium-3 content, using 3 different ratios of preatmospheric to postatmospheric radii and 2 different assumptions as to position of the sample with respect to the center of gravity of the body. The maximum value of cosmic ray absorption was found to be 560 g per  $\text{cm}^2$ . — D. B. V.

- 182-66. Anders, E. The record in the meteorites-II. On the presence of aluminium-26 in meteorites and tektites: Geochim. et Cosmochim. Acta, v. 19, no. 1, p. 53-62, 1960.

The sensitivity and specificity of gamma-gamma coincidence spectrometry were sufficient to permit nondestructive determination of aluminum-26 in a 70-g specimen of the Plainview chondrite; the specific activity was found to be  $0.058 \pm 0.005$  positrons per min per g, in agreement with the value found by Ehmann and Kohman (see Geophys. Abs. 175-330).

In the case of tektites chemical separation of the aluminum fraction was necessary because of interference by the uranium and thorium series. Correcting for contaminant, the counting rate for an australite was found to be  $0.000 \pm 0.009$  positrons per min per g and the upper limit for the aluminum-26 content of australites to be  $\leq 0.022$  disintegrations per min per g; this limit corresponds to a "flight time" of  $\leq 5 \times 10^5$  yr, and makes a terrestrial origin of tektites a possibility. — D. B. V.

- 182-67. Maringer, R. E., and Manning, G. K. Aerodynamic heating of the Grant meteorite: Geochim. et Cosmochim. Acta, v. 18, no. 3/4, p. 157-161, 1960.

The "heat-affected zone" near the surface of the Grant meteorite has been examined by metallographic means. This zone, produced by aerodynamic heating during fall, serves as a record of the thermal gradient that produced it. The thermal gradient has been reconstructed on the basis of comparison of structure and hardness within this zone with artificially heat-treated meteorite specimens. From the shape of the thermal gradient, the rate of heat transfer into the meteorite has been calculated as 220 cal per  $\text{cm}^2$  per sec, and the average rate of ablation as at least 1-2 mm per sec. — D. B. V.

- 182-68. Dietz, Robert S. Meteorite impact suggested by shatter cones in rock: *Science*, v. 131, no. 3416, p. 1781-1784, 1960.

A giant meteorite should strike the earth with a velocity of about 15,000 m per sec. A principle effect of this impact is generation of an intense shock wave, which spreads out from the impact point and engulfs a great volume of rock before it finally decays into an elastic wave. As it is doubtful that volcanic explosions are powerful enough to develop shock waves in rock and as lightning could do so only very locally, the presence of intense natural shock effects in rock should constitute a definite criterion for past meteorite impacts.

Shatter cones have been found in this country only very near the centers of cryptovolcanic structures. (The term "cryptoexplosion" is preferable to "cryptovolcanic," as it does not exclude the possibility of extraterrestrial origin.) The orientation of the shatter cones is useful for establishing the direction of impact.

Astroblemes (fossil meteorite impact scars) may be useful for understanding the origin of lunar craters. At the very least, all deformations that contain shatter cones must be assigned a single mode of origin. — D. B. V.

- 182-69. Schaeffer, O[liver] A., and Zähringer, J. Helium- und Argon-Erzeugung in Eisentargets durch energiereiche Protonen [Helium and argon production in iron targets by high-energy protons]: *Zeitschr. Naturforschung*, v. 13a, no. 4, p. 346-347, 1958.

The helium and argon isotopes produced by bombarding small iron targets with protons of 0.16, 0.43, and 3.0 Gev energy in the Harvard and Chicago synchrocyclotrons and in the Brookhaven cosmotron have been measured and compared with the amounts found in meteorites. It is calculated that for an average energy of 3 Gev (corresponding to cosmic radiation) the production cross section for helium-3 is 240 mb; for tritium, 100 mb; for argon-37, 6 mb; and for argon-38, about 15 mb. The  $(He^3+T)/Ar^{38}$  ratio calculated from these figures is 23, which corresponds with amounts measured in meteorites. — D. B. V.

- 182-70. Herr, W., Hoffmeister, W., and Langhoff, J. Die Bestimmung von Rhenium und Osmium in Eisenmeteoriten durch Neutronaktivierung [The determination of rhenium and osmium in iron meteorites by neutron activation]: *Zeitschr. Naturforschung.*, v. 15a, no. 2, p. 99-102, 1960.

The average rhenium and osmium content of 10 iron meteorites has been determined by means of neutron activation to be 0.071 atoms of rhenium per  $10^6$  iron atoms and 0.64 atoms of osmium per  $10^6$  iron atoms. Concentrations within individual meteorites are very uniform.

Inasmuch as iron meteorites contain practically no uranium and little potassium, the possibility of dating by the rhenium-osmium method is of great interest, particularly because the disintegration process is not affected by cosmic-ray spallation processes. This will be treated in a later publication. — D. B. V.

- 182-71. Eberhardt, Peter, and Hess, David C. Helium in stone meteorites: *Astrophys. Jour.*, v. 131, no. 1, p. 38-46, 1960.

The helium in 13 stone meteorites was measured by isotopic dilution. The helium-4 ages for 7 chondrites range from 1.0 to 4.4 billion years. Cosmic-ray ages deduced from the helium-3 content are lower by several orders of magnitude.

All chondrites show very low cosmic-ray ages, whereas some iron meteorites have been found with ages up to 1.7 billion years. An explanation of this discrepancy is offered as follows: Collisions between fragments in the asteroidal belt are frequent; stone meteorites are liable to break up rapidly into very fine particles, but iron meteorites are more resistant and should have a much longer life. If the average life of a stone meteorite against destruction by collisions ("collision life") is small compared with the life against capture by planets, then the collision life will determine the time of exposure to cosmic radiation and, therefore, the cosmic-ray age. As the irons have a much longer collision life than the stones, much greater cosmic ages are possible.

The experimental data agree with this model. The average collision life of stone meteorites in the asteroidal belt would be about 10 million years, compared to several hundred million years for iron meteorites. The model favors the survival of iron meteorites; the observed ratio of iron to stone meteorites is shifted by a factor of 10 or more in favor of the irons. — D. B. V.

- 182-72. Hoffman, J[ohn] H., and Nier, A[lfred] O. Cosmic-ray-produced helium in the Keen Mountain and Casas Grandes meteorites: *Jour. Geophys. Research*, v. 65, no. 3, p. 1063-1068, 1960.

The helium-3 and helium-4 distributions have been measured in the Keen Mountain and Casas Grandes iron meteorites. No depth effect was noted in the former, which is small (6.75 kg), but in the latter (1,550 kg) a depth effect was observed and contours of constant helium-3 and helium-4 could be drawn.

The results are explained in terms of the model presented earlier in connection with similar work on the Grant meteorite (see *Geophys. Abs.* 180-23). The preatmospheric radius calculated from this model affords an estimate of the amount of shielding surrounding the center of the meteorite; thus, the central helium concentration may be related quantitatively to the time integral of the cosmic-ray flux. Assuming a constant cosmic-ray flux of 0.25 particles per  $\text{cm}^2$  steradian, the radiation ages are calculated to be  $2 \times 10^8$  yr for Keen Mountain and  $7 \times 10^8$  for Casas Grandes. The latter is similar to that of two other large iron meteorites, Grant and Carbo. Their similar ratios of post-atmospheric to preatmospheric radius ( $r/R$ ) suggest that these three also had similar velocities of approach to the atmosphere, whereas the Keen Mountain appears to have a somewhat lower radiation age and likewise a higher geocentric velocity, indicated by the low value of 0.20 for  $r/R$ . — D. B. V.

- 182-73. Schaeffer, Oliver A., and Fisher, David E. Exposure ages for iron meteorites: *Nature*, v. 186, no. 4730, p. 1040-1042, 1960.

It is possible to establish a scale of the production rate of a given nuclide as a function of a rare gas ratio in meteorites; these production cross sections are not very sensitive to the energy and so are practically independent of the depth of the sample in the meteorite (see also *Geophys. Abs.* 182-69).

When the results in the literature are plotted on a graph, it can be seen that there is a definite change in the production rate of helium-3 with the ratio  $\text{He}^3/\text{Ar}^{38}$ . It should be possible to use this rate to interpret results on rare gas contents of iron meteorites. Using the production rate as shown in the graph, the  $\text{He}^3/\text{Ar}^{38}$  ratio, and the helium-3 content, the cosmic-ray exposure

ages of 18 meteorites are calculated. These ages show a variation extending to nearly 2 billion years, with a most probable value near 100-200 million years. This can be interpreted as characteristic of a continual breaking-up process of bodies in space, leading to freshly exposed surfaces. — D. B. V.

Singer, S. F. Production of tritium in nuclear spallations. See Geophys. Abs. 182-373.

- 182-74. Groeneveld, D. A new iron meteorite from Bellsbank, Barkly West district: South Africa Geol. Soc. Trans. and Proc., v. 62, p. 75-78, 1959.

An iron meteorite found in 1955 on Bellsbank Estate, 27 miles north-north-west of Brakly West, South Africa, is described. The meteorite, a nickel-poor iron meteorite of subgroup hexahedrite, consists of kamacite (Fe-Ni alloy) and irregular veins of schreibersite [(Fe, Ni)<sub>3</sub>P] up to 1 cm wide. Silicates are minor constituents, and goethite and magnetite occur as weathering products. Results of etch tests, physical-property tests, X-ray diffraction data, and chemical analyses of the kamacite and schreibersite are given. — V. S. N.

- 182-75. Gentner, W., and Zähringer, J. Das Kalium-Argon-Alter von Tektites [The potassium-argon age of tektites]: Zeitschr. Naturforschung, v. 15a, no. 2, p. 93-99, 1960.

The ages of various kinds of tektites have been determined by the potassium-argon method. Bediasites and moldavites are  $29.4 \times 10^6$  and  $8.7 \times 10^6$  yr, respectively, and tektites from different localities between Australia and Indo-china give concordant ages of 610,000 yr. These results agree with the ages of the formations in which the tektites occur. It is concluded that tektites are probably formed from terrestrial material as a result of impact of asteroids or comets (see also Geophys. Abs. 179-17). — D. B. V.

- 182-76. Hawkins, Gerald S., and Wolfson, Sumner H. Solar furnace glass: Nature, v. 186, no. 4730, p. 1027-1028, 1960.

To elucidate the suggestion that tektites are formed by fusion of terrestrial material, samples of sandstone and topsoil from regions in Texas and Georgia where tektites have been found were fused in a solar furnace. A thin section of one of the resulting glasses shows flowlines and bubbles but no evidence of lechatelierite particles. Strain was indicated by incomplete extinction; Texas and Philippine tektites, on the other hand, show extinction with crossed nicols. The tektite glass may have cooled more slowly or may have been annealed at ordinary temperatures over a long period of time.

It is calculated that about 5 minutes must elapse before a sphere 2 cm in diameter could be fused by passage through the upper atmosphere at a velocity of 10 km/psec. Single tektites, therefore, could not be fused in the atmosphere, as particles of this size would decelerate in a few seconds. There is sufficient energy for tektites to form as drops from the surface of a much larger object, but glass objects have never been recovered from the 590 stone falls already observed. It is further calculated that only a small quantity of glass could be produced by meteor impact on the moon, and only a portion of this would reach the earth. It is more probable that the effective heat of fusion ( $2 \times 10^{11}$  ergs per g) is supplied by terrestrial phenomena such as volcanic activity or lightning. — D. B. V.

- 182-77. Moore, Patrick. Problems of the moon: *Adv. Sci.*, v. 17, no. 65, p. 33-41, 1960.

A few of the outstanding problems associated with the study of the moon's surface are discussed including a brief review of interpretations of these problems today and in the past. It is not known whether the surface of the moon is changeless or whether minor activity still occurs, how the maria and craters were produced, what the precise nature of the surface layer is, or whether or not a trace of atmosphere exists.

A summary of observations indicates that major alterations of the lunar surface do not occur, but in two cases—Linné and Alphonsus—reports of minor activity are sufficiently convincing to merit close attention. Two theories are considered to explain the surface topography: The first supposes the craters to be igneous, and the second attributes them to meteoric impact. A review of the evidence suggests the rejection of the meteoric origin for the majority of the large formations and indicates that the craters can be due only to the release of forces within the moon. It is known that the surface layer of the moon is a poor conductor of heat and is likely to be composed of dusty or ashy material. There is no agreement on the depth of this material. Finally, it seems that the lunar atmosphere is negligible. — V.S.N.

- 182-78. Urey, H[arold] C. The origin and nature of the moon: *Endeavour*, v. 19, no. 74, p. 87-99, 1960.

Present theories concerning the origin and nature of the moon are reviewed. Study of photographs of the moon's surface leads to the conclusion that the relief was fashioned mostly by great collisions some 4.5 billion years ago during a relatively short period—probably less than a million years. Since then it has been bombarded by lesser objects which have produced mostly smaller craters. No new important conclusions can be drawn from the pictures of the other side of the moon so far made available.

The most immediate task of lunar exploration should be to determine the composition and physical character of the maria. If the story of the moon presented here is correct, the usual processes of geology will have little application to selenology. — D.B.V.

- 182-79. Lacroute, Pierre. Sur la formation des mers lunaires [On the formation of the lunar maria]: *Acad. Sci. [Paris] Comptes Rendus*, v. 249, no. 23, p. 2495-2496, 1959.

An attempt is made to explain the relatively small number of maria shown in the photograph of the back of the moon in terms of meteor impact origin. Calculations show that the earth's gravity exerts a lens effect on the trajectories of certain groups of meteorites arriving parallel to the earth's orbital plane; therefore, a larger number of falls on the side of the moon facing the earth should be expected. Craters appear to be more homogeneously distributed than maria; if this is so, then the meteorites that cause craters must be on very different orbits from those that produce maria. — D.B.V.

- 182-80. Hédervári, Péter. A jelenlegi Hold-vulkánizmus kérdéséről [The question of present-day moon volcanism]: *Földtani Közlöny*, v. 89, no. 3, p. 313-316, 1959.

A new red spot in Alphonsus crater on the moon, observed by Wilkins in England 16 days after the volcanic gas explosion reported by Kozyrev (see *Geophys. Abs.* 177-368), probably represents lava. The quantity of lava and

the estimated volume of gas emitted ( $100,000 \text{ m}^3$ ) are small in comparison to the dimensions of Alphonsus. The eruption apparently was an Etna-type explosion. It is suggested that Alphonsus has two vents. The main vent is wider and contains a huge plug whose upper part forms the central peak. The gas and lava were erupted from a narrower vent, which has no plug and which forms a parasite crater on the side of the main vent. — D. B. V.

## EARTH CURRENTS

- 182-81. Hessler, V. P., and Wescott, E. M. Correlation between earth-current and geomagnetic disturbance: *Nature*, v. 184, no. 4686, supp. 9, p. 627, 1959.

The close correlation between geoelectric and geomagnetic activity is demonstrated quantitatively. Correlation coefficients were calculated for each of six months, using magnetic and earth-current records taken at College, Alaska. The correlations were made between the equivalent daily amplitude,  $A_{co}$ , of the magnetic activity and the daily earth-current activity. The values of the correlation coefficients for six randomly selected months range from 0.939 to 0.975. Scatter diagrams were plotted and least-squares regression lines calculated for each month; there were no widely scattered points. The correlation coefficient of earth-current activity (in mv per km) versus magnetic activity (in gammas) calculated for the 3-hr periods of April 1958 (240 values) is 0.833.

These very high correlation coefficients show that earth currents may be used interchangeably with magnetic disturbances as an indicator of ionospheric activity. In areas free from d-c interference an earth-current recording system can be set up more readily than a comparable magnetic system; only 1 recorder and 1 pair of electrodes oriented in the preferred direction of the earth-current disturbance are required, and none of the equipment needs to be isolated from the usual laboratory activities that would interfere with operation of a magnetometer. — D. B. V.

- 182-82. Schmucker, Ulrich. Erdmagnetische Tiefensondierung in Deutschland 1957/59: Magnetogramme und erste Auswertung [Geomagnetic deep sounding in Germany in 1957-59—magnetograms and preliminary interpretation]: *Akad. Wiss. Göttingen Abh., Math.-Phys. Kl.*, no. 5, 51 p., 1959.

"Geomagnetic deep sounding" is the study of the form and position of inhomogeneities in the earth's outer mantle and crust by means of geomagnetic observations. The penetration of earth currents induced by geomagnetic variations varies directly with their period; for diurnal Sq ( $T=24 \text{ hr}$ ) the depth of penetration is 500 km.

This paper is a detailed investigation of the anomalies in electrical conductivity observed in north Germany by means of a system of geomagnetic satellite stations (temporary observatories). The distribution and equipment of these stations is discussed, and the observations are described and evaluated.

There is no anomalous inner portion in the declination; the anomaly runs nearly east and west. Both of the models that were postulated to explain the anomaly yield a zone of increased conductivity (at least  $10^{-11} \text{ cgs}$ ) below a line from Lüneburger Heide (Ebtorf) to Emsland (Lathen). The anomaly cannot be explained in terms of inhomogeneities in the sedimentary layer, nor of deeper inhomogeneities in material reflected by gravity surveys. It is suggested that the cause is an irregular temperature distribution in the mantle, due either to unequal distribution of radioactive sources or to irregularities in heat conductivity. — D. B. V.

Hutton, Rosemary. Regular micropulsations of the earth's field at the equator. See Geophys. Abs. 182-384.

Miguel [y Gonzales Miranda], Luis de. Induction coil for the study of the rapid variations of the geomagnetic field. See Geophys. Abs. 182-402.

#### EARTHQUAKES AND EARTHQUAKE WAVES

- 182-83. Woppard, G[eorge] P[rior]. Current developments in seismological research: Am. Geophys. Union Trans., v. 41, no. 2, p. 155-157, 1960.

Progress in seismological research in the United States during the International Geophysical Year was made in the following directions: (a) epicentral studies on earthquake distribution, (b) body-wave studies of the internal structure of the earth, (c) Rayleigh- and Love-wave studies of the crust and mantle, (d) crustal strain studies, (e) microseism studies, (f) explosion-blast studies of the crust, and (g) explosion-blast studies of surficial geology. Some of the more significant results are summarized briefly. — D. B. V.

- 182-84. da Costa, Jose A. Water-level fluctuations caused by Montana earthquake: Am. Geophys. Union Trans., v. 40, no. 4, p. 346, 1959.

The earthquake of August 17, 1959, near the Montana-Wyoming border had marked effects on water levels and artesian pressures in wells throughout the United States. Preliminary reports from offices in 21 states show that water-level fluctuations were recorded in 136 wells; the distribution of these wells and the maximum double amplitude of the fluctuations are tabulated. In some areas fluctuations produced by aftershocks were also recorded.

The maximum fluctuation reported was more than 10 ft; it occurred in a 304-ft artesian well about 85 miles south of the epicenter. Fluctuations of up to 0.10 ft and of 0.01 ft were recorded in Hawaii and Puerto Rico, respectively. Fluctuations of 0.05-0.17 ft in three mine-water pools in northeastern Pennsylvania are of particular interest. — D. B. V.

- 182-85. Hopkins, W. B., and Simpson, T. A. Montana earthquakes noted in Pennsylvania mine-water pools: Am. Geophys. Union Trans., v. 41, no. 3, p. 435-436, 1960.

The major shock wave of the Montana earthquake of August 18, 1959, was recorded by continuous water-level recorders in three mine shafts in northeastern Pennsylvania. The maximum rise and fall and the double amplitude in each shaft are tabulated.

The shock-wave front approached at approximately right angles to the structure, a large northeast-trending synclinorium. The initial shock along the northwest flank may have caused the structure to decrease in volume as the result of compressional stress, so that the water level rose. As the shock wave passed through and across the structure, a corresponding decrease in water level occurred owing to removal of the stress. Seiche effects, if present, would have been damped by the complicated form of the pools. (See also Geophys. Abs. 182-84.) — D. B. V.

- 182-86. Hudson, D. E., and Housner, G[eorge] W. Response spectrum analysis of the San Francisco earthquake of March 22, 1957, in San Francisco Earthquakes of March 1957: California Div. Mines Spec. Rept. 57, p. 115-123, 1959.

Strong-motion accelerometer records for the San Francisco earthquakes of March 22, 1957, were obtained from five stations located in buildings in San Francisco and Oakland, Calif. The ground motion was somewhat different from most recorded strong-motion earthquakes in that the time durations were relatively short and peak accelerations were large for a shock of this magnitude. Spectrum curves indicate that the influence of damping in reducing the peak values was not as marked as in more typical damaging earthquakes. This was a consequence of the short duration of the earthquake and the fact that the maximum structural responses occurred near the start of the motion. (See also Geophys. Abs. 174-46.) — V. S. N.

- 182-87. Leonov, N. N. Khaitskoye zemletryaseniye 1949 g. i geologicheskiye usloviya ego vozniknoveniya [Khait earthquake of 1949 and the geologic conditions of its origin]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 409-424, 1960.

An earthquake of magnitude 9 recorded on July 10, 1949, at 9<sup>h</sup>54<sup>m</sup> local time occurred in the Garm region near Khait in the Tadzhik S. S. R. Geomorphological consequences of the earthquake are discussed, and seismic and geological maps are presented. The Khait earthquake took place at the juncture of the Tien Shan and Pamir where the Djirgatal' block and the northern part of Peter I Range are undergoing intense uplift while the Kabut-Crimea block and the valley of the Surkhob River are under an equally intense subsidence. The relationship of this earthquake to the ruptures that separate the blocks is confirmed by: (1) the configuration of the epicentral zone and the characteristic distribution of the seismic waves; (2) the distribution of geomorphological dislocations on the surface of the earth; (3) the location of the main focus; and (4) the distribution of the aftershocks and the character of the dislocations. — A. J. S.

- 182-88. Quarterly Journal Seismology. The Etorofu-Oki earthquake of November 7, 1958 [in Japanese]: Quart. Jour. Seismology [Tokyo], v. 24, no. 3, p. 65-89, 1959.

The Etorofu-Oki earthquake occurred on November 7, 1958, at 07<sup>h</sup>08<sup>m</sup>09<sup>s</sup>; its epicenter was at lat 44° N.; long 148.7° E., the focal depth was 80 km, and the estimated magnitude was 8-8 $\frac{1}{4}$ . The following items are discussed and well illustrated: distribution of intensities, origin and traveltimes, distribution of initial motion, aftershocks, magnitude, tsunami, sea shock, and damage to manmade structures. — V. S. N.

- 182-89. Gzovskiy, M. V. Tektonofizika i seysmicheskoye rayonirovaniye [Tectonophysics and seismic regionalization]: Akad. Nauk SSSR Sovet po Seismologii Byull., no. 8, p. 67-72, 1960.

Seismotectonic maps should show zones where earthquakes have occurred and will occur on a basis of depth, energy, and frequency of occurrence. The sum of seismostatistical data can best be expressed for each point (or for each uniform zone) by means of the main parameters of the logarithmic curve of frequency of earthquakes with different energies: The maximum energy of earthquakes occurring at this point ( $U_{S\max}$ ); the angular coefficient  $\nu$  of the straight part of the curve in regions of weak earthquakes; and the position of the straight part of the curve, determined by the frequency of earthquakes of some particular energy ( $N_j$ ).

Gzovskiy considers that the most important element of a seismotectonic map should be delineation of zones of different values of  $U_{S\max}$  for earth-

quakes of a particular focal depth; the parts of the zones drawn on the basis of earthquake data should be distinguished from those based on extrapolation and interpolation of geologic evidence. The earthquake frequency  $N_i$  should be superposed on these traces, and it might be expedient to show the value of  $\nu$ .

The determination of each of these parameters from earthquake data and geologic structure is discussed. — D. B. V.

- 182-90. Kats, A. Z. O fizicheskikh osnovakh metodiki seysmicheskogo mikrorayonirovaniya [On the physical principles of the method of seismic microregionalization]: Akad. Nauk SSSR Sovet po Seismologii Byull., no. 8, p. 73-79, 1960.

It has been shown that the intensity of ground oscillations depends largely on the physical properties of the surface layer, its thickness, and the physical properties of the underlying medium. In this paper amplitude-period relationships are examined, using data obtained by the Krasnopolyana seismic expedition.

It is concluded that the resonance character of vibrations at the surface must be taken into account in calculating the properties of the ground for purposes of seismic microregionalization. If the thickness of the surface layer is small in comparison with wavelength, the vibrations of the surface cannot be distinguished in practice from vibrations of the bedrock surface. If the surface layer is thick, not only the fundamental maximum but also maximums corresponding to shorter periods become significant. — D. B. V.

- 182-91. Malaroda, Roberto, and Raimondi, Carlo. Linee di dislocazione e sismicità in Italia. Parte 1: Le linee de faglia e di scorrimento in Italia. Parte 2: Caratteristiche sismiche italiane secondo dati macrosismici [Lines of dislocation and seismicity in Italy. Pt. 1: The lines of faulting and overthrusting in Italy. Pt. 2: Italian seismic characteristics according to macroseismic data (with French, German, and English summaries)]: Boll. Geodesia e Sci. Aff., v. 16, no. 3, p. 273-323, 1957.

A 1:2,500,000-scale map of Italy is presented on which are indicated faults and overthrusts with dips of  $45^{\circ}$ - $90^{\circ}$  and of  $0^{\circ}$ - $45^{\circ}$ ; boundaries of several nappes and of the Verampio dome; inferred faults; faults buried beneath the Po Plain; epicenters of earthquakes of intensity 6-7, 8-9, 10-11, and 12 (Mercalli scale), submarine earthquakes, and zones of earthquake swarms. The earthquake data were compiled by Raimondi on the basis of macroseismic observations since 1750.

The first part of the paper discusses the most important aspects of the faulting in each part of the country. The present structure of Italy was determined mainly by Alpine deformation, which still continues locally at the present time.

The second part of the paper discusses the seismicity of Italy in the light of the major tectonic lines. Small maps show the distribution of elongated epicenters; focal depths and intensity of earthquakes since 1900; isoseismal maps of 10 earthquakes; and variations in propagation of energy from principal focuses in northern and central Italy. Data on 180 earthquakes of intensity 6 or more are tabulated, and these and several smaller earthquakes are cataloged by compartmenti. — D. B. V.

- 182-92. Kárník, V[it], Tobiash [Tobyáš], V[ladimfr], and Vaněk, I. [Jiří]. Eksperimentalnoye issledovaniye seysmichnosti oblasti Komarno [Experimental investigations of the seismicity of the Komarno region]: Akad. Nauk SSSR Sovet po Seismologii Byull., no. 6, p. 48-51, 1957.

The Komarno region in southern Slovakia is seismically the most active part of Czechoslovakia. Experimental investigation of the seismicity of this area was carried on in two stages, first the study of microtremors and second the tracing of active seismogenic lines.

The apparatus used in these studies is described very briefly in this preliminary report. Results of the studies are to be published in Czechoslovakian geophysical journals (see Geophys. Abs. 174-18). — D. B. V.

- 182-93. Kondorskaya, N. V. Some results of investigation of earthquakes from Kurile-Kamchatka zone [with Russian summary]: Československa Akad. Věd Studia Geophys. et Geod., v. 3, no. 4, p. 360-368 and 408a-408b, 1959.

Kurile-Kamchatka earthquakes recorded at various stations in the permanent seismic network of the U. S. S. R. have been studied with regard to their traveltimes, distribution, and dynamic features of seismic waves. Traveltimes were studied separately for Kamchatka and for the area southeast of Hokkaido because these regions apparently differ with respect to the dynamic characteristics of the seismic waves and conditions of earthquake occurrence. For epicentral distances up to  $10^{\circ}$  the traveltimes coincide with the Wadati curves. Differences between observed and Jeffreys-Bullen times are plotted for the two main epicentral regions for distances of  $15^{\circ}-20^{\circ}$ ,  $20^{\circ}-30^{\circ}$ ,  $50^{\circ}-60^{\circ}$ , and  $70^{\circ}-80^{\circ}$ ; the results suggest that crustal structure under central Asia and the Caucasus differs from the average crustal structure of the earth.

Identification of sP arrivals permitted determination of focal depth for most Far East earthquakes recorded at stations in the U. S. S. R. Geographic location, focal depth, and magnitude of earthquakes in 1954-57 are plotted on a map. Epicenters are clustered in groups separated by weakly seismic or aseismic zones that coincide with troughs, axes of furrows, or fracture lines. Elastic strain-rebound curves show that these groups are tectonically independent. Similar curves for different focal depths indicate a sharp difference in the earth's material above and below 90 km.

Study of P-wave amplitudes as a function of epicentral distance shows maximum values at  $40^{\circ}-45^{\circ}$  (central Asia); this may be due either to differences in P-wave absorption at different depths in the mantle or to differences in absorption in different regions. — D. B. V.

- 182-94. Medvedev, S. V., and Petrouchevsky [Petrushevskiy], B. A. Les principes méthodiques et essai de répartition de la séismicité en URSS [The methodological principles and attempt at seismic regionalization in the USSR]: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 239-253, 1959.

A revised edition of the seismicity map of the U. S. S. R. is being prepared, using information from the present seismic atlas of the country, the seismic bulletins of the past three years, the data of seismological geology, observations of strong earthquakes, and reports of engineering seismologists. This paper examines the accuracy of the information. The principal difficulty is that of finding a more reliable method of territorial division into earthquake intensity zones. — D. B. V.

- 182-95. Sultanova, Z. Z. Nekotoryye suzhdeniya iz issledovaniy zapisey izverzheniy vulkanov [Some considerations from the studies of records of volcanic eruptions]: Akad. Nauk Azerbaydzhan. SSR Doklady, v. 15, no. 10, p. 901-905, 1959.

A study was made at the Baku observatory of the records of mud and gas eruptions on Glinyanyy, Los', Svinoy, and Bulla Islands and on Kuman, Lokbatan, and other banks. These eruptions are not volcanic; rather, they are associated with gas deposits. The focuses of the eruptions were rather shallow; the deepest was the Kuman eruption. The wave periods of the eruptions had a wide range and were similar to the periods of microseisms observed at the Baku station. Three seismic tape records are presented and discussed. — A. J. S.

- 182-96. Gzovskiy, M. V., Krestnikov, V. N., Nersesov, I. L., and Reyzner, G. I. Novyye printsipy seysmicheskogo rayonirovaniya na pribereze tsentral'noy chasti Tyan'-Shanya I [New principles of seismic regionalization as exemplified by the central part of Tien Shan, pt. 1]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 177-194, 1960; pt. 2, ibid., no. 3, p. 353-370, 1960.

An attempt is made to determine zones of various degrees of seismic danger on the basis of the seismicity and geologic structure of the Tien Shan. The linear correlation between the log of the number of earthquakes and that of their energy, discussed in part 1 of this paper, led to the conclusion that the seismicity zones of the Tien Shan can be qualitatively determined from the mean values of the gradient of tectonic movements in the zones. Various geologic methods used in the determination of these mean values are described in detail in part 2. Strong earthquakes originate in the zone of junction of large structural elements of the earth's crust that have movements of different sense. It was also found that the energy of strong earthquakes is directly proportional to the size of these elements. — A. J. S.

- 182-97. Krestnikov, V. N. O svyazi geologicheskikh i seysmicheskikh yavleniy Tyan'-Shanya [On the relation between geologic and seismic phenomena of the Tien-Shan]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 3, p. 81-94, 1957.

The relation between seismicity and structure in the Tien Shan is examined in some detail. Maps show the distribution of areas of uplift and of subsidence in Miocene, Pliocene, and Recent times; the plan of recent movements, the structural plan, and the location of epicenters with respect to structures for the northern Tien Shan; and the location of epicenters with respect to structure in the whole Tien Shan.

The analysis leads to compilation of a map of seismic regionalization for the northern Tien Shan; a similar map compiled by A. V. Goryachev covering a wider area is also reproduced. A zone of intensity 9 in the north encompasses mainly the northern ranges of the Tien Shan; in the central Tien Shan there is a zone of intensity 8, and south of that another zone of intensity 9. To the north and south of these zones the seismicity falls off abruptly. — D. B. V.

- 182-98. Vvedenskaya, N. A., and Fogel', A. A. O karte epitsentrov Severnogo Tyan'-Shanya [On the map of epicenters of the northern Tien Shan]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 3, p. 106-117, 1957.

Study of the seismicity of the northern Tien Shan has resulted in a map of epicenters of strong earthquakes for the years 1911-55 and a more detailed map for the period 1951-54, for which instrumental data are available. The greater part of the earthquakes in 1950-54 occurred in the meganticlinal belt

of the Zailiysk and Kungey-Alatau ranges, which is bounded on the south by the basin of Lake Issyk-Kul', on the north by the Ili and Chuy River basins, and on the west by the Kirgiz range. Activity on the west and south border of the Issyk-Kul' basin is greater than on the east margin. Activity within the Ili and Issyk-Kul' basins is very weak.

Focal depths have been determined for 122 earthquakes; most lie at between 15 and 20 km. The deepest (18-23 km) are located in the central part of the Zailiysk and Kungey-Alatau. In the vicinity of Kurmenta focal depths are only 8-12 km. — D. B. V.

- 182-99. Goryachev, A. V. *Mezozoysko-Kaynozoyskaya struktura, istoriya tektonicheskogo razvitiya i seysmichnost' rayona ozera Issyk-Kul'* [Mesozoic-Cenozoic structures, history of tectonic development, and seismicity of the region of Lake Issyk-Kul']: Moscow, Akad. Nauk SSSR Inst. Fiziki Zemli, 179 p., 1959.

The geology of the region of Lake Issyk-Kul' in north Tien Shan is treated with particular attention given to clarification of the causes of its high seismicity and to its seismic regionalization.

The high seismicity of this region has long been known. About 2,000 earthquakes have been recorded since 1854, including 5 that were catastrophic. Isoseismic maps are presented for earthquakes of 1885, 1887, 1889, 1902, 1914, 1915, 1934, and 1938. The 31 strongest earthquakes between 1885 and 1954 are listed in a table. A seismostatistical map of Tien Shan for the period 1800-1945, two maps of epicenters and density of epicenters of earthquakes of north Tien Shan for 1950-53, and a map of the densities of epicenters of earthquakes of north Tien Shan for 1950-54 are also included. Other maps show the relation of seismicity to geology and structure.

The high seismicity of the Lake Issyk-Kul' area is a reflection of the long and complicated tectonic history of the Tien Shan as a whole. — J. W. C.

- 182-100. Kondorskaya, N. V., and Postolenko, G. A. *Analiz nablyudeniy nad zemletryaseniyami Kurilo-Kamchatskoy Oblasti* [Analysis of observations on earthquakes occurring in the Kurilian-Kamchatka region]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1448-1454, 1959.

The study made by Kondorskaya and Postolenko on the seismicity of the Kamchatka Peninsula and the Kurilian Archipelago (see *Geophys. Abs.* 176-42) is continued. Analysis of earthquakes having their epicenters in this region during the period 1954-57 shows that the epicenters are scattered over three separate zones. The boundary areas between these zones have very weak seismicity or are completely aseismic. These boundaries coincide with the axes of deep troughs. The observed earthquakes can be divided into three groups according to the depth of the focus: 0-90 km, 100-280 km, and >300 km. Several graphs are included in the article. — S. T. V.

- 182-101. Ninzhbadgar, S. *Nekotoryye dannyye o zemletryaseniyakh na territorii Mongol'skoy Narodnoy Respubliki* [Some data on earthquakes in the territory of the Mongolian People's Republic]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 6, p. 33-35, 1957.

As Mongolia does not yet have its own seismic service, observations on earthquakes there are all macroseismic. The earthquakes of 1902 and 1905 were the strongest and most destructive of the last 50 years. More recently

there were noteworthy shocks on April 4, 1950, and January 1, 1951. Earthquakes are most frequent and strongest in the northern, northeastern, and extreme western part of Mongolia. The eastern Sayan and eastern Transbaikal seismic regions of the U. S. S. R. extend into Mongolia. — D. B. V.

- 182-102. Shan-pan, Li. Ob issledovanii zemletryaseniy Kitaya po istoricheskim dokumentam [On the investigation of earthquakes in China according to historical documents]: Akad. Nauk SSSR Sovet po Seismologii Byull., no. 6, p. 26-32, 1957.

A map of epicenters of strong earthquakes and a seismicity map of China are constructed on the basis of macroseismic data from historical records dating back to several hundred years B. C. Most of the early records concern the eastern part of the country. About 1,400 earthquakes have been registered instrumentally in China, mostly in the western part. — D. B. V.

- 182-103. Savarenskiy, Ye. F., and Mey, Shi-yun. Po povodu otsenki intenzivnosti zemletryaseniy na territorii Kitaya [With regard to estimation of the intensity of earthquakes in the territory of China]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 135-138, 1960.

A method is developed for determining approximate values of seismicity in China based on geophysical data and the earthquake chronicles of the country. Eleven earthquakes that have occurred in China since 1918 are analyzed, and their magnitudes ( $M$ ) evaluated according to  $M=(2/3)I_0+(4/5)\log h-(1/2)$ , where  $I$  is intensity of the earthquake analyzed according to Medvedev's scale (see Geophys. Abs. 159-152), and  $h$  is depth of the focus determined from the mean values of isoseists according to the chronicles data. — A. J. S.

- 182-104. Mey, Shi-yun. O seismicheskoy aktivnosti Kitaya [On the seismic activity of China]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 381-395, 1960.

This is a continuation of studies of the seismic activity of China by Savarenskiy and Mey (see Geophys. Abs. 182-103). An improved formula is presented that correlates magnitude  $M$ , focal depth  $h$ , and intensity  $I_0$  of an earthquake:  $I_0=(0.9\pm 0.6)+(1.5\pm 0.08)M-(1.3\pm 0.36)\log h$ , derived by the least square method from the data on 23 earthquakes (1918-58) of magnitude 4.4 to 8.5. Seismicity maps from instrumental and historical data (for 3,000 years) are given. Seismicity characteristics of separate zones are discussed and compared. The variation of seismic activity with time is studied, and the possibility of a 1,000 year periodicity in the seismicity of China is suggested. Recurrence of earthquakes as a function of their magnitudes is discussed. — A. J. S.

- 182-105. Wadati, Kiyoo, and Hirono, Takuzo. Abnormal distribution of seismic intensity observed in Japan: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 223-238, 1959.

Regardless of location of the epicenter, acceleration of seismic motion is greater in a certain area in Japan for deep-focus and intermediate, and even to some extent shallow earthquakes. This "area of abnormal perceptibility" comprises the southeast coast of Hokkaido, the east coast of northeast Honshu, and the Kanto district. Short-period waves evidently reach this area without being absorbed in the medium through which they travel. As the surface geology offers no explanation of the phenomenon, the cause is sought deeper in

the crust or at the Mohorovičić surface. The abnormal area coincides well with a zone of positive Bouguer anomaly; however, this fact cannot explain the detailed mechanism of the phenomenon. More information on crustal structure under Japan is needed. — D. B. V.

- 182-106. Gutenberg, B[eno]. Magnitude and energy of earthquakes: Am. Geophys. Union Trans., v. 41, no. 2, p. 148-149, 1960.

Progress in the study of earthquake magnitude and energy in the United States during 1957-60 is reviewed. If the formula  $\log E = 5.8 + 2.4 \text{ m ergs}$  (where  $E$  = energy and  $m$  = unified magnitude) is correct, the energies released in earthquakes of different focal depths ( $h$ , in km) have been as follows (in  $10^{24}$  ergs)—for 1956:  $h \leq 60$ , 1.2;  $60 < h \leq 300$ , 0.46;  $h > 300$ , 0.29; total 1.9—for 1957:  $h \leq 60$ , 6.4;  $60 < h \leq 300$ , 0.91;  $h > 300$ , 0.27; total 7.6. The corresponding averages for 1908-55 were:  $h \leq 60$ , 6.0;  $60 < h \leq 300$ , 1.55;  $h > 300$ , 0.29; total 7.9. — D. B. V.

- 182-107. Bisztricsány, E[de]. On a new method of determining earthquake magnitudes: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 9-15, 1959.

On the basis of records obtained with the Wiechert seismograph in Budapest, Hungary, from 1931 to 1955, a linear relation is shown to exist between earthquake magnitude ( $M$ ) and surface wave duration ( $t$ ) that is practically independent of epicentral distance ( $\Delta^\circ$ ), especially from small distances. The equation obtained,  $M=2.12 \log t + 0.0005\Delta^\circ + 2.98$ , is also valid for deep-focus earthquakes. The standard deviation of magnitudes thus determined is 0.27, which is smaller than that of magnitudes determined by the Gutenberg-Richter method. (See also Geophys. Abs. 179-65, 181-104.)—D. B. V.

- 182-108. Shebalin, N. V. Correlation between magnitude and intensity of earthquakes; asthenosphere: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 31-37, 1959.

Shocks from focuses lying just under or above the boundary of a low-velocity layer should be felt at the surface with equal intensity, but at the same time the boundary would exert an essential influence on rays propagating in different lateral directions. The existence of such a layer was examined by a correlation of epicentral intensity and magnitude for different focal depths. Magnitude ( $M$ ) was determined by the surface wave method, using data from some Russian seismic stations and various earthquake bulletins. Focal depth ( $h$ ) was taken from the bulletins or determined from the  $pP$  and  $sS$  phases or, for depths less than 80-100 km (within the crust), by the  $sP$ -phase method. Data on intensity ( $I$ ) were taken from numerous publications.  $M$ ,  $h$ , and  $I$  were obtained for a total of 225 earthquakes with magnitudes ranging from 3.3 to 8.3, focal depths from 3 to 640 km, and intensities from 3 to 12.

At depths of 80-100 km the value of  $\delta(h)=1.5 M - I$  suddenly decreases (within 10-15 km), then increases again. This can be explained only by an essential reduction of surface-wave amplitudes of waves from focuses underlying some discontinuity, which is identified as the upper boundary of the asthenosphere. The depth of this boundary differs from place to place; preliminary results suggest that it lies at 80 km in the Kurile-Kamchatka and Pamir-Hindu Kush regions, at 65 km under the Andes, at 55 km under the Caucasus, at 100 km under the Carpathians, and at 90 km under the Aegean Sea and Crete.

The problem of magnitude determination for deep-focus earthquakes is considered. Down to 80 km the curves of  $\delta'(h)=1.5 M_p$ , s-I and of  $\delta(h)=1.5 M_L$ -I plotted as a function of depth coincide; below that depth both are displaced to the left, but  $\delta'(h)$  less so. This displacement shows that Gutenberg's  $f(\Delta, h)$  curves for magnitude determination of deep-focus earthquakes contain a systematic error of about 0.7 below 80 km. — D. B. V.

- 182-109. Kárník, V[ít], Vaněk, J[iří], and Zátopek, A[lois]. Contribution au problème des magnitudes unifiées [Contribution to the problem of unified magnitudes]: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 67-80, 1959.

Methods used at Prague for determining earthquake magnitudes are reviewed (see Geophys. Abs. 171-79, 174-41, -42). Magnitudes determined from PH, PV, PPH, and SH waves are compared with those based on MH waves; the results obtained are comparable to those of Báth (see Geophys. Abs. 173-58). Reduction of  $M_{MH}$  values to the equivalent  $m_{MH}$  values, determined at the same time as  $M_B$ , gives constants close to those of Gutenberg and Richter. The unified magnitudes  $m$  are generally very close to  $m_B$ .

The uniformity of results confirms the importance of unified magnitudes for cases where it is necessary to characterize each earthquake by a numerical value. For special studies it is recommended that the magnitudes of individual waves be published. — D. B. V.

- 182-110. Neumann, Frank. Analysis of earthquake intensity distribution maps: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 213-222, 1959.

Additional evidence is presented concerning the correlation of instrumentally recorded ground vibrations with earthquake intensity and their use in obtaining more accurate epicenters and further evidence on ground structure. The use of instrumental data in explaining the complex nature of intensity phenomena is also discussed.

It is concluded that intensity data can be put to more productive use than in the past, especially after their true relation to ground motion has been more thoroughly established. Intensity has been correlated with acceleration within a limited epicentral area, and a broader interpretation may correlate intensity with energy (as represented in maximum building motions rather than in the ground). To advance research in this field it is important to improve the efficiency of earthquake information services, especially the questionnaires. — D. B. V.

- 182-111. Medvedev, S. V. Opredeleniye ball'nosti zemletryaseniy [Determination of the intensity of earthquakes]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 6, p. 105-108, 1957.

The new Russian seismic scale was worked out by Medvedev in 1953 (see Geophys. Abs. 159-152). The scale groups earthquakes in three categories—A, B, V—according to macroseismic effects (on buildings, on the ground, and other), and also classifies them quantitatively according to the value  $x_0$ , which represents the maximum displacement (in millimeters) of a spherical pendulum having a natural period  $T_0=0.25$  sec and logarithmic decrement of damping  $\lambda=0.50$ . For intensity 5,  $x_0=0.5-1.0$  mm; for intensity 10,  $x_0=16.1-32.0$  mm.

The spectrums of the effect of seismic oscillations on structures are represented by  $\chi$ , which is determined by the formula  $\chi=x_0\cdot\psi\cdot\epsilon$  (where  $\psi$  is the

spectral coefficient, depending on period  $T$ , and  $\epsilon$  is the coefficient of deformation, depending on damping  $\lambda$ ). Spectral anomalies are caused by variations in ground conditions, and they are important in seismic regionalization. — D. B. V.

- 182-112. Solov'yev, S. L. K voprosu o sootnoshenii mezhdu energiyey ob'emykh voln i intensivnost'yu zemletryaseniy [On the problem of the relation between energy of body waves and earthquake magnitude]: Akad. Nauk SSSR Sovet po Seismologii Byull., no. 6, p. 109-121, 1957.

Methods of calculating earthquake magnitude and energy from body wave data are reviewed. A map of epicenters of strong earthquakes in the U. S. S. R. in 1911-53 is compiled; it includes earthquakes in the Kurile-Kamchatka region, deep-focus earthquakes in the Hindu Kush with  $M \geq 6\frac{1}{2}$ , and earthquakes in other seismically active areas with  $M \geq 5\frac{1}{2}$ . Magnitude and energy are calculated for strong earthquakes from 1911 to 1956 in the U. S. S. R. using transverse wave data. Results are tabulated. (See also Geophys. Abs. 181-105.) — D. B. V.

- 182-113. Panner, Norbert. Die Ableitung der Magnitudengleichung für Oberflächenwellen für die seismische Station Collmberg [The derivation of the magnitude equation for surface waves for the Collmberg seismic station]: Československá Akad. Věd Studia Geophys. et Geod., v. 3, no. 3, p. 242-255, 1959.

On the basis of surface wave data from 109 earthquakes, the magnitude equation  $M = \log A + 1.64_1 \log \Delta + 1.84_6 + 0.27 + D$  is derived for the Collmberg seismic station of the University of Leipzig, East Germany.

The second part of the paper presents the results of a statistical analysis of the regional deviations ( $dM$ ) and compares their distribution with the Prague regional corrections. — D. B. V.

- 182-114. Savarensk[i]y, E. [Ye.] F. Determination of earthquake magnitude and intensity in the U. S. S. R.: Annali Geofisica, v. 12, no. 3, p. 369-376, 1959.

The determination of earthquake magnitude in the U. S. S. R. is based on instrumental observations using the international magnitude scale. The relationship between intensity grade (B), magnitude (M), and focal depth (H) was found by analysis of several hundred earthquakes to be  $B=1.5 M - 3.5 \log H + 3$ ; this formula is valid for focal depths up to 60 km (see Geophys. Abs. 163-167), and is based on the assumption that the properties of the medium lying between the focus and the earth's surface are uniform. For more accurate determination of intensity of a given earthquake, it is necessary to consider the effect of the local geologic structure in the epicentral region on the amplitude of oscillations.

In compiling the seismicity map of the U. S. S. R. earthquakes were divided into five groups according to magnitude:  $>7\frac{1}{2}$ ,  $6\frac{1}{2}-7\frac{1}{2}$ ,  $5\frac{1}{4}-6\frac{1}{2}$ ,  $4\frac{1}{4}-5\frac{1}{4}$ , and  $<4\frac{1}{4}$ . The quarterly bulletins of the seismic stations of the U. S. S. R. give magnitudes to within  $\frac{1}{4}$  for earthquakes of  $M \geq 4$ . — D. B. V.

- 182-115. Savarenskiy, Ye. F., Kondorskaya, N. V., and Belotelov, V. L. Ob opredelenii energii uprugikh voln, porozhdayemykh zemletryaseniyem [On determination of the energy of elastic waves generated by an earthquake]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 633-643, 1960.

An attempt is made to determine accurately the absolute value of elastic wave energy generated and emitted by an earthquake source. On the assumptions of a spherical source a formula is derived for the total energy of body seismic waves from a distant anisotropic source; the effects of interlayer reflection, refraction, and absorption are disregarded here. An example of application of the formula to the earthquake of January 3, 1957, ( $\phi=44^\circ$  N.;  $\lambda=130^\circ$  E.;  $k=560$  km) using the seismic records of 36 stations is given. On the above assumptions the mean energy of the earthquake was found to be  $\bar{E}_p=1.3\times 10^{20}$  ergs, and  $\bar{E}_s=2.4\times 10^{20}$  ergs. — A. J. S.

- 182-116. Senshu, Toshio. On the time interval distribution of aftershocks [in Japanese with English abstract]: Zisin, v. 12, no. 4, p. 149-161, 1959.

An investigation was made of the variations in the observed number of aftershocks of an earthquake as compared to the number calculated by means of a formula. The frequency distribution of the time interval between consecutive aftershocks is described and empirically expressed by a formula. When the time interval distribution is not small, the occurrence of aftershocks at a suitable time interval is random, that is, one aftershock does not exert an influence on the following one. When the time interval distribution is small, consecutive aftershocks increase according to the time elapsed since the previous aftershock; this is known as Tomoda's distribution of the time interval. Formulas are presented for the derivation of Tomoda's distribution. — V. S. N.

- 182-117. Aki, Keiiti. Interpretation of source functions of circum-Pacific earthquakes obtained from long-period Rayleigh waves: Jour. Geophys. Research, v. 65, no. 8, p. 2405-2417, 1960.

The source functions (cross-correlation functions between the actual seismogram and the theoretical impulse response) of 53 shocks in the circum-Pacific belt were obtained by a method of equalization applied to Rayleigh waves in the period range 35-150 sec recorded at Pasadena. The source functions were interpreted in terms of the direction of forces at the source, and the interpretation was checked by additional information concerning the earthquake and by error analysis. The horizontal forces deduced from the source functions showed a systematic geographic distribution, which favors Benioff's hypothesis concerning circum-Pacific tectonics (see Geophys. Abs. 178-73). The vertical forces were found to be mostly directed upward on the oceanic side. (See also Geophys. Abs. 181-111.) — D. B. V.

- 182-118. MacCarthy, Gerald R. The formation of joints as a possible cause of certain seismic phenomena: Southeastern Geology, v. 1, no. 4, p. 117-119, 1960.

Computations are made of the approximate order of magnitude of energy released during rupture of rocks. Results indicate that sufficient elastic energy may be liberated during formation of major joints to produce such "cryptoseismic" effects as light localized earth tremors, underground rumbling sounds, and the like. — V. S. N.

- 182-119. Komura, Saburo. A consideration about the mechanism of occurrence of large-scale earthquakes, pts. 1 and 2: Kyoto Univ. Coll. Sci. Mem., ser. A, v. 28, no. 4, p. 363-378; p. 379-389, 1958.

In part 1 the period of the first maximum ground motion of P-waves, due to a large-scale earthquake as observed at various seismological stations, is discussed. The period is shown to have a systematic pattern of distribution, the regularity of which may be explained by assuming that the seismic crack, composed of a series of small cracks generating seismic waves, develops with a certain definite velocity from one end to the other along either of the nodal lines of initial motion, and by assuming that the period of the waves originating from the crack and propagating in various directions is modified by Doppler effect.

These assumptions were applied with satisfactory results to observational data from six large-scale earthquakes occurring in Japan between 1926 and 1952. They were further tested by a model experiment in which the propagating speed of tremors from a crack was recorded as it developed in plate glass.

In part 2, the earthquakes discussed in part 1 are reexamined according to the dislocation of the earth's crust and to the energy of the seismic waves produced by a large-scale earthquake. The direction of crustal dislocation accompanying an earthquake does not always coincide with that of the initial ground motion of the P-wave. In the Kita-Tango, Kita-Izu, and Fukui earthquakes, however, the horizontal dislocation of the crust computed according to Honda and Miura (1935) or Whipple (1936) agrees approximately with the one actually surveyed. Moreover, the estimate of the length of the great crack accompanying each earthquake may be verified by recognizing that the seismic energy calculated from the length of the crack coincides fairly well in order with the seismic energy computed according to Gutenberg and Richter's recently reported relation between the magnitude and the energy of an earthquake (see Geophys. Abs. 166-78). — V. S. N.

- 182-120. Keylis-Borok, V. I., and Malinovskaya, L. N. O dislokatsiyakh v ochagakh slabikh zemletryaseniy Severnogo Tyan'-Shanya [On dislocations at the focuses of weak earthquakes of the northern Tien Shan]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 3, p. 118-122, 1957.

Fault-plane solutions are worked out for 33 weak earthquakes in the northern Tien Shan registered by the network of seismic stations in the Kazakh and Kirgiz S. S. R. in 1953-55. The results are plotted on a map showing the geographic structure of the area, and the relationships of the direction of movement to the structural trends are discussed. — D. B. V.

- 182-121. Scheidegger, A[drian] E[ugen]. Table of Russian fault plane solutions: Dominion Observatory Ottawa Pubs., v. 19, no. 3, p. 99-109, 1957.

Tables of Russian fault-plane solutions extracted from charts published in the Soviet Union are presented. Notations and representations used in earlier publications of the Dominion Observatory are employed in these charts to make them readily useable for the western worker in the field. — V. S. N.

- 182-122. Glivenko, Ye. V. Ob opredelenii prelomlyayushchey granitzypo dannym azimutal'noy stantsii [On determination of the refracting boundary from the data of an azimuthal station]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 475-481, 1960.

The method of correlation of refracted seismic waves proposed by Gamburtsev and Gal'perin (see Geophys. Abs. 157-75) is discussed, and positions of

refracting boundaries are determined from the records of local earthquakes by an azimuthal station which consists of several seismographs. This problem was solved with the aid of geometric constructions based on the assumption of a plane refracting layer which is located at a depth that is small compared with the distance from the station to the focus of the earthquake, and which lies on a homogeneous medium. A mathematical treatment of the problem is given. Examples show that the bearings of the recorded seismic rays provide qualitative data on the refracting boundary parameters, and more reliable results are obtained even without the use of statistics. — A. J. S.

- 182-123. Bonelli [Rubio], Juan María. Nota sobre sismología edilicia [Note on engineering seismology]: Rev. Geofísica, v. 18, no. 71, p. 275-280, 1959.

The 13 catastrophic earthquakes that have occurred in Spain since 1884 are listed briefly, giving damage incurred, and the problem of earthquake-proof construction is discussed. The results of research mainly in the United States on the effect of earthquakes on buildings are summarized briefly. Although Spain is a seismic country there are no laws at present regulating construction from the point of view of safeguarding against earthquake damage. It is urged that construction standards such as those required in Los Angeles, Calif., for example, be adopted in Spain. — D. B. V.

- 182-124. Glukhov, I. G. O zemletryaseniyakh kak ob odnom iz faktorov aktivizatsii opolzney Gornogo Kryma [Earthquakes as one of the factors of activation of slump in the mountainous Crimea]: Moskov. Univ. Vestnik, no. 4, p. 143-147, 1959.

Mass wastage ranging from catastrophic landslides to slow creep is examined with respect to frequency of earthquakes. During the wet autumn and winter months, earthquakes exert considerable influence on initiating slumping. During the summer, however, even intense earthquakes do not activate such movements. — J. W. C.

- 182-125. Shurbet, D. H. The P phase transmitted by crustal rock to intermediate distances: Jour. Geophys. Research, v. 65, no. 6, p. 1809-1814, 1960.

Analysis of records of earthquakes at intermediate distances (1,038-2,810 km) recorded at Lubbock, Tex., shows a strong P-phase, which is identified as a wave-guide phase. The phase is called P and is the longitudinal wave corresponding to Lg. A strong recording of this phase may be used to indicate thick crustal sections. All of the crust is probably involved in its propagation. Some energy loss must occur upon reflections at the surface; therefore, since the phase is still strong at rather great distances, the lower boundary of the wave guide is probably due to increasing velocity with depth. A lower boundary made up of an interface would involve greater losses of energy. — D. B. V.

- 182-126. Kondorskaya, N. V. Travel times and some dynamic characteristics of seismic waves: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 113-121, 1959.

The first part of this paper is an investigation of the systematic divergences of observed traveltimes from the Jeffreys-Bullen curves for earthquakes recorded by seismic stations in the U. S. S. R. for epicentral distances of 2°-80°,

particularly those from the Kamchatka-Kurile region. The second part is a study of the dynamic features of Far East earthquakes as recorded by stations in the U.S.S.R. It is concluded that the absorption of P-waves is different for different depths in the mantle and for different regions.

This paper is very similar to the one published in the Československá Akad. Věd Studia Geophys. et Geod., v. 3, no. 4, p. 360-368, and 408a-408b, 1959 (see Geophys. Abs. 182-93). — D.B.V.

- 182-127. Berzon, I. S. Experimental investigation of dynamic parameters of seismic waves in real media: Československá Akad. Věd. Studia Geophys. et Geod., v. 3, no. 3, p. 232-241, 1959.

This is the substance of a lecture delivered before the Geophysical Institute of Charles University (Universitas Carolinensis) in Prague. The methods and equipment used and results obtained in recent experimental field investigations of the dynamic parameters of seismic waves in the U.S.S.R. are summarized, and the methods of interpretation of these parameters and the results of study of absorption of longitudinal waves are examined. — D.B.V.

- 182-128. Gal'perin, Ye. I., and Frolova, A. V. Azimutal'no-fazovaya korrelyatsiya seysmicheskikh voln, poliarizovannykh po ellipsu [Azimuthal-phase correlation of seismic waves elliptically polarized]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 195-208, 1960.

The azimuthal-phase correlation of seismic waves (Gamburtsev, see Geophys. Abs. 152-14292) makes it possible to interpret the type of a seismic wave by its polarization. An azimuthal seismogram of linearly polarized waves provides data for a determination of the direction of the displacement vector. Elliptically polarized waves provide data on the wave polarization plane in space and on the form and orientation of the ellipse in that plane. Regularities in the azimuthal seismograms are analyzed, and methods for determination of the polarization parameters of seismic waves are suggested. — A.J.S.

- 182-129. Bátth, M[arkus]. Seismic channel waves—new observations and discussion: Gerlands Beitr. Geophysik, v. 69, no. 6, p. 360-376, 1960.

Channel waves have been measured on a large number of records of the Hungarian earthquake of January 12, 1956, and of the Crimean earthquake of March 18, 1957. The Li, Lg 1, Lg 2, and Rg waves have been followed from station to station and their velocities determined as follows: Li=3.82 km/p, Lg 1=3.53-3.55 km/p, Lg 2=3.35 km/p, and Rg=3.01-3.03 km/p. Two other waves, L(3.23) and L(3.15), were also clearly observed for the first time.

The propagation of Lg 1 is influenced by surface topography, as is to be expected of a wave propagating in the uppermost layer; when the layer surface becomes irregular and thickness varies, as in mountainous areas, the conditions for constructive interference are no longer fulfilled and the wave dies out. Lg 2 propagates in slightly deeper layers and should be less affected by surface irregularities. There are nearly three times as many Lg 2 observations for the Hungarian earthquake as for the Crimean; in the latter they are probably masked to a large extent by the well developed Lg 1 waves.

The reality of these waves and the problems connected with their explanation as channel waves or as higher mode surface waves are discussed. There are reasons for the existence of both, and the difference between the two ex-

planations is not as large as it may appear. They both require constructive interference, but the channel wave hypothesis requires low-velocity layers whereas the higher mode hypothesis does not. More theoretical and observational knowledge is required before a judgment can be made. (See also Geophys. Abs. 180-62.) — D. B. V.

- 182-130. Jobert, Nelly. Calcul de la dispersion des ondes de Love de grande période à la surface de la Terre [Calculation of the dispersion of Love waves of long period at the surface of the earth]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 5, p. 890-892, 1960.

The phase velocity of long-period Love waves has been calculated for Gutenberg's earth model with a continental crust by numerical integration of the differential equation of motion. The continental crust was represented by a homogeneous surface layer 35 km thick, having an S-wave velocity of 3.6 km/ps, coefficient of rigidity of  $0.368 \times 10^{12}$ , and density of 2.84 g per cm<sup>3</sup>. A maximum and minimum of group velocity appear for the first harmonic, but not for the fundamental mode. — D. B. V.

- 182-131. Crenn, Y[vonne], and Metzger, J[oseph]. Quelques observations d'ondes de Rayleigh de séismes atlantiques enregistrés à la bordure du continent africain [Some observations of Rayleigh waves from Atlantic earthquakes recorded at the margin of the African Continent]: Annales Géophysique, v. 15, no. 4, p. 555-560, 1959.

Analysis of records of 22 of the strongest earthquakes in the central Atlantic Ocean in 1957 and 1958 obtained at the M'Bour seismic station on the West Coast of Africa shows that shock waves that cross shallow parts of the ocean before approaching the continent present a very regular train of Rayleigh waves; those that approach directly furnish few Rayleigh waves but instead are characterized by other shorter waves that have a vertical component and a 10-15 sec period. — D. B. V.

- 182-132. Kogan, S. Ya. Ob opredelenii energii seysmicheskikh voln proizvol'noy formy [Determination of the energy of seismic waves of an arbitrary form]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 644-652, 1960.

A formula for evaluation of the energy of Rayleigh surface waves of an arbitrary form is derived from the ground displacement and the rate of the displacement at the point of observation. This formula is based on a general expression for the density of energy flux. The Zöppritz-Wiechert formula for longitudinal body waves is derived as an example of application of the above general expression. — Author's abstract, A. J. S.

- 182-133. Levshin, A. L. Interpretatsiya dannykh o dispersii poverchnostnykh voln s pomoshch'yu bilogarifmicheskikh paletok teoreticheskikh dispersionnykh krivykh [Interpretation of surface wave dispersion data with the aid of bilogarithmic master charts of the theoretical dispersion curves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 318-322, 1960.

Parameters of a surface layer and an underlying medium can be determined from data on phase velocity dispersion of Love waves in the media, and those of the earth's crust from the dispersion of group velocities of Ray-

leight waves. A method of interpretation of the observational dispersion data by comparing them with theoretically constructed bilogarithmic master charts is discussed. This method produces a more complete and accurate interpretation of seismic surface wave dispersion in a layered medium and is also simpler than other methods. — A. J. S.

- 182-134. Kizawa, T[akashi]. Some new phases observed in a study of earthquake swarms relating to volcanic activity (1): Geophys. Mag. [Tokyo], v. 29, no. 4, p. 477-498, 1960.

Two hitherto unknown phases with remarkably slow group velocities were recorded in the earthquake swarms of 1943-45, which were associated with the 1944 activity of Usu volcano in Japan. They are termed as the third and fourth phases.

The third phase, distinctly a surface wave, occurs about 1 minute after P in both A-type (preceding the eruption) and B-type earthquakes (following the eruption; very shallow, associated with the rise of a lava dome in the crater). Its group velocity at maximum amplitude is 0.6 km/psec, and its amplitude is large especially in the A-type shocks. Particle motion is of Rayleigh-wave type. This phase is a water-coupled wave, explained in terms of Pekeris' theory (see Geophys. Abs. 135-10569, 178-99).

The fourth phase is clearer in the B-type earthquakes. It begins with a group velocity of 340 m per sec. It is regarded as the air-coupled surface wave reported by Ewing and Press (see Geophys. Abs. 141-11953, 145-12783, 146-13011) or possibly as a surface Rayleigh wave affected by the sedimentary material in the upper low-velocity layer. Several models are being investigated with the aid of electronic computers in order to clarify the nature of both of these phases. — D. B. V.

Press, Frank. Seismic wave propagation. See Geophys. Abs. 182-149.

Neumann, Frank. Crustal structure in the Puget Sound area. See Geophys. Abs. 182-351.

Utsu, T[okuji]. Observations of the Lg waves and crustal structure in the vicinity of Japan. See Geophys. Abs. 182-357.

- 182-135. Press, Frank. Seismic instruments: Am. Geophys. Union Trans., v. 41, no. 2, p. 145-146, 1960.

The most important developments in seismographs in 1957-60 have been in the direction of recording new types of long-period waves. — D. B. V.

- 182-136. Murphy, L[eonard] M. Changes in United States seismograph stations and equipment: Am. Geophys. Union Trans., v. 41, no. 2, p. 146-148, 1960.

This is a compilation of data on changes in operation and in instrumentation of seismograph stations in the United States during 1957-60. — D. B. V.

- 182-137. Gilbert, Freeman. Application of electronic computers to seismological problems: Am. Geophys. Union Trans., v. 41, no. 2, p. 169-172, 1960.

Recent developments in theoretical and observational seismology that have been achieved with the aid of electronic computers are reported. The increase in our knowledge of seismic processes is due largely to the handling of problems that otherwise would have been very difficult or intractable. The successful blending of results of theoretical investigations in elastodynamics, communication theory, and methods of computational analysis should lead to further seismological advances. A bibliography of 34 items is given. — D.B.V.

- 182-138. Newstead, Gordon, and Watt, P. A. A telemetered seismic net in Tasmania: *Nature*, v. 186, no. 4726, p. 704-705, 1960.

Recent work toward the establishment of a telemetered seismic network in Tasmania has brought seismology and electronics into close contact and given rise to new ideas. Developments have followed two lines, the application of electronic amplifiers and principles of feedback servomechanisms to the design and construction of seismographs, and the consideration of problems in observational seismology from the point of view of information theory such as the problem of extracting a message from a noisy background.

The Newstead-Watt seismograph uses a transducer with variable reluctance but with an a-c magnet; the output then consists of amplitude-modulated alternating current which is easy to amplify and telemeter. The response of the seismograph can be readily controlled by feeding back to the pendulum, in the correct proportion, the demodulated output of the amplifier together with its derivative and integral. With the particular combination of feedback used the seismograph acts as an accelerometer between 1 and 100 sec, and its response is above the envelope of the performance shown for conventional seismographs.

The instrument has been adjusted as a broad-band accelerometer purely for comparison purposes and could equally well be adjusted in other ways. For the present it is proposed to record the whole of the information contained in the band and to experiment with filtering and other processes on the record itself. If external noise is the factor that limits the performance, this procedure will not affect the signal-to-noise ratio in the record.

Pen recording on paper is being used initially, but work is being done on magnetic tape recording with electronic reduction of the information. — D.B.V.

- 182-139. Fogel', A. A. Avtomatika na seysmicheskikh stantsiyakh severo-Tyan'-Shan'skoy zony [Automation of seismic stations of the north Tien Shan zone]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 229-235, 1960.

The APZO seismic apparatus is described. It regulates automatically the temperature of the collimator tube filament to keep the recording commensurate with the incoming signal amplitude and the technical parameters of the recorder, and it produces both audible and optical signals of the seismic disturbances being recorded. The apparatus can be used both at regional and local seismic stations. Its introduction in seismic stations of the northern Tien Shan zone has improved their earthquake recording considerably. — A.J.S.

- 182-140. Willmore, P. L. The detection of earth movements: Dominion Observatory Ottawa Contr., v. 3, no. 26, p. 230-276, [1959 ?]. Reprinted from Runcorn, S. K., (ed.). *Methods and techniques in geophysics*: London, Interscience Pub. Lt., 1959.

This paper is primarily a description of various types of seismographs and of the theory underlying their operation. Willmore discusses the general principles of the seismograph; the representation of seismograph response;

the theory of pendulum seismographs including the direct-coupled pendulum seismograph, the moving-coil seismographs, the variable-reluctance seismometer, the calibration of pendulum seismographs, and practical details or design features of some pendulum seismographs; seismographs that measure stress or strain, that is, the pressure-sensitive hydrophone and the strain seismometer; and the further development of seismometry. In the last section it is concluded that the chief improvements that can arise in the detection of earth movements are in filtering the output of a single detector, or in methods of compounding the outputs from arrays of detectors in such a way that desired signals are added in phase and the noise components at random. It is possible that conventional seismograms may be supplemented to an increasing extent by analogue or digital records. — V. S. N.

- 182-141. Sutton, George [H.], and Oliver, Jack [E.]. Seismographs of high magnification at long periods: *Annales Géophysique*, v. 15, no. 4, p. 423-433, 1959.

Tests of several seismometers and galvanometers used at the Lamont Geological Observatory Palisades station demonstrated the variety of response characteristics that can be obtained by varying the free period and by damping. New vertical component seismographs detect surface waves from small shocks at very great distances and, apparently for the first time, record microseisms in the 10-30 sec period range almost continuously.

Two other types of seismographs are operated throughout the world in co-operation with other institutions. The 15-80 with improved long-period response for both body and surface wave phases is used in the International Geophysical Year long-period seismology program, and the 15-7 with improved resolution of body phases and short-period components of the surface wave train is used in the International Geophysical Year Lg program. — D. B. V.

- 182-142. Watanabe, Hikaru. A rotational strain seismometer [in Japanese with English abstract]: *Zisin*, v. 12, no. 4, p. 162-170, 1959.

A new type of rotational strain seismometer, designed to observe the rotational strain component around the vertical axis, is described and illustrated by diagrams and reproductions of seismograms. — V. S. N.

- 182-143. Miura, T. Influence function  $F_n(t)$  of electronic seismograph—its introduction and properties with applications: *Geophys. Mag. [Tokyo]*, v. 29, no. 4, p. 465-475, 1960.

An influence function group  $F_n(t)$  has been deduced from the equations of motion of an electromagnetic seismograph; this function expresses the transient responses of the galvanometer coil for some simple fundamental shocks of different types according to  $n$ . Examples of the displacement function  $F_3(t)$ , regarded as a weight function or after-effect coefficient, are computed for different types of instruments. The equations show that the response of the Kirnos seismograph is more faithful to ground motion in the period range 0.3-10 sec than the Galitzin, although the former sacrifices magnification. Differences in seismograms obtained with different instruments can be interpreted easily by comparing their  $F_3(t)$ . — D. B. V.

- 182-144. Neumann, Frank. Principles underlying the interpretation of seismograms: U. S. Coast and Geod. Survey Spec. Pub., no. 254, 42 p., revised (1959) ed., 1960.

This booklet, first printed in 1951, is designed to cover the interpretation of earthquake seismograms in sufficient detail to meet the needs of the seismograph station director, the student beginning a career in seismology, or the amateur seismologist. The text has 5 chapters as follows: 1) Seismic waves and earth structure, 2) response of seismographs to seismic waves, 3) traveltimes tables and charts, 4) interpretation of seismograms, and 5) miscellaneous, which includes operational problems affecting interpretation, earthquake intensity and magnitude, determination of instrumental magnitude, seismological bulletins, nomenclature used in instrumental reports, and examples of interpretation. — V. S. N.

- 182-145. Kamamoto, H. Analysis of irregular rotation of seismograph recording drum: Quart. Jour. Seismology [Tokyo], v. 23, no. 3, p. 1-10, 1958.

The arrival time of the initial motion of an earthquake is calculated from the record on the drum of the seismograph by interpolation or extrapolation from the nearest adjacent minute mark. However, investigation shows that the rotation of the drum is not uniform, and as a cause of the irregularity the effect of the eccentricity of the gears is discussed. A formula is presented for calculating the deviation from the normal rotating angle. The gear mechanism for a Wiechert seismograph recording unit is illustrated, and the error of the rotating angle of the drum is shown. It is concluded that the eccentricity of the gear has a serious effect on the precision of the drum rotation. — V. S. N.

#### EARTH TIDES AND RELATED PHENOMENA

- 182-146. Slichter, Louis B. Gravity tide measurements: Am. Geophys. Union Trans., v. 41, no. 2, p. 160-161, 1960.

During the International Geophysical Year two LaCoste-Romberg gravity-tide meters were used to obtain observations at 13 stations in the equatorial belt. Observations were made for 30 to 45 days at each station. Results, referred to the major semidiurnal constant  $M_2$ , are tabulated. — D. B. V.

- 182-147. Jobert, Georges. Perturbations des marées terrestres [Perturbations of the earth tides (with English and Esperanto summaries)]: Annales Géophysique, v. 16, no. 1, p. 1-55, 1960.

Certain perturbations of earth tides stem from crustal deformations due to surficial loads. In the first part of this work the effect of underground structure (exponential variation of elastic properties with depth) and of surface relief on earth tides is examined mathematically.

The second part treats the effect of thermoelastic deformations. It is shown that only very localized variations of surficial temperature can produce perturbations of earth tides. — D. B. V.

- 182-148. Pícha, Jan. Vergleich der Methoden harmonischer Analyse und einige Bemerkungen zu den Kontrollen der Berechnungen [Comparison of methods of harmonic analysis and some remarks on the controls of the calculations (with Russian summary)]: Československá Akad. Věd Studia Geophys. et Geod., v. 4, no. 1, p. 85-94, 1960.

Earth tide observations made during March 1959 at the station in the Anna mine in the Březové Hory (Příbram mining district, Czechoslovakia) at a

depth of 1,300 m (772 m below sea level) were analyzed harmonically by three methods: the Doodson-Lennon, Lecolazet, and Pertsev. No significant differences appear in the results, thus showing that all three methods are equally applicable in this case. The Lecolazet method appears to require the least work.

Ways of checking the calculations made by the Pertsev and Doodson-Lennon methods are suggested in the second part of the paper. — D. B. V.

#### ELASTICITY

- 182-149. Press, Frank. Seismic wave propagation: Am. Geophys. Union Trans., v. 41, no. 2, p. 150-151, 1960.

In the United States in 1957-60 the major emphasis in research on seismic wave propagation has been on theoretical studies of fundamental aspects of wave propagation and combined theoretical and experimental studies pointed at unraveling the complicated nature of seismograms to glean more information about the propagating medium and the source. New developments are reviewed briefly, and a bibliography representative of recent progress is given. — D. B. V.

- 182-150. Collins, Francis. Plane compressional Voigt waves: Geophysics, v. 25, no. 2, p. 483-504, 1960.

A complete solution for plane waves is developed, valid for all distances and times; it is based on the assumption that the wave source is in the form of a single pressure impulse. A method similar to Ricker's (see Geophys. Abs. 149-13586) is outlined for obtaining an asymptotic solution suitable for computations at large distances.

The wavelets from the pressure impulse do not decay as rapidly as Ricker's doublet displacement solutions; this is in better agreement with observed facts. On the other hand, the pressure impulse wavelets have only a single lobe, a definite move away from the observations. There is some reason to believe, however, that the corresponding spherical waves would be more oscillatory than the plane waves.

More mathematical work is needed for further tests of the Voigt solid as a theoretical model for seismic waves. The next step suggested is computation of spherical waves from a pressure impulse. — D. B. V.

- 182-151. Bland, D. R. On the foundations of linear isotropic visco-elasticity: Royal Soc. [London] Proc., ser. A, v. 250, no. 1263, p. 524-549, 1959.

The properties of a linear visco-elastic material are developed mathematically from the hypothesis that the microscopic structure of the material is mechanically equivalent to a network of elastic and viscous elements. It is shown that models consisting of Voigt elements in series or Maxwell elements in parallel can represent the mechanical properties and the stored and dissipated energies of any visco-elastic material. The analysis can be extended to networks containing an infinite number of elements. Examples are given for two different cases. — D. B. V.

- 182-152. White, J. E. Use of reciprocity theorem for computation of low-frequency radiation patterns: Geophysics, v. 25, no. 3, p. 613-624, 1960.

Starting with a simple word statement of the reciprocity that exists between forces and displacements in a general elastic solid, it is shown that low-fre-

quency radiation of shear and compressional waves from relatively complex sources can be obtained by solving relatively simple problems in static elasticity. Illustrative examples include radiation from radial and tangential pairs of forces acting on the wall of a cylinder, pressure in a finite cylinder, and a pair of radial forces in a hole in a plate. For the last case, measurements in a plexiglass plate compare favorably with computations.—Author's abstract

- 182-153. Grine, D. R., and Fowles, G. R. The attenuation of shock waves in solid materials with seismic applications, in Third symposium on rock mechanics: Colorado School of Mines Quart., v. 54, no. 3, p. 251-269, 1959.

Shock waves in solids are attenuated, in general, by several mechanisms. Those common to attenuation in fluids include the overtaking of the shock by a rarefraction wave, geometrical divergence, and heating due to irreversible processes occurring within the shock front. Mechanisms peculiar to solids include absorption of energy in plastic deformation and fracture. Application of existing theory for fluids to solids requires knowledge of the equation of state of the solid. The theory must then be modified to include plastic deformation and fracture. Recent experiments to determine equations of state of rocks and other experiments to determine dynamic yield strengths and fracture energies [are] described. Application to the problem of energy transfer in a shot hole [is] discussed. — Authors' abstract

- 182-154. Miles, John W. Scattering of elastic waves by small inhomogeneities: Geophysics, v. 25, no. 3, p. 642-648, 1960.

Rayleigh scattering theory is extended to determine the perturbation on an arbitrarily prescribed elastic wave field produced by small inhomogeneities in an otherwise homogeneous isotropic medium. The general result is applied to the specific problems of the scattering of both plane P- and S-waves. It is found that a change in compressibility acts at a distance as a simple source and a change in density as a dipole, as in the acoustical problem, while a change in shear modulus contributes both simple-source and quadrupole fields. — Author's abstract

- 182-155. Hervas Burgos, Pablo. Propagación de ondas sísmicas en los medios elásticos imperfectos [Propagation of seismic waves in imperfectly elastic media (with English summary)]: Rev. Geofísica, v. 18, no. 71, p. 227-235, 1959.

An attempt is made to give a general and systematic method of finding the equations of wave propagation in imperfectly elastic media, and to calculate velocities and absorption coefficients to obtain for every substance its dynamic equation of motion and the equations of longitudinal and transverse wave propagation. Selective absorption and strong dispersion are found to occur due to the viscosity and elasticity of such media.

Only the case of viscous fluids is examined; the study of firmo-elastic substances—plastic bodies and surface rocks—is left for later articles. — D. B. V.

- 182-156. Kun, V. V. Osobennosti seysmicheskikh voln v sredakh s vertikal'nyimi granitsami razdela [Peculiarities of seismic waves in media having vertical boundaries of discontinuity]: Akad. Nauk SSSR Izv., Ser. Geofiz., no. 5, p. 658-670, 1960.

A model study of characteristic dynamic features of several kinds of seismic waves including diffracted waves, is carried out for a medium having a

vertical boundary and a covering layer. The relationship between the dynamic features and a ratio of velocities and densities in the media in contact at the vertical boundary, the thickness of the covering layer, and the distance between the source and the vertical boundary are analyzed and discussed. It was found that the results obtained from the models are identical with the results of field investigations of the first arrivals from thin layers over the vertical boundary. — A. J. S.

- 182-157. Adachi, Ryuzo. On the wave motion propagated along an elastic cylinder with infinite length: Kumamoto Jour. Sci., ser. A., v. 4, no. 2, p. 134-143, 1959.

Calculations for formulas to determine the velocity of the wave propagated along an elastic cylinder satisfying boundary conditions on its surface are presented. The velocity  $c=\sqrt{E/\rho}$  can be obtained approximately only where the radius of the cylinder is small. If the radius is very large the circumstance is similar to that of a semi-infinite body bounded by a plane, and the wave may be similar to a Rayleigh wave. — V. S. N.

- 182-158. Spencer, T. W. The method of generalized reflection and transmission coefficients: Geophysics, v. 25, no. 3, p. 625-641, 1960.

The objective of this work is to provide a method for predicting the surface response of a stratified half space to the radiation from a localized source when neither the assumptions of the plane wave theory nor the assumptions of the normal mode theory are valid. The earth model consists of a finite number of perfectly elastic, homogeneous, isotropic layers separated by interfaces which are plane and parallel to one another. The method leads to an infinite series for the Laplace transform of the response function (displacement, velocity, stress, and others) in a multi-interface system. Each term in the series describes all the energy which traverses a particular generalized ray path between the source and the receiver. The specification of the mode of propagation across each stratum (either as an irrotational wave or as an equivoluminal wave) and of the sequence in which the strata are traversed serve to define a generalized ray path. A prescription is given for constructing the integral representation for the disturbance which has traversed such a path directly from the integral representation for the source radiation. The method therefore obviates the necessity for solving a tedious boundary value problem. The time function associated with each term can be obtained by using Cagniard's method. — Author's abstract

- 182-159. Sato, Y[asuo], Landisman, M[ark], and Ewing, M[aurice]. Love waves in a heterogeneous, spherical earth. Pt. 1. Theoretical periods for the fundamental and higher torsional modes: Jour. Geophys. Research, v. 65, no. 8, p. 2395-2398, 1960.

Free periods of torsional oscillation have been calculated for the Jeffreys-Bullen and Lehmann I earth models. Results are given for the first nine radial modes and for azimuthal modes up to  $n=44$ . The calculation allows for sphericity, an arbitrary number of discontinuities, gradients within each shell, and a liquid core. — Authors' abstract

- 182-160. Sato, Y[asuo], Landisman, M[ark], and Ewing, M[aurice]. Love waves in a heterogeneous, spherical earth. Pt. 2. Theoretical phase and group velocities: Jour. Geophys. Research, v. 65, no. 8, p. 2399-2404, 1960.

Love-wave phase and group velocities have been calculated for the first 14 radial modes for the Jeffreys-Bullen and Lehmann I models. Sphericity, an arbitrary number of discontinuities, gradients within each shell, and a liquid core have been taken into account. A new result is the prediction of maximum values of group velocity of about 7.5 km/s for all the higher modes and the relation of these maximums and the period cutoffs to traveltimes results. — Authors' abstract

- 182-161. Perri, E[milio]. Teoria e caratteristiche di due onde superficiali dispersive vibrante nel piano principale [Theory and characteristics of two dispersive surface waves vibrating in the principal plane (with English abstract)]: Annali Geofisica, v. 13, no. 1, p. 1-41, 1960.

The existence of two kinds of surface waves,  $E_1$  and  $E_2$ , that differ markedly from typical Rayleigh and Love waves is demonstrated mathematically. The first of these shows anomalous dispersion, the second normal dispersion. Although the waves are distinctly different from one another, they satisfy two common structural equations. If their group or phase velocity and period are known, the elastic constants of the medium in which they propagate can be determined.

The  $E_1$  wave, with short path, is found mainly in the rapid vibrations produced by surface perturbations, such as microseismic activity or explosive impulses. The  $E_2$  wave is absorbed increasingly with increasing depth; unlike typical Rayleigh waves, channel waves, or Stoneley waves, it can travel long distances without appreciable loss of energy. — D. B. V.

- 182-162. Knopoff, L[eon], and MacDonald, G[ordon] J. F. Models for acoustic loss in solids: Jour. Geophys. Research, v. 65, no. 7, p. 2191-2197, 1960.

A macroscopic model for the attenuation of small-amplitude stress waves in solids is presented. The loss mechanism described is that of solid friction which varies as the gradient of the local stress. The model is illustrated by a mass-spring system sliding on a rough surface in which the roughness of the surface increases in either direction with distance from the equilibrium position of the mass. The Q for the model is independent of frequency. Experimental evidence for the dependence of Q on surface area in silicate aggregates suggests the validity of a solid-friction model. — Authors' abstract

- 182-163. Chauveau, Jean, Grau, Gerard, and Lavergne, Michel. Réalisation de sismogrammes synthétiques comprenant toutes les réflexions multiples au moyen d'un système analogique électroacoustique [The making of synthetic seismograms including all the multiple reflections by means of an electroacoustic analog system]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 5, p. 887-889, 1960.

Synthetic seismograms are obtained at normal incidence, with all the multiple reflections, by means of a bar whose section varies as the acoustic impedance of the ground, the diameter remaining low with respect to the mean wavelength of the impulse which propagates in it. — Authors' abstract, D. B. V.

- 182-164. Hayakawa, M[asami]. Model seismology: Current Sci. [India], v. 29, no. 4, p. 122-123, 1960.

Model studies of seismological problems using ultrasonic pulses are now being conducted in Japan. The principle and apparatus are described briefly. Models representing a semi-infinite solid, a two-layered earth, and faults are being investigated. The equipment can also be used for direct measurement of elastic wave velocities in rock samples. — D. B. V.

- 182-165. Gil'bershteyn, P. G., and Gurvich, I. I. O primenenii dyrchatykh materialov dlya dvukhernogo seysmicheskogo modelirovaniya [Use of perforated materials for two-dimensional seismic modeling]: Vyssh. Ucheb. Zavedeniya Izv., Geologiya i Razvedka, no. 1, p. 139-156, 1960.

The use of layered materials with controllable elastic properties and density for study of elastic waves is examined. This control is gained by perforating the layers and thereby changing these properties. The layers are composed of duraluminum and plexiglass of 1.5-2.0 mm thickness. A seismoscope is used to generate the elastic waves.

The results of the experiments are very encouraging for the use of perforated materials in the study of seismic waves. In two-dimensional perforated models, longitudinal, transverse, and surface waves were produced, each with velocities determined by the properties of the material. These properties were dependent not only on the modulus of elasticity and density of the material, but also on the number of the holes and the pattern of their distribution. — J. W. C.

- 182-166. Sato, Ryosuke. On the determination of crustal structure by the dispersion curves of surface waves, 3 [in Japanese with English summary]: Zisin, v. 12, no. 4, p. 191-201, 1959.

In the first two parts of this paper Sato investigated the best method for determination of crustal structure from analyses of seismic surface waves where no vertical discontinuities occur between epicenter and point of observation (see *Geophys. Abs.* 175-62, 179-91). In this paper, seismic surfaces that cross vertical discontinuities before reaching the observing point are investigated by a simple model composed of two elastic plates in contact in a plane perpendicular to the plates. A formula for the observed group velocity is given for the case where waves are incident almost perpendicularly to the discontinuity planes. The observed phase-velocity gives information concerning local structure in the vicinity of the point of observation. The position of the discontinuity line between the Pacific Ocean and the North American Continent is deduced by using the dispersion of Rayleigh waves observed by Brilliant and Ewing (see *Geophys. Abs.* 158-138). — V. S. N.

- 182-167. Ito, Ichiro; Terada, Makoto; and Sakurai, Takehisa. Stress waves in rocks and their effects on rock breakage: Kyoto Univ. Fac. Eng. Mem., v. 22, pt. 1, p. 12-29, 1960.

Characteristics of stress waves produced in rocks by detonators or explosives are investigated experimentally. The dynamic characteristics of rocks under impulse loading produced by explosion of a detonator are discussed in the first part of the paper, and the following results were observed: Young's moduli for rocks are about two or three times greater than those obtained statically; dynamic strengths of rocks are greater than static ones; and various shock effects appear in accordance with the physical properties of rocks.

In the second part of the paper the changes in the propagation velocities of the induced stress waves near the point of an explosion are observed. Changes

in the velocity of propagation of the stress waves with distance indicate the existence of a plastic wave of higher order in the region very near the point of explosion, and the appearance of this plastic wave seems to depend not only on the physical characteristics of the rocks but also on the shattering effect of the explosives. The compressibility of a rock under impulsive high pressure is peculiar to the physical properties of the rock and has no relation to the nature of the explosive. The peak pressure of the wave front decreases very rapidly with distance and only within a few centimeters of the point of explosion do the explosives develop a different high pressure in proportion to their shattering effect. — V. S. N.

- 182-168. Fogelson, David E., Atchison, Thomas C., and Duvall, Wilbur I. Propagation of peak strain and strain energy for explosion-generated strain pulses in rock, in Third symposium on rock mechanics: Colorado School of Mines Quart., v. 54, no. 3, p. 271-284, 1959.

This paper presents the results from a series of linear array strain tests arranged by the Bureau of Mines and designed to determine the strain-producing abilities of six explosives when detonated in a granite gneiss. Both peak strain and strain energy were found to propagate through the rock according to an exponential decay law. The amount of strain produced in the rock by the explosive was found to correlate with the calculated detonation pressure. The amount of strain energy transferred to the rock, divided by the calculated energy of the explosive, was found to correlate with the characteristic impedance of the explosive. Five to nine percent of the total energy released by the explosive was transferred to the rock as strain energy.—Authors' abstract

- 182-169. Szemerédy, P. Determination of the velocity of propagation of elastic vibrations by the standing-wave method: Univ. Sci. Budapest. Eötvös Annales, Sec. Geol., v. 1, p. 89-95, 1957.

This paper describes a new variant of the resonance method for determining elastic wave velocities on small samples. The principles, apparatus, and techniques are discussed, and the results of measurements on 11 samples (tuffs, limestones, andesites, and a sandstone concretion) are tabulated. The measurement error was not more than 2 or 3 percent for samples 2.5 cm in diameter and 7-8 cm long, depending on the nature of the material; in non-porous rocks and metals the error was less than 1 percent. — D. B. V.

- 182-170. Balakrishna, S. Effect of granular texture on ultrasonic velocities in some rocks: Indian Mineralogist, v. 1, no. 1, p. 57-59, 1960.

Ultrasonic velocities were measured in granites, limestones, and marbles from different localities. Particle size was found to have considerable effect upon the ultrasonic velocity—in coarse grained rocks the velocities are low and absorption high; in fine grained rocks the velocities are high and absorption low. (See also Geophys. Abs. 179-130.)—V. S. N.

- 182-171. Matsushima, Shogo. Variation of the elastic wave velocities of rocks in the process of deformation and fracture under high pressure: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 32, 8 p., 1960.

Variation of ultrasonic velocities in granite in the process of deformation and fracture caused by axial compressional stresses was observed under high

confining pressure up to 5,000 atmospheres. At the initial stage of deformation, velocities increased with the overlapped stresses and then reached a constant value for both the axial and transverse directions. Upon reaching the fracture range, however, the velocities of waves passing through in a transverse direction decreased remarkably as fracturing progressed, whereas very little velocity change occurred in the axial direction. With increasing pressures, this velocity changes in the transverse direction disappeared.

In conclusion, it is suggested that it may be possible to explain velocity distribution in the crust of the earth by considering the stress distribution. A seismic wave passing through a relatively shallow region in the crust, where rocks are highly stressed and being fractured by overlapped forces, will have a decreased velocity in a direction transverse to the applied force. In a deeper part of the crust, these effects may not be observed because confining pressures are strong enough to prevent change in velocity by the overlapped stresses. — V. S. N.

Hess, H. H. Caribbean research project. Progress report. See Geophys. Abs. 182-261.

- 182-172. Howell, B[enjamin] F., Jr. Energy represented by seismic waves from small explosions: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 55-66, 1959.

The energy contained in seismic waves may divide unequally into kinetic and potential energy at any point, preventing dependable calculation of energy flux from a seismogram. The case of horizontally polarized shear waves reflected at the surface is developed as a simple example. The energy represented by a seismic pulse of a given amplitude depends also on transmission velocity and in the case of surface waves, on wavelength, as well as on other less critical factors. Equations showing the penetration of Rayleigh waves are developed in some detail to illustrate this. — Author's abstract.

- 182-173. Nagumo, S[hozaburo]. On the pressure component of elastic wave [in Japanese with English summary]: Butsuri-Tanko, v. 12, no. 2, p. 74-77, 1959.

The differential pressure of an elastic wave is a function of the dilatational component; therefore, a pressure phone responds to the dilatational component. At the surface of an elastic medium the pressure component of an elastic wave does not vanish because a part of the dilatational component of the incident wave is converted to the distortional component.

In an area of water-covered ricefields, a pressure phone may be used effectively to reduce the disturbant waves because it does not respond to the equivolume component of disturbances. — V. S. N.

- 182-174. Oliver, Jack [E.], Pomeroy, Paul, and Ewing, Maurice. Long-period seismic waves from nuclear explosions in various environments: Science, v. 131, no. 3416, p. 1804-1805, 1960.

Large nuclear explosions in the solid earth, the hydrosphere, and the lower and upper atmosphere have generated seismic waves of periods greater than 5 seconds, which have been detected at great distances from the source. This report is a summary of the principle evidence now available on the subject.

Although there is great contrast between the explosive sources discussed and natural earthquakes, and although several unexpected waves were generated by nuclear explosions, virtually all the waves so generated can be identified and explained in terms of knowledge of seismic-wave propagation based on earthquake data. — D. B. V.

- 182-175. Adams, W[illiam] M[ansfield], Flanders, P. L., Perret, W. R., Preston, R. G., and Sachs, D. C. Operation Hardtack, phase II—Summary report of strong motion measurements, underground nuclear detonations: U.S. Atomic Energy Comm. [Pub.] ITR-1711, 80 p., 1960.

Subsurface and surface motion measurements were made on six underground nuclear detonations in the Oak Springs tuff of the Nevada test site during Operation Hardtack II. Strong motion data from surface stations up to 9 miles distance indicate that vertical, radial, and tangential components of surface acceleration follow an equation of the form  $A=3.2 \times 10^6 W^{0.7} R^{-2}$  where A is peak acceleration in parts of gravity, W is the energy released by the detonation, and R is the radial range from the detonation point (slant range) in feet. The free-field peak radial acceleration decreased as the inverse third or fourth power of the slant range; particle velocities attenuated at a rate between the inverse square and inverse cube; maximum radial and tangential subsurface stress varied as the inverse cube of the radial range; and the observed peak strain suggested attenuation at a rate between the inverse cube and the inverse square of the range.

The velocity of the tuff is 6,200 feet per second, and that of the underlying dolomite 11,700 feet per second. The crust at the test site has a velocity of 6.58 km/s and a thickness of 30 km, and the top of the mantle has a velocity of 8.08 km/s and dips to the east. — V. S. N.

- 182-176. Nabeoka, S. On the velocity of the elastic wave through the rock at the dam site [in Japanese with English summary]: Butsuri-Tanko, v. 12, no. 2, p. 78-86, 1959.

The results of measurements of the apparent mean velocity of elastic waves in the bedrock at two damsites are discussed. Assuming that the velocity increases linearly with depth, the velocity increase factor (k) was calculated and the approximate velocity distribution was determined. — V. S. N.

International Geophysical Year Bulletin (No. 34). Seismic crustal studies during the IGY. Pt. 2: Continental program. See Geophys. Abs. 182-350.

Báth, Markus. Crustal structure of Iceland. See Geophys. Abs. 182-354.

#### ELECTRICAL EXPLORATION

- 182-177. Wait, James R. On the electromagnetic response of a conducting sphere to a dipole field: Geophysics, v. 25, no. 3, p. 649-658, 1960.

The electromagnetic coupling between an electric and a magnetic dipole in the presence of a spherical ore body is discussed in the present paper. It is shown that both electric and magnetic modes must be considered even though all dimensions are small compared to the wavelength. The results have application to a geophysical prospecting scheme where the exciting fields are set up by a straight insulating wire grounded at its end points and the secondary fields are detected by an ungrounded closed wire loop. — Author's abstract

- 182-178. Petr, Vaclav. Perekhodnoye pole vertikal'nogo magnitnogo dipolya v neodnorodnom poluprostranstve [The transient field of a vertical magnetic dipole in an inhomogeneous half space (with English and Czech summaries)]: Československá Akad. Věd Geofys. Sborník, no. 94, p. 401-424, 1958.

A solution is given for the transient field of a varying vertical magnetic dipole at the surface of a two-layered earth, the ground being represented by a plane-parallel plate lying on an infinite half space, and the dipole being formed by an electric loop lying horizontally on the surface. The solution was obtained by means of Fourier transformation, assuming that there is little difference between the conductivities of the two layers.

The transient mutual impedance between the horizontal loop and a horizontal dipole (formed by a vertical loop) was calculated and the result plotted for  $h/\rho=1/4$ , where  $\rho$  is the distance between the horizontal loop and the dipole and  $h$  is the thickness of the plane-parallel plate. The ratio  $\sigma_2/\sigma_1$  of the electrical conductivities of the two layers was also plotted. The mutual transient impedance between two horizontal electric loops was plotted for the same parameters  $h/\rho$  and  $\sigma_2/\sigma_1$ . These curves show that the mutual transient impedance of the two horizontal loops is more suitable for distinguishing between two media with similar conductivities than that of a horizontal and a vertical loop. — D. B. V., J. H. S.

- 182-179. Metzger, Adolf A. T. On a special case of geoelectric sounding: Geophysica [Helsinki], v. 7, no. 1, p. 23-30, 1959.

A method of resistivity prospecting suggested by Jakosky is analyzed for a homogeneous earth, for a single horizontal contact, and for a single sloping contact. In this electrode array, the two potential electrodes are arranged with one current electrode at their midpoint; the second current electrode is moved along the common line to vary the effective current penetration.

The usual image method is applied to both types of contact, and the method of reference curves is indicated by an example along with three observed curves. — I. R.

- 182-180. Chetayev, D. N. Opredeleniye koeffitsienta anizotropii i ugla padeniya odnorodnoy anizotropnoy sredy po izmereniyu impedansii yestestvennogo elektromagnitnogo polya [Determination of anisotropy coefficient and the dip of a homogeneous anisotropic medium from measurements of impedance of the natural electromagnetic field]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 617-619, 1960.

A half-space  $z' > 0$  filled with a uniform anisotropic conducting medium having a dip angle  $\alpha$  is considered for determination of apparent specific resistivity around a point source of direct current placed on the surface of the medium, and a method is proposed for determining separately the angle  $\alpha$  and the anisotropy coefficient of the medium from impedance of the natural electromagnetic field. A mathematical analysis of the problem results in an impedance modulus formula for various azimuths. The maximum of the modulus was found to be along the strike, and the minimum across the strike of the deposit. — A. J. S.

- 182-181. Semenov, A. S., Veshev, A. V., and Fokin, A. F. Pole tochechnego istochnika v anizotropnom prostranstve [Field of a point source in anisotropic space]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 249, p. 90-113, 1958.

The problem of the electric field of a point source in the lower half space of a homogeneous anisotropic medium is studied from observations in boreholes. New formulas are derived for the potential and potential gradient in the mediums studied, and graphs for vertical boreholes are constructed. — A. J. S.

- 182-182. Kataoka, Hisashi, and Matsuoka, Bun-ichi. On the forms of  $\rho$ - $a$  curves for buried plate conductor and the method of determining its depth [in Japanese with English summary]: Butsuri-Tanko, v. 12, no. 2, p. 57-64, 1959.

In the ground resistivity method the  $\rho$ - $a$  curves are distorted by subsurface structures that differ from horizontally layered beds, that is, by such features as ore bodies, faults, and unconformities. To establish criteria for recognizing the form and position of nonlayered structures from these distorted curves some examples of distortions are calculated theoretically for a semi-infinite plate conductor buried in a horizontal, vertical, and inclined position. From the results, master curves are plotted for use in determining depth to the buried structure. — V. S. N.

- 182-183. Ono, Yoshihiko. On the improvement of interpretation of electrical sounding data [in Japanese with English summary]: Japan Geol. Survey Bull., v. 10, no. 8, p. 669-676, 1959.

In applying the two-layer standard curve method or the Sundberg curve-matching method to interpretation of electrical sounding data from three layers or more, sets of auxiliary curves based on Hummel's idea of equivalent resistivity have been used. This method is fairly accurate when the three-layer curve has a minimum, but it may lead to serious errors for other cases. To solve this difficulty, equations are presented for new auxiliary curves based on Muskat's potential equation, which expresses the potential far away from the single current source for the three-layer case.

The accuracy of the new method is discussed and illustrated by examples. Good results are also expected with this method for four-layer curves when the relative thickness of each layer is large. — V. S. N.

- 182-184. Brant, A[thur] A. Historical summary of overvoltage developments by Newmont Exploration Limited, 1946-1955, in Overvoltage research and geophysical applications: New York, Pergamon Press, p. 1-3, 1959.

The phenomenon of overvoltage was discovered in 1946 and first field tested in 1947 on sulfide deposits in southwestern United States. Research has centered on distinguishing background responses from anomalies due to ore deposits. — J. W. C.

- 182-185. Roux, A. T. A review of airborne electromagnetic systems—Some factors affecting the choice of system and the interpretation of data: South Africa Geol. Soc. Trans. and Proc., v. 62, p. 203-217, 1959.

Geophysical investigation by airborne electromagnetic methods is now widely used in the search for sulfide bodies. Six electromagnetic systems, which differ mainly in coil configuration, have advantages and shortcomings not necessarily common to all systems. These six systems are listed in a table that gives for each the coil configuration, parameters measured, normal flight elevation, power into the transmitter coil, type of body giving maximum response, and response from a horizontal sheet.

The choice of a particular electromagnetic system for an airborne survey is determined by the expected shape, attitude, and electrical properties of the type of body sought; also by the geological environment, the topography, and the electrical properties of the overburden. The success of the survey depends upon the system selected, the skill and experience of the interpreter, and the care in planning the subsequent ground follow up. — V. S. N.

- 182-186. Lundberg, Hans. High resolution of anomalies from airborne two-plane EM method: Canadian Mining Jour., v. 80, no. 4, p. 101-106, 1959.

The rotary electromagnetic field, in which both phase and amplitude anomalies caused by electric conductors are recorded, has been introduced to provide an efficient and reliable means of airborne electromagnetic surveying. The rotary field is produced by two identical coils placed at right angles to each other, connected over a current-controlling phase-shifting device to an oscillator so that the current in one coil is 90° out-of-phase with that of the other; the electromagnetic field thus becomes circularly polarized. The receiving device also has two identical coils, one mounted vertically and the other horizontally. During survey flights the axis of rotation of the transmitting coils is aligned with that of the receiver, and the system balanced so that the recorded voltage and phase is zero as long as no secondary fields from subsurface conductors exist. If a conductor exists, voltage induced at the receiver from the secondary field is recorded in percent of the normal field. Variation in distance between transmitter and receiver has but little effect on the scale factor of the recordings.

To perform surveys successfully even on windy days and at low-level flying, two planes are flown in tandem. The leading plane with receiver equipment carries the coils in a bird suspended by a short cable; the rear plane with the transmitter flies at the same elevation as the bird. When flying 300 feet above the ground at a plane separation of 800 feet, the clear depth detection for a vertical ore body is some 400 feet below the ground surface. With geological conditions encountered in Canada, where surface resistivity is high in relation to that of ore bodies, variations in surface conditions cause no anomalies exceeding ordinary background noise level. Resistivity of overburden in Canada is 100 ohm-m or more and tests show that a variation in overburden thickness of 60 feet will cause a phase anomaly as high as 0.8° but the amplitude anomaly will never exceed 0.2 percent. If the survey grid is adequate, no conductors are missed with the rotary field method, regardless of direction or orientation of the flight line. Therefore, the rotary EM two-plane method is particularly applicable to the exploration of large tracts.

The resolving power of the rotary EM method is still limited when compared with the seismic reflection method, but for locating and mapping near-surface structures it is already a valuable tool particularly for preliminary exploration in remote and inaccessible territories. — V. S. N.

- 182-187. Fritsch, Volker. Geoelektrische Tiefsondierungen und ihre Übereinstimmung mit Bohrbefunden [Geoelectric deep soundings and their correlation with drilling results]: Geofisica Pura e Appl., v. 44, p. 144-153, 1959.

The principles, methods, and apparatus used for electrical resistivity soundings (using the Wenner configuration) to a depth of 4,000 m are described. Results obtained in Austria and Yugoslavia were confirmed by deep drilling and by seismic measurements. The discrepancy between the geoelectrical predictions and the findings in 10 boreholes was ±8-13 percent. — D. B. V.

- 182-188. Cagniard, L[ouis]. Abaque pour sondage électriques sur glace [Chart for electrical soundings on ice]: Annales Géophysique, v. 15, no. 4, p. 561-563, 1959.

In measurements made on ice the effect of a thin, partly melted, conducting surface layer on the apparent resistivity has been calculated, and a bilogarithmic chart has been constructed for use in interpreting the results of such surveys. The chart is reproduced on a reduced scale. — D. B. V.

- 182-189. Dizioğlu, Mehmet Y. The development and study of a resistivity method of prospecting applicable in valleys; its application to the Azdavay Carboniferous area, and the correlation of the results with those of seismic, well logging and geological surveys: Turkey Mineral Research and Explor. Inst. Bull., no. 53, p. 39-81, 1959.

Because any point in a valley cannot be considered to be in a semi-infinite or infinite medium, present resistivity methods must be developed to allow for the effects of the geometrical shape of a valley before they can be applied in such cases. A factor K embodying the effects of the shape of a valley is introduced. Its variation for different types of valleys with different electrode positions was studied by means of small scale models, and the directional resolving power of the method was investigated. The resistivity formulas so determined were studied for different types of geologic structure that are frequently encountered in nature.

The method was then applied to the Azdavay Carboniferous area in Turkey; the results are compared in detail with those obtained by geological and seismic reflection surveys and by resistivity and SP logging in a test borehole. It is concluded that where the ratio  $a/d$  ( $a$  = electrode spacing,  $d$  = valley width) is between 0 and 5 the rate of change of  $K$  is very large and the part of the resistivity curve corresponding to this interval must be interpreted with great care; that when  $a/d$  is more than 8 the  $K$  factor can be chosen quite accurately and interpretation error from this source is negligible; that if the disturbing body is near the valley, small electrode spacings are more effective than larger ones; and that the proposed method must be used if lithologic type, true resistivity, and correlation of formations are to be obtained from resistivity surveys in valleys. — D. B. V.

- 182-190. Poldini, E., Burri, J. -P., and Inagaki, M. Quelques résultats d'études géophysiques réalisées dans la région de l'Eau Morte (canton de Genève) [Some results of geophysical studies carried out in the Eau Morte region (Geneva canton)]: Archives Sci. (Genève), v. 12, no. 3, p. 271-291, 1959.

The results of gravity and electrical resistivity surveys in the area of the Eau Morte alluvial cone in Geneva canton, Switzerland, are presented and discussed. Pre-Riss valleys cut in the Molasse and filled with Quaternary deposits are clearly revealed by the resistivity anomalies. The resistant gravels of the alluvial cone lie on conducting Würm clays (resistivity=30 ohm-m), which in turn rest on resistant interglacial gravels that overlie the Molasse (resistivity=28 ohm-m). The residual gravity anomalies confirm the electrical results and also trace the Molassic backbone of the Bernex Hill that plunges under the Quaternary sediments in the direction of Cartigny, Laconnex, and Soral.

Maps of resistivity, Bouguer, and residual gravity anomalies are given. — D. B. V.

- 182-191. Diceglie, Stefano, and Mosetti, Ferruccio. Applicazione dei metodi geoelettrici alle esplorazioni archeologiche. Saggio di prospezione nella città di Gnathia [Application of geoelectrical methods to archeological explorations. Experience with prospecting in the city of Gnathia (with French, German, and English summaries)]: Boll. Geodesia e Sci. Aff., v. 16, no. 3, p. 367-381, 1957.

The discovery of a tomb by electrical resistivity methods in the ancient city of Gnathia on the Adriatic has proved that these methods are useful for archeological purposes. — D. B. V.

- 182-192. Ghazarian, G. B. Final report on the electrical resistivity survey carried out at Wadi El Kharruba, March 1957: L'Institut du Desert d'Egypte Pub., no. 10, p. 121-131, 1957.

Results are given from an electrical resistivity survey made at the site of a proposed dam in the Wadi el Kharrouba in the western desert of Egypt. The survey showed the absence of a continuous layer of impermeable material that could serve as a barrier to keep water behind the proposed dam from leaking away. This difficulty might better be overcome by building two small dams at the mouth of each branch of the Wadi. — V. S. N.

- 182-193. Shayins'kyy, O. M., and Haman, B. O. Zastosuvannya elektrorozvidky dlya rozshukiv vod v merhelyakh kreydovoho viku u L'viv'skiy mul'di [Use of electrical surveying for prospecting for water in the Cretaceous marls in the Lvov basin]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 19, no. 4, p. 103-107, 1959.

The results of electrical resistivity surveys for ground water in the Cretaceous marls of the Lvov basin in the Ukrainian S. S. R. show that such surveys are suitable for locating water wells in this type of terrane. Optimum conditions for the occurrence of water are found in places of maximum anisotropy in areas of minimum resistivity values.

In prospecting for cavernous water-bearing horizons in areas of widespread marls it is recommended that reconnaissance surveys be made using the method of vertical electric sounding. These serve as a basis for more detailed work by the method of resistivity profiling, which establishes the areas of minimum apparent resistivity. Vertical electric sounding within these areas then can be used to locate the places of maximum anisotropy, which represent cavernous marl.

Use of this combination of methods should increase the effectiveness of electrical surveying as applied to such problems. — D. B. V.

- 182-194. Yokoyama, Hidekichi, and Kunori, Shoichi. Results of electrical prospecting at Kudo mine [in Japanese with English abstract]: Tohoku Kozan, v. 5, no. 4, p. 139-149, 1959.

Self-potential and resistivity surveys were made in conjunction with an experimental geothermal study in the vicinity of the Kudo mine to locate extensions of the copper-, lead-, and zinc-bearing quartz veins. Test borings made on the basis of temperature anomalies and of results of the electrical surveys located new veins. — V. S. N.

- 182-195. Nosske, Gerhard. Eine neue leichte Feldausrüstung für die induzierte Polarisation mit Gleichstromimpulsen [A new light field outfit for induced polarization with direct-current impulses]: Zeitschr. Angew. Geologie, v. 5, no. 11, p. 528-533, 1959.

A direct-current induced polarization apparatus, developed by VEB Geophysik in Leipzig and based on Bleil's method (see Geophys. Abs. 154-14646), is described and illustrated with photographs. Results obtained with it on disseminated pyrite in the Erzgebirge, on red iron ore in limestone and carbonaceous schists in the Harz, and on a model (aluminum plate in water) are compared with those obtained by other methods. — D. B. V.

- 182-196. Mizyuk, L. Ya., Gol'dgefter, V. I., and Zubov, V. G. Dvoynoy elektrorazvedochnyy tranzistornyy avtokompensator DETA-58 [Dual electroprospecting transistor automatic compensator DETA-58]: Vyssh. Ucheb. Zavedeniya Izv., Geologiya i Razvedka, no. 12, p. 134-139, 1959.

Recording of constant and slowly changing voltage is necessary in electrical exploration with d-c methods and also in the study of the telluric field. For this purpose an oscillator may be used in conjunction with an automatic compensator. The DETA-58 compensator is described, and a schematic diagram is given. — J. W. C.

- 182-197. Roeschmann, Fritz. Rechnenschieber für die Auswertung geoelektrischer Messungen [Slide rule for the evaluation of geoelectric measurements]: Zeitschr. Angew. Geologie, v. 6, no. 1, p. 35, 1960.

A slide rule designed for rapid determination of apparent resistivity from geoelectric measurements is described. It is so constructed that it can be used for either the Wenner or the Schlumberger electrode arrangement. — D. B. V.

#### ELECTRICAL LOGGING

- 182-198. Garland, G. D. Magnetic disturbances and electric logging: Canadian Oil and Gas Industries, v. 13, no. 4, p. 115-117, 1960.

Studies of natural earth currents (or telluric currents) conducted at the University of Alberta have indicated some reasons for the anomalous readings of the self-potential curve of electric logs and have resulted in a quantitative estimate of the error. To detect any vertical component of these earth currents, two electrodes were placed permanently in a dry well at Calmar, Alberta, at depths of 3,800 and 800 feet. These were connected to the surface by separate cables which were in turn connected to recorders by cables along the surface. Potentials were recorded between the two hole electrodes, between the surface and depth, and between points on the surface. Records of observations show important variations in vertical potential gradient both between the surface and 800 feet, and between 800 and 3,800 feet; the variations are considerably larger across the upper interval. It is shown graphically that the maximum potential disturbance in the well increases with magnetic activity, but that there can be periods of considerable magnetic disturbance for which the potential gradient is not disturbed. It is concluded that at Calmar significant vertical electric disturbance is observed only during periods of magnetic activity and then only when the telluric current passes in a north-south direction; the usual direction of current flow is more east-west. In other fields or holes, bodies of anomalous conductivity may be so located as to distort the usual direction of current flow and, in these cases, the vertical direction may be much more frequent. The studies at Calmar were limited to the upper 3,800 feet of the hole and emphasis was thus on the near-surface effect. At greater depth, the effect of undulations of the boundary between the resistant carbonate rocks and more conducting formations could produce similar effects.

Magnetic disturbances tend to occur in 27-day cycles and to persist for 2-3 days, and the effects increase as the auroral zone at about the northern boundary of the Canadian prairie provinces is approached. Thus, it would be advantageous to avoid periods of magnetic disturbance for electric logging, especially in the north; if this is not possible, the hour of day should be noted on a log for later comparison with observatory records in the case of dubious self-potential results. — V. S. N.

- 182-199. Wyllie, M. R. J. Log interpretation in sandstone reservoirs: Geophysics, v. 25, no. 4, p. 748-778, 1960.

The interpretation of fluid content and physical properties of sandstones from well logs is relatively simple. From an exploration standpoint the precise porosity and thickness of the formation and its exact hydrocarbon saturation are secondary considerations; the significant fact is whether or not it will produce oil or gas.

Some of the principal difficulties involved in determining interstitial water resistivity, porosity, and formation resistivity are examined. It is confirmed that the "low-zone" significantly decreases the resistivity of an oil-bearing sand as found from an induction log. Diffusion and convective mixing of the filtrate and interstitial water have been found to do little to mitigate the problem. Future correction charts for induction logs should recognize this fact.

DeWitte's interpretation procedure (see *Geophys. Abs.* 169-109) is found to be substantially correct for sands containing interstitial clay. The real problem is to decide how the clay content is disposed in a typical dirty sand.

Measurements on the effect of the porosity of sandstones on the difference between velocities through them when dry and when fully water saturated show, paradoxically, that the velocity difference is greatest when porosity is least. Significant velocity differences between gas- and water-saturated sandstones are not to be expected in the porosity range of practical significance.—D. B. V.

- 182-200. Doll, H. G., Dumanoir, J. L., and Martin, Maurice. Suggestions for better electric log combinations and improved interpretations: *Geophysics*, v. 25, no. 4, p. 854-882, 1960.

Several resistivity measuring devices are now available or are under development which cover a wide range of radial investigations. These include, in order of increasing penetration, the proximity log for recording formation resistivity close to the wall of the hole, a laterolog having a shallow investigation and adapted for simultaneous recording with an induction log, an induction log appropriate for moderate invasion, and a deep investigation induction log. All these devices have high vertical resolution and their readings are practically unaffected by the mud column.

This paper deals essentially with logging in fresh mud. The information on saturation that can be obtained with combinations of 2, 3, or all 4 of these new devices is discussed. The general case where nothing is known about depth of invasion is first treated. Where depth of invasion is known from local experience, one or even two of the devices can be omitted. Charts used in the procedures described are presented, and the discussion is illustrated with field examples.—D. B. V.

- 182-201. Segesman F., and Tixier, M. P. Some effects of invasion on the SP curve: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 216, Tech. Paper 8067, p. 138-146, 1959.

Explanations based on theory and laboratory tests are presented for certain SP log anomalies that may be confusing in interpretation, namely the "sawtooth" SP and the reduction or increase of SP with time.

The sawtooth frequently appears on SP recordings of thick, very permeable water sands of the Louisiana Gulf Coast and is explained on the basis of a thin shale streak within the sand under which the invading filtrate accumulates. The electromotive force appearing across the shale streak gives rise to the anomalous SP. Reduction of the SP on successive logging runs is often observed in very permeable sands when resistivity curves indicate invasion depth to be practically zero. Laboratory results verify that this may be due

to pressure of an electromotive force across the mud cake when fluids on either side differ in activity. In some cases an increase of SP deflection occurs on successive logging runs because the electromotive force initially present across the mud cake disappears as the somewhat saline water just behind the mud cake is progressively flushed out by the invading filtrate. Field examples and laboratory data are presented. — V. S. N.

- 182-202. Biggs, W. P. Fundamentals of electric logging: Petroleum Engineer, v. 32, no. 2, p. B-26-B-34, 1960.

The following fundamentals of electric logging are discussed: the electric log and its three recording tracks; the fundamentals of log interpretation including a definition of resistivity and of the expressions used to give the relationships for converting electric-log data to reservoir-rock and fluid data; logging methods; resistivity measuring devices including the electric log, the induction log, induction-electric log, and the laterolog; determination of porosity; porosity-determination devices including microdevices, and sonic logs; and the development of a logging program. — V. S. N.

- 182-203. Alger, R. P. Log evaluation at the well: Petroleum Engineer, v. 32, no. 4, p. B-80, 83, 88, 90, 95, 98, 100, 1960.

The importance of qualitative or semiquantitative interpretation of electrical logs at the well, the fundamentals of quantitative interpretation, and the principal methods used today are discussed. Field interpretation for high-, medium-, and low-porosity formations, and interpretation of pay zones from gradients by the invaded zone methods and from porosity index (or  $F_a$ ) comparisons are described.

In practice only a few of the methods apply to any one well. For best results, focused logging tools should be run, and in difficult areas two properly selected porosity logs can be very worthwhile. No one porosity log can be interpreted by itself without knowledge of lithology and (or) extent of flushing. — V. S. N.

- 182-204. Burton, R. P. New log interpretation techniques for the Gulf Coast: Gulf Coast Assoc. Geol. Soc. Trans., v. 9, p. 179-183, 1959.

Two new qualitative log interpretation techniques for estimating saturation have been successful in detecting the presence of hydrocarbons in reservoir rocks of the Texas Gulf coast region. These new methods require a sonic and a resistivity log, preferably an induction-electric log combination, and are most advantageous where conventional quantitative methods are relatively difficult. In the first technique a comparison is made of the values of the formation water resistivity computed from the resistivity log and from the sonic log; actually, apparent formation water resistivities are calculated assuming that all sands are wet. With this concept of continuity, a quick determination of zones of saturation in shaly sand can be made; this also applies in cases where there are appreciable variations in formation water salinity with depth. The second technique consists of a comparison of the apparent formation factor obtained from the sonic log with that computed from a short-investigation resistivity log; this may reveal the presence of residual oil or gas and thus detect potentially productive formations.

The first procedure works better where the porosity of the formation is high and the mud is fresh; the second is better in formations of low porosity and with little contrast between mud and formation water resistivities. Examples of the application of the two techniques in the Miocene, Frio, and Wilcox sections of the Gulf Coast are given. — V. S. N.

- 182-205. Ono, Yoshihiko. Various problems on the resistivity of formation water (Rock resistivity I) [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 10, no. 7, p. 617-626, 1959.

The importance of ground water in electrical prospecting is discussed briefly, and the effect of various factors on the resistivity of formation water is considered in detail. In fossil water the concentration of dissolved salt (NaCl) and the temperature of the water have considerable influence on the resistivity; the general composition of the fossil water is not important.

In fresh water the composition is important for interpretation of the electric log. The relative contributions of important ions to the water conductivity and their conversion factors to NaCl concentrations are calculated approximately. Fresh water resistivity ( $\rho$ ) is expressed by the formula  $\rho = m / \sum (m_i / \rho_i)$  where  $\rho_i$  is resistivity of each salt in a given fresh water that has a "concentration in normality" equal to the total electrolyte "concentration in normality"  $m$ , and  $m_i$  is the actual "concentration in normality" of each salt in the water.

The possible application of ground water resistivity to geological problems is considered. — V. S. N.

- 182-206. Dakhnov, V. N., and Dolina, L. P. Geofizicheskiye metody izucheniya neftegazonosnykh kollektorov [Geophysical methods of study of oil-gas reservoirs]: Moscow, Gostoptekhizdat, 268 p., 1959.

This book is designed to bring together in a single manual the information necessary to use geophysical logs in interpretation of reservoir properties. The chapter headings are as follows: discrimination of reservoirs; determination of the specific electrical resistivity of formation waters; determination of the coefficient of porosity of rocks; determination of the clay content of reservoirs; discrimination of oil-bearing and gas-bearing rocks; determination of the coefficient of oil saturation of the rocks; and use of geophysical logging data for calculating oil and gas reserves. — J. W. C.

- 182-207. Per'kov, N. A. Ispol'zovaniye diagramm mikrozondov dlya vydeleniya kollektorov v karbonatnykh razrezakh [Use of microsonde logs for distinguishing reservoirs in carbonate rocks]: Geologiya Nefti, no. 3, p. 45-48, 1958.

Tests were made in the Ural-Volga oil region on the comparative effectiveness of various types of logging techniques in distinguishing reservoirs in carbonate rocks. The apparent resistivity microsonde method proves better than the neutron-gamma or the self-potential methods in estimating the porosity of thin-bedded sections. — J. W. C.

- 182-208. Dakhnov, V. N. Geofizicheskiye metody izucheniya kollektorskikh svoystv gornykh porod [Geophysical methods of study of reservoir properties of rocks]: Geologiya Nefti, no. 8, p. 55-65, 1958.

The various methods of geophysical well logging applicable to determination of reservoir properties are discussed. The following techniques are considered: Standard method of apparent resistivity, symmetrical gradient sonde, microlog, laterolog, self-potential method, induced polarization method, induction method, natural gamma-radiation method, diffused gamma-radiation method, isotope method, neutron-neutron method with epithermal neutrons, neutron-neutron method with thermal neutrons, neutron gamma method, magnetic methods, caliper log, and ultrasonic seismic method. Each of these is evaluated for its use in determining porosity, clay content, tortuosity, and permeability. — J. W. C.

- 182-209. Kotyakhov, F. I. Ob opredelenii fizicheskikh parametrov nefte-soderzhashchikh porod dlya podscheta zapasov nefti v zalezakh po elektrometricheskim i radiometricheskim dannym [On the determination of the physical parameters of oil-bearing rocks for calculation of oil reserves in deposits according to electrometric and radiometric data]: *Geologiya Nefti*, no. 10, p. 36-39, 1958.

Determination of oil reserves on the basis of core analysis is very approximate; therefore, much attention is given to refining various logging methods. A combination of electrical resistivity and radiometric logs designed for calculating oil reserves is described. A formula is derived whereby the porosity is determined from the coefficient of absorption of gamma rays, the resistance of the stratum as determined by the laterolog, and the densities of the oil and water under formation conditions. The value for the porosity is then used in another formula to determine the water saturation, which is a basis for estimating the reserves. — J. W. C.

- 182-210. Umantsev, D. F., and Petrov, Ye. N. Elektricheskaya kharakteristika [Electrical characteristics], in *Geologiya i neftenosnost' Zapadno-Sibirskoy nizmennosti: Vses. Neft. Nauchno-Issled. Geol.-Razved. Inst. Trudy*, no. 114, p. 77-83, 1958.

Laterolog determinations of resistivities characteristic of the various units in the Mesozoic and Cenozoic section of the West Siberian Lowland are reported. These measurements are the basis for stratigraphic subdivision, which is otherwise difficult owing to a paucity of fossils. The resistivity of these rocks increase with (a) increase in age, which gives rise to an increase in density, (b) decrease in sorting, (c) increase in silica and carbonate, and (d) decrease in salt content of formation water. — J. W. C.

- 182-211. Lang, Joe W. Value of electric log in water well drilling: *Mississippi Water News*, v. 1, no. 8, p. 1-2, 1959.

An electric log, giving potential and resistivity to a depth of 712 feet, is shown for a water well near Biloxi, Miss. This log, supplemented by the driller's log, indicated a zone to be developed for a good supply of soft artesian water.

An electric log generally indicates depth of rock formations more accurately than a driller's log and supplies valuable data for subsurface geologic mapping. — A. J.

- 182-212. Haeberle, Frederick R. Comparison of porosity logs with core porosity, Oficina area, eastern Venezuela: *Bol. Inf.*, v. 3, no. 4, p. 107-117, 1960.

The various logging methods used for determination of porosity in the Oficina area, Venezuela, are evaluated. Although the microlog is the simplest for sand counts and qualitative indications of porosity, it is the poorest method for quantitative work. The microlaterolog proved best under these conditions. In cased holes the neutron log is not very satisfactory.

The majority of porosity logs tend to give results that are somewhat too low when compared with values determined from cores. Only 46.4 percent of the results showed 10 percent or less variation above or below the core porosities. However, 72.2 percent of all porosities from all types of logging tools showed less than 20 percent variation above or below the core porosities. — J. W. C.

## ELECTRICAL PROPERTIES

- 182-213. Cook, John C. RF electrical properties of salty ice and frozen earth: *Jour. Geophys. Research*, v. 65, no. 6, p. 1767-1771, 1960.

Radiofrequency losses at 100 megacycles per second in artificial samples of salty ice and frozen freshwater-saturated earths were measured in the laboratory, and pronounced attenuation of radio waves within distances of a few meters are predicted as a general rule. Salty ice dielectric constants averaged 3.5, and resistivities "across the grain" varied from about 55 ohm-m at -10°C to about 1,200 ohm-m at -40°C for ice containing about 5 permil of salts. These results may or may not apply to natural sea ice and permafrost. — Author's abstract

- 182-214. Parkhomenko, Ye. I., and Bondarenko, A. T. Vliyaniye odnosto-ronnego davleniya na elektricheskoye soprotivleniye gornykh porod [Effect of unilateral pressure on electric resistivity of rocks]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 2, p. 326-332, 1960.

The effect of unilateral compression stress on the electrical resistivity of samples of sandstone, shale, basalt, peridotite, and diabase with varying degrees of moisture was investigated experimentally. It was found that the maximum change in resistivity occurs at a certain average percentage of moisture but neither at maximum nor minimum. The greatest increase in electric conductivity was observed under comparatively low mechanical stresses (up to 200 kg per cm<sup>2</sup>), and the greatest change in conductivity (50-100 percent) was observed in shale containing 28-32 percent of water. Such an increase in electrical conductivity of moist rocks is attributed to formation of continuous liquid current-conducting channels during compression of the rock. The results obtained should be taken into consideration in interpretation of deep electric-logging diagrams. — A. J. S.

## EXPLORATION SUMMARIES AND STATISTICS

- 182-215. Johnston, John E., Trumbull, James, and Eaton, Gordon P. The petroleum potential of the emerged and submerged Atlantic Coastal Plain of the United States [with French abstract]: *World Petroleum Cong.*, 5th, New York, Proc., sec. 1, paper 22, p. 435-442, 1959.

Seismic and magnetic surveys along the Atlantic continental shelf of the United States indicate that the basement is deeper and more irregular than previously supposed and that a basement ridge may separate the shelf sediments into two major elongate basins parallel to the shelf edge, thus forming possible trapping structures and possibly restricted depositional basins.

It can be expected that petroleum will eventually be discovered beneath the continental shelf and perhaps the emerged coastal plain, but not until geologists have projected paleogeographic settings into the sediments beneath the shelf from the data obtained through onshore and submarine geology, drilling, and geophysics. — V. S. N.

- 182-216. Halbouty, Michel T., and Hardin, George C., Jr. A geological appraisal of present and future exploration techniques on salt domes of the Gulf region of the United States [with French abstract]: *World Petroleum Cong.*, 5th, New York, Proc., sec. 1, paper 5, p. 95-107, 1959.

In this paper the term salt dome is used primarily with reference to shallow and intermediate depth piercement-type salt domes because the geology of the deep-seated salt domes is, in general, similar to that of the normal anticlinal structure. Almost all of the known types of oil traps occur in connection with salt domes, and Halbouty and Hardin emphasize the fact that as much mineral wealth will be found in the future on these structures and in their areas of influence as has been found in the past provided that a systematic exploration procedure based on sound geological and geophysical reasoning is followed. Certain basic principles of exploration and exploitation are recommended. Current seismic reflection techniques have been found to be of little value for mapping of unconformities, stratigraphic traps, or unrelated fault systems found in beds of different ages on the flanks of salt domes, and too much emphasis has been placed on correlation of electric logs for all geologic and structural interpretation. It is essential that an experienced salt dome geologist work with the geophysicist in the interpretation of seismic data and that micropaleontologic studies be combined with electric log interpretations. Future exploration techniques will be based on improved geophysical methods and their specific application to the flanks of salt domes, and upon the use of the vast amount of additional subsurface information that becomes available each year. — V. S. N.

- 182-217. Blanpied, B. W. Trends in exploratory methods based on statistics from study of basis of location of new-field wildcat wells: Am. Assoc. Petroleum Geologists Bull., v. 44, no. 7, p. 987-999, 1960.

Much information gathered from files of the statistical data presented by members of the Committee on Statistics of Exploratory Drilling is presented herewith for the first time for the states of Texas, Louisiana, and New Mexico in 14 tables. Also, 6 figures are presented for the 12-year period 1948-59 inclusive, showing statistical percentages in the use of geology, geophysics, and combined geology and geophysics in making new-field wildcat locations. Data show that more than half of the successful technically located wells were located on a geological basis, and approximately 25 percent on geophysical methods alone. — Author's abstract

- 182-218. Byerly, P. Edward, and Joesting, H[enry] R. Regional geophysical investigations of the Lisbon Valley area Utah and Colorado: U. S. Geol. Survey Prof. Paper 316-C, p. 39-50, 1959.

Aeromagnetic and gravity surveys were conducted in the Lisbon Valley area of the Paradox Basin in the east-central part of the Colorado Plateau. Exposed rocks range in age from Pennsylvanian to Quaternary and include the intrusive rocks of the La Sal Mountains of probable Tertiary age. The major structure in the valley is a faulted salt anticline, which is indicated by a negative gravity anomaly of about 15 mgals. This structure differs from other large salt anticlines of Paradox Basin in that the evaporites do not intrude the overlying rocks. Gravity anomalies also indicate a piercement salt plug north of the Lisbon Valley anticline and local thickening of salt in the western and northwestern parts of the area. Alineation of Late Paleozoic salt intrusions with the South Mountain group of igneous intrusions in the La Sal Mountains indicates that this group was intruded along a zone of previous structural activity.

Magnetic data indicate a prominent basement ridge or platform in the southwestern part of the area flanked by a basin to the northeast. — V. S. N.

- 182-219. Peters, Jack W. Geophysical case history of the Horse Creek field, Laramie County, Wyoming: *Geophysics*, v. 25, no. 3, p. 602-612, 1960.

The Horse Creek oilfield in Wyoming was discovered and developed following a reconnaissance gravity survey and preliminary and detail seismic surveys. The gravity survey, made in 1940, delineated a strong maximum anomaly about 5 mgal in magnitude. Limited seismic work in 1941 and 1942 showed an anticline with about 2,000 feet of closure. The discovery well, on the apex of this structure, was started in September 1942; it produced from the Lakota sand. The second well, completed in April 1943, constituted the Muddy sand discovery for the field. Further seismic work in 1944 and 1945 filled in the structural picture. The Muddy sand is the primary producer for the field. — D. B. V.

- 182-220. Smellie, D. W. Technology. Mining exploration: *Canadian Mining Jour.*, v. 81, no. 2, p. 166-168, 1960.

A brief review of geophysical surveying in Canada during 1959 and a discussion of technological developments, both airborne and ground, are presented. Some 220,000 line miles of conventional airborne and helicopter-borne magnetic surveying and 50,000 line miles of airborne electromagnetic surveying were accomplished. Airborne electromagnetic work was down from previous years reflecting a decrease in mineral exploration activity. Geochemical exploration, geological exploration, and drilling are also discussed. — V.S.N.

- 182-221. Latus, T. J. 10th Annual review of the industry—Developments in western Canada: *Canadian Oil and Gas Industries*, v. 13, no. 4, p. 38-41, 1960.

A review of the significant exploratory and development activities for 1959 in the sedimentary regions of British Columbia, Alberta, Saskatchewan, Manitoba, the Yukon Territory, and the Northwest Territories including the Arctic Islands is presented. Geophysical exploration declined sharply (down 33 percent) below 1958 levels, particularly in Saskatchewan. The use of seismic tools, however, increased in the folded foothills belt of northeast British Columbia, and gravimeter work increased in the Northwest and Yukon Territories. (See also Geophys. Abs. 180-152.) — V.S.N.

- 182-222. Oil in Canada. Canada tops world geophysical decline: *Oil in Canada*, v. 12, no. 35, p. 12, 1960.

Canada had a drop in geophysical exploration crews of 25.6 percent from 1958 to 1959 as compared to a world decline of 8.9 percent. The United States had a decline of only 0.61 percent, whereas the Western Hemisphere total was down 5.1 percent.

The 1959 reduction of seismic activity in Canada was borne almost entirely by the contract geophysical companies; as in past years, contractors did all the aeromagnetic work and 95 percent of the gravity work. Increased use of the aerial magnetometer in petroleum exploration was reported for the year. — V.S.N.

- 182-223. Bateman, J. D. Saskatchewan focal point of search for rare helium: *Oilweek*, v. 11, no. 9, p. 34-36, 1960.

In view of the reported discovery of helium in five widely separated wells in southwestern Saskatchewan suggesting the presence of commercially recoverable quantities of the gas in this area, a review of the geologic occurrence of helium is presented. At the present time the world production of helium outside the communist block nations is confined to the United States with 99 percent of the reserves found within a radius of 250 miles of Amarillo, Tex., leading to the conclusion that this occurrence is geologically unique.

Helium on and within the earth is either primordial or radiogenic in origin. Primordial helium, derived from the sun, must have been largely dissipated in space during the early evolution of the earth. Radiogenic helium is derived from the spontaneous atomic disintegration of naturally occurring radioactive elements in association with beryl-, amblygonite-, and spodumene-bearing rocks. Deposits have developed in the United States in areas above granite ridges in the basement where reservoir formations with adequate porosity, impervious cap rocks, and structures or traps for the accumulation of the gas are present. Basement topography may be detected from magnetic, gravity and seismic surveys.

The Precambrian basement of southwestern Saskatchewan has topographic relief up to 600 feet or more. It is overlain by the Cambrian Deadwood formation, the lower part of which is a basal sand and the upper part generally a shale. Thus, where a suitable source of radiogenic helium is generated in the basement, the Deadwood may provide an adequate reservoir for helium accumulation. — V. S. N.

- 182-224. Sawatzky, H. B., Agarwal, R. G., and Wilson, W. Helium prospects in southwest Saskatchewan: Oil in Canada, v. 12, no. 23, p. 54-57, 60-62, 64, 66-68, 70, 72-76, 1960.

The possible origin and sources of helium and the geologic conditions conducive to trapping the gas are discussed. Magnetic and gravity data have been important in evaluating regional tectonic trends and basement lithology in southwestern Saskatchewan, and have indicated promising areas to be subjected to more detailed seismic and subsurface investigations. A classification outline of a random selection of a number of promising anomalies in the area of investigation is presented. The importance of analyzing the intervals between certain seismic reflection horizons is emphasized since this commonly may be the only reliable key to revealing deep anomalies. This technique is not entirely dependent on such factors as refined velocity control and presence or absence of anomalous conditions in shallower formations. — V. S. N.

- 182-225. Campbell, W. G. Oil and gas exploration techniques in northern Yukon and Northwest Territories: Oil in Canada, v. 12, no. 39, p. 42-44, 1960.

Initial reconnaissance exploration for oil and gas in this northern area of Canada has covered approximately 8,000,000 acres extending across the Arctic Circle in Yukon and Northwest Territories. The area is divided by the Richardson Mountains; thick sections of sedimentary rocks occur on both sides of this range. Most of the activities reported in this paper have been concentrated on the west side in the Eagle Plains basin where Precambrian to Tertiary sediments occur. Seismic and gravity data indicate a structure of major dimensions. Magnetic data show no significant anomaly, however. Oil was not found in the first well drilled in 1957, but in the second well, drilled in 1959, there were shows of oil and gas.

The equipment used and the difficulties encountered as a result of terrain, climate, and permafrost are discussed briefly. — V. S. N.

- 182-226. International Geophysical Year Bulletin (No. 30). Ice thickness and bottom topography of the Filchner Ice Shelf and along the Ellsworth-Byrd traverse route: Am. Geophys. Union Trans., v. 40, no. 4, p. 423-426, 1959.

The oversnow traverse from Ellsworth station during the Antarctic summer of 1957-58 was confined mainly to the Filchner Ice Shelf and its fringes. It provided much new information on the areal extent and thickness of the shelf and on the bedrock configuration.

The Ellsworth-Byrd Station traverse of the 1958-59 summer season provided further information on the ice shelf as well as on ice thickness and bedrock configuration inland from the shelf. Both traverses used seismic, gravity, and magnetic techniques. Details are summarized and presented in the form of profiles. —D. B. V.

- 182-227. Evrard, Pierre, and Van Weelden, Arie. Les recherches géophysiques dans la cuvette congolaise et leur interpretation (Congo Belge) [Geophysical investigations in the Congo basin and their interpretation (Belgian Congo) (with English abstract)]: World Petroleum Cong., 5th, New York, Proc., sec. 1, paper 29, p. 539-549, 1959.

Results of geologic studies accompanied by ground gravimetric, magnetic, and seismic reflection and refraction surveys, done since 1952 in the central basin of the Belgian Congo, are described. Best results were obtained from the seismic refraction surveys which, despite the wide distribution of the network, when combined with the geologic studies gave the most information on the actual geology of the basin. Gravimetric results were sufficient only for geodetic purposes. Over the greater part of the basin magnetic anomalies ranged from -100 to +100 gammas; however, some important anomalies were observed on the borders, one amounting to 18,000 gammas.

It was found that the region between the Congo River to the west and north, the Lualaba River to the east, and the Kasai and Sankuru Rivers to the south is a vast basin with a depth of at least 4,000 m. Three major formation groups were determined: (1) An upper cover composed of Permo-Carboniferous, Upper Jurassic, and Quaternary sediments; (2) older, little metamorphosed sediments of Early Paleozoic or pre-Paleozoic age; and (3) the basement crystalline or eruptive rocks. Results were not sufficiently detailed to make conclusions on petroleum possibilities owing to the difficulties in penetrating the jungle terrain. —V. S. N.

Beneo, Enzo. Petroleum exploration in southern Italy. See Geophys. Abs. 182-313.

- 182-228. Yelanskiy, L. N. O nekotorykh zakonomernykh izmeneniyakh fizicheskikh parametrov gornykh porod Kuybyshevskogo Zavolzh'ya [On some regularities of the changes of physical parameters of the rocks of the Kuybyshev Trans-Volga region]: Geologiya Nefti, no. 10, p. 48-53, 1958.

The density, electrical properties, and magnetic properties of the rocks of the sedimentary cover of the Kuybyshev Trans-Volga area are discussed. The regularities in change of the physical parameters of these rocks serve as a guide in oil exploration.

The density of the rocks of the sedimentary cover increases gradually in a southeast direction. This is due to the appearance of carbonates in the section and also to the subsidence of the basement in this direction thereby subjecting the base of the sedimentary section to greater pressure and consolidation.

The electrical resistivity of the upper part of the section was determined, and the values are contoured on a map. The higher values of resistance correspond to areas of uplift, and lower value to areas of depressions.

Magnetic interpretations in the past have been based on the assumption that all magnetic sources are concentrated in the Precambrian basement. The iron content of some of the sediments that fill the deeper troughs of the Russian platform indicate, however, that the broad positive anomalies are due to these sediments rather than to the basement. — J. W. C.

- 182-229. Milton, B. E. Geo-electrical and magnetic prospecting for sulphide ore—Talisker mine area: South Australia Dept. Mines Mining Rev., no. 108, p. 43-48, 1959.

Magnetic, self-potential, electromagnetic, and equipotential surveys were made over the area of the old Talisker mine near Cape Jervis, Hindmarsh County; this mine had been previously worked for galena and arsenopyrite. Because of the difficult terrain, the methods used had poor penetration and no conclusive results were obtained. — V. S. N.

- 182-230. Weihaupt, John G. Victoria Land traverse, Antarctica, 1959-60: Arctic, v. 13, no. 2, p. 135-136, 1960.

This paper is a preliminary note describing the work of one of the two ground traverse parties in Antarctica under the administration of the Arctic Institute of North America during the Antarctic summer of 1959-60. The party departed from Scott Base, crossed part of the Ross Ice Shelf to Skelton Glacier, journeyed over 600 miles west to the end of the French traverse of 1958-59, and finally turned east toward the head of Tucker Glacier. A new range of mountains, tentatively named the Arctic Institute Range, was sighted in the vicinity of lat  $72^{\circ}15' S.$ ; long  $159^{\circ}45' E.$ ; and a new and sizeable glacier, tentatively named Rennick Glacier, was discovered between lat  $72^{\circ}38.0' S.$ ; long  $161^{\circ}31.8' E.$  and Rennick Bay on the Oates Coast. A total of 75 seismic reflection and refraction shots were made, and over 450 gravity and magnetic stations established. The maximum ice thickness measured was over 10,000 feet. — V. S. N.

#### GENERAL

- 182-231. Stearn, J. L., and Richardson, H. A variant least-squares method of solution of a system of observation equations: Jour. Geophys. Research, v. 65, no. 4, p. 1308-1309, 1960.

A mathematical device is presented for using a suspect observation equation as a quasi-normal equation, so that if desired this equation, which is placed last in the normal equations, may be dropped from the solution, thereby precluding the necessity for forming a new set of normal equations and a new forward solution for the effect of the removal of the suspected observation.

This variant method is easily adapted for least-squares solution and has practical application in geodesy and geophysics. With a large system of equations the method is more efficient and more economical, and in view of the tremendous volume of computations being run by the high-speed machines today, is believed to be preferable to the standard method. — D. B. V.

- 182-232. Dobrin, Milton B. *Introduction to geophysical prospecting*: New York, McGraw-Hill, 446 p., 1960.

The second edition of "Introduction to geophysical prospecting" is a complete revision of the original text, much of which was entirely rewritten to cover the extensive technical changes in the field of geophysical exploration since the first edition. With the needs of the practicing geophysicist particularly in mind, the book is intended as a resume in nonmathematical form of recent advances in the various geophysical techniques along with references to the most useful and accessible papers for the use of those who may have difficulty in keeping up with original sources. The following chapters are included: introduction, seismic wave propagation, earthquakes and the structure of the earth, seismic instruments and seismic surveys, the seismic refraction method, the seismic reflection method, interpretation and geologic coordination of reflection data, fundamental principles of gravity prospecting, the earth's gravity and the concept of isostasy, instruments for measuring gravity, gravity field measurements and reductions, the interpretation of gravity data, magnetic prospecting (fundamental principles and instruments, the magnetism of the earth, magnetic measurements on land and interpretation of vertical-field data, prospecting with the airborne magnetometer), electrical prospecting methods, prospecting for radioactive minerals, and integration of geophysical methods as illustrated by case histories. — V. S. N.

- 182-233. Russell, William L. *Principles of petroleum geology*: New York, McGraw-Hill, 503 p., 1960.

The aim and general plan of the second edition of this book remain the same as for the first edition. It is intended to serve as an advanced text and reference volume for petroleum geologists. As in the first edition, electrical and radioactivity well logging and the magnetic, gravimetric, electrical, and seismic methods of prospecting are discussed. — V. S. N.

- 182-234. Johnson, Hamilton M. Duties of a logging co-ordinator in an operating company: *Geophysics*, v. 25, no. 4, p. 734-747, 1960.

Quantitative log analysis should constitute only a small part of the duties of a well-logging coordinator for an operating oil company. His duties should also include compilation and preparation of auxiliary reservoir data, field research and evaluation of new tools and methods designed to solve problems of particular areas and conditions, coordination of logging and drilling programs, and development of interpretation techniques. The coordinator should also maintain a constant check on log quality, conduct schools on formation evaluation for field personnel, and serve as advisor on unitization committees. In realization of such a program he can be helped by a logging research group within the overall research effort of the company; such a group should aid him in specific problems and keep him abreast of current research. — D. B. V.

- 182-235. Bryant, Harvey L. Production well logging techniques: *Geophysics*, v. 25, no. 4, p. 905-927, 1960.

The various production logging techniques are summarized and grouped into the three phases of well production: (1) Temperature logs, radioactive tracer logs, and velocity logs are used to obtain cement tops and indications of cement channeling in well completion work; (2) various neutron logging techniques and temperature, flowing fluid density, gamma-gamma, and conductivity logs can locate encroaching gas and water in well repair work; (3)

radioactive tracer logs and the flowmeter log can facilitate well evaluation work including fracture location, injectivity profiles, and productivity profiles.

Use of many of these techniques is demonstrated by field examples. The Humble flowmeter is described briefly. Future development trends in production well logging are discussed in the final section. — D. B. V.

- 182-236. Braun, T. H., and Wheatley, G. Y. Electrical analog approach to dipmeter computation: *Geophysics*, v. 25, no. 4, p. 928-938, 1960.

An electrical analog instrument has been developed to calculate dip and strike from continuous dipmeter logs. The particular model described is designed specifically for the Schlumberger CDM-P, or Poteclinometer, logs and it can be used with hole deviations up to 36°.

Every control on this instrument corresponds to one of the recorded parameters of the dipmeter log. It is thus easy to see the effect of any one parameter on the resolved dip and strike. The instrument is portable and can therefore be used at the well site, if necessary, to make on-the-spot decisions regarding further drilling operation after a dipmeter log has been run. No elaborate training in procedure is required.

The rapidity with which the computations can be made also permits a larger number of levels to be computed. This frequently results in more accurate information and a considerable saving in computation expense. — Authors' abstract

- 182-237. Garland, G. D., ed. Canadian geophysical bulletin: *Canadian Geophys. Bull.*, v. 12, 95 p., 1959.

This volume contains reports of activities by Canadian scientists during 1958 and includes bibliographies for each of six major fields of geophysics: geodesy (including gravity), seismology and physics of the earth's interior, meteorology, hydrology, geomagnetism and aeronomy, and oceanography and glaciology. The names of subcommittee chairmen who compiled most of the material in these fields are given at the beginning of each section. — V. S. N.

- 182-238. Hodgson, J[ohn] H. National report for Canada—Seismology and physics of the earth's interior 1957-60; *Dominion Observatory Ottawa Contr.*, v. 3, no. 25, 28 p., 1960.

This report was prepared for presentation to the 12th General Assembly of the International Union of Geodesy and Geophysics in 1960 at Helsinki, Finland. It outlines briefly all work in Canada from 1957 to 1960 in noncommercial geophysics in those fields which are of interest to the Association of Seismology and Physics of the Earth's Interior. The subject matter is presented in 5 sections as follows: (1) Seismology including earthquake, theoretical and laboratory, field, and engineering seismology; (2) radioactivity including the work by the Geological Survey of Canada, and the Universities of Toronto, Western Ontario, Alberta, McMaster's, and British Columbia; (3) heat flow; (4) tectonophysics; and (5) gravity including regional mapping and structural studies, other mapping, earth tide measurements, and isostatic studies. — V. S. N.

- 182-239. Engineering and Mining Journal. Exploration developments 1959: *Eng. Mining Jour.*, v. 160, no. 6, p. 201-207, 1959.

A brief survey is made of modern geophysical and engineering techniques including descriptions of the following: the Aero-Newmont electromagnetic surveying method, which differentiates to a large extent between types of conductors; the M-49 portable magnetometer; the induced polarization method as applied to sulfide-ore search; the principle of AFMAG; the measurement of natural audiofrequency currents in the ground and its use; the two-plane method of aerial electromagnetic surveying; and a guide to diamond core drill tools. — V. S. N.

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- 182-240. Mouton, Jean. Possibilitá di applicazione dei metodi geofisici nei problemi posti per lo scavo dei canali [Possibility of application of geophysical methods to problems in excavation of canals]: Geotecnica, v. 7, no. 3, p. 125-132, 1960.

Excavation of canals requires the removal of such large masses of earth and rock that it is imperative to select a course where this removal will be easiest. Electrical and seismic refraction surveys are the best methods for selecting areas for test drilling. Examples are presented to illustrate the contribution of geophysics to canal construction in the Rhone Valley in France. — J. W. C.

- 182-241. Godin, Yu. N., Polshkov, M. K., Ryabinkin, L. A., Fedynsk[i]y, V. V., and Fotiadý [Fotiadil], E. E. Progress in geophysical methods for prospecting for oil and gas in the U.S.S.R. [with French abstract]: World Petroleum Cong., 5th, New York, Proc., sec. 1, paper 33, p. 603-624, 1959.

From 1955 to 1958 the number of geophysical crews exploring for oil in the U.S.S.R. increased 1.8 times. Most of the work was conducted in the Caucasus, the Ukraine, the eastern regions of the European part of the U.S.S.R., Siberia, and central Asia. New geophysical instruments produced and used during these years include: the nuclear-resonance magnetometer, the gravity gradiometer, the damped marine gravimeter, apparatus for the study of telluric currents, portable 24-channel seismic stations, apparatus for river and marine seismic prospecting, and instruments for controlled directional reception of seismic waves.

Regional geophysical investigations to be used as a guide for further detailed studies were conducted in central Asia, the Ukraine, the Russian platform, the Caspian Sea, the Pacific Ocean, and in other regions with a combination of gravity and magnetic mapping and deep seismic soundings of the main layers of the earth's crust and the Mohorovičić surface. Typical of the important results of these surveys was the determination that the oilfields in the Russian platform are associated with uplifts of the crystalline basement and their steep flanks.

Reflection seismic prospecting remained the principal method used for petroleum exploration; application of this method, however, is still difficult in detailed exploration of the very gently dipping structures of the platform region. Radiometric and other geophysical methods were tried for direct detection of oil and gas deposits from the surface. No definite results were obtained, although there are grounds for continuing the experiments. — V. S. N.

- 182-242. Andreyev, B. A. O perspektivakh razvitiya strukturnoy geofiziki [Prospects of development of structural geophysics (with English summary)]: Sovetskaya Geologiya, no. 6, p. 3-12, 1959.

Structural geophysics is a combination of geophysical methods designed to solve structural problems such as the nature of the deep subsurface and of the basement of platform regions and the exploration of oil-bearing structures. Seismic and gravity surveys have been used successfully. Examples are given in which gravity anomalies coincide with basement structure and metallogenetic zones. — J. W. C.

- 182-243. Safronov, N. I., Polikarpochkin, V. V., and Trushkov, Yu. N. Kompleksnyye metody poiskov mestorozhdeniy zolota [Combined method of exploration of gold deposits]: Sovetskaya Geologiya, no. 4, p. 92-110, 1960.

The various combinations of exploration methods best suited for particular types of primary and placer gold deposits are discussed. Among the geophysical methods recommended are multifrequency electrical exploration (amplitude phase measurements), ultrasonic location and ultrasonic radioscopy, induced polarization, gravity methods using a gradientometer, electrosounding, and magnetometer methods. Geochemical methods recommended for use in conjunction with the geophysical methods are also outlined. — J. W. C.

#### GEODESY

- 182-244. U. S. Coast and Geodetic Survey. Geodetic operations: Am. Geophys. Union Trans., v. 41, no. 2, p. 131-143, 1960.

This is a report on the geodetic activities of various agencies in the United States covering the period January 1, 1957, through December 31, 1959, prepared for the Twelfth General Assembly of the International Union of Geodesy and Geophysics.

Gravity observations and reductions have been made by the U.S. Coast and Geodetic Survey (mainly base lines, -calibration lines, and gravity ties), U.S. Army Map Service, Inter-American Geodetic Survey (in Latin America), U.S. Air Force (about 30 new pendulum measurements in Alaska, South America, the Far East, Australasia, and Antarctica and a 130-station gravimeter base network at airports).

The Coast and Geodetic Survey continued work on a precise geoid profile across the United States along the 35th parallel. The Army Map Service extended its computation of geoid heights by astrogeodetic data into India, Japan, Korea, the Caribbean, and Brazil; made a statistical and harmonic analysis of free-air gravity anomalies and topography; obtained a new estimate of flattening ( $1/298.3$ ) from Vanguard I satellite observations; and combined astrogeodetic, gravity, and satellite data to obtain shifts for the North American, European, and Tokyo datums, ellipsoid and standard gravity formula parameters, and an expression of the geoid in spherical harmonics to the eighth degree. The Air Force contracted for computations of gravimetric deflection components and geoid heights of 35 selected first-order astrogeodetic stations in the United States, Europe, Japan, and Manchuria. The first reduction of European, North American, and Tokyo datums into a common earth-centered geodetic system was accomplished in March 1958. — D. B. V.

- 182-245. Johns, R. K. C. The figure of the earth: Royal Astron. Soc. Canada Jour., v. 53, no. 6, p. 257-263, 1959.

This is a general discussion of problems and methods of measuring the figure of the earth from the days of Aristotle and Eratosthenes to the present. Nongeodetic earth satellites have already yielded valuable information, and there are indications that a special satellite for geodetic purposes will become a reality in the not-too-distant future. — D. B. V.

- 182-246. Uotila, Urho A. K. Investigations on the gravity field and shape of the earth: Ohio State Univ. Inst. Geodesy, Photogrammetry, and Cartography Repts., no. 6, 139 p., 1959.

The theory and computational methods used in the worldwide gravity project are discussed and explained. New high-speed computer methods have been devised for calculation of geoid undulations based on mean anomalies; for numerical integration of the effect of distant areas on deflection of the vertical; for handling vast amounts of gravity data; and for determining the shape of geopotential surfaces at elevations above 100 nautical miles. Templates for manual computation of the effect of distant areas on deflection of the vertical are presented; these are used in conjunction with mean anomaly stereographic charts.

A general relationship is shown to exist, within limited areas, between free-air anomalies and elevation; such correlations are useful in estimating mean free-air anomalies for regions where few gravity observations are available. A general technique has been devised for determining and estimating  $1^\circ \times 1^\circ$  mean free-air anomalies throughout the world; approximately 10,000 of these have been calculated, but have not yet been released for publication. The various national reference stations of the world have been related to a single world gravity system. — D. B. V.

- 182-247. Uotila, Urho A. [K.]. Determination of the shape of the geoid: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pubs., no. 7, p. 90-97, 1957.

The procedures are outlined that give the undulations of the geoid and deflections of the vertical when sufficiently reliable gravity observations correctly reduced to sea level and converted to the same World Gravimeter System are available. Free air anomalies have been used in the computations of the Ohio State gravity project; for unsurveyed areas free air anomalies were assumed to be zero.

The gravity formula obtained using all available free air anomalies of  $1^\circ \times 1^\circ$  squares except those exceeding 75 mgal is

$$\gamma = 978.0496 (1 + 0.005 2934 \sin^2 \phi - 0.000 0059 \sin^2 2\phi).$$

With this formula the correction to the equator value of the international gravity formula is only +0.6 mgal, and the polar flattening is 1/297.4; therefore, use of the international ellipsoid appears to cause no trouble. — D. B. V.

- 182-248. Arnold, Kurt. Zur strengen Theorie der Figur der Erde [On the rigorous theory of the figure of the earth]: Gerlands Beitr. Geophysik, v. 68, no. 5, p. 257-262, 1959.

The equation for rigorous determination of the figure of the earth, derived earlier by Arnold [see Geophys. Abs. 182-288], is simplified by some mathematical transformations. — D. B. V.

- 182-249. Boaga, Giovanni. Sulla determinazione della forma della Terra per mezzo di misure gravimetriche [On the determination of the figure of the earth by means of gravimetric measurements (with French, English, German, and Spanish summaries)]: *Boll. Geodesia e Sci. Aff.*, v. 18, no. 4, p. 451-458, 1959.

A mathematical treatment shows that the problem of determining the figure of the earth from observed gravity using Somigliana's formula should be approached with great caution, taking into account the effect of gravity anomalies. — D. B. V.

- 182-250. Fischer, Irene. An astrogeodetic world datum from geodetic heights based on the flattening  $f=1/298.3$ : *Jour. Geophys. Research*, v. 65, no. 7, p. 2067-2076, 1960.

The value  $1/298.3$  for the flattening of the earth is accepted in the determination of a world ellipsoid. The astrogeodetic geoid is extended into the Caribbean, India, and Burma, and modified in the Soviet Union and the Far East. The resulting world ellipsoid is very small, with an equatorial radius of about 6,378,160 m. The agreement between astrogeodetic and gravimetric geoid profiles is greatly improved by the small ellipsoid.—Author's abstract

- 182-251. Arnold, Kurt. Zur Bestimmung der Geoidundulationen aus Freiluft-anomalien [On the determination of geoid undulations from free-air anomalies]: *Potsdam Geod. Inst. Veröffentl.*, no. 12, p. 1-50, 1959.

Jeffrey's method of free-air reduction (see *Geophys. Abs.* 33-557, 150-13807) is extended to include terms of the second and higher orders, neglecting only those that are demonstrably smaller than 1 cm. — D. B. V.

- 182-252. Burša, Milan. Bestimmung der Dimensionen des Erdellipsoides aus den europäischen astronomisch-geodätischen Netzen [Determination of the dimensions of the earth's ellipsoid from the European astronomic-geodetic network (with Russian summary)]: *Ceskoslovenská Akad. Věd Studia Geophys. et Geod.*, v. 3, no. 4, p. 297-333, 1959.

The theory of the translative surface method and projective surface method of determining the dimensions of the earth's ellipsoid from astronomic-geodetic measurements (including conversion from the former to the latter) is reviewed, and then both methods are applied to the European networks. If a correction is introduced the projective method gives practically the same results as the translative and has the advantage of being simpler. Polar flattening cannot be determined with sufficient accuracy because the networks in question involve too small a segment of the earth's surface.

Alternative solutions are as follows: original solution— $a = 6,378,140$  m,  $\alpha = 1/294.8$ ; for  $\alpha = 1/298.3$ ,  $a = 6,378,161$  m; for  $\alpha = 1/297$ ,  $a = 6,378,154$  m ( $a$  = major semiaxis,  $\alpha$  = polar flattening). These results agree closely with those obtained by Lieberman using an entirely different method (see *Geophys. Abs.* 170-147).

The Bessel and Hayford ellipsoids are found to be unsuitable as reference surfaces for the European astronomic-geodetic networks; the major semiaxis of the former is about 750 m shorter and of the latter 200-250 m shorter than that of the best-fitting ellipsoid. The Krassovskiy ellipsoid ( $a = 6,378,245$  m,  $\alpha = 1/298.3$ ), already used in a number of countries in eastern and middle Europe as well as in the U.S.S.R., is the most suitable. — D. B. V.

- 182-253. Boaga, Giovanni. Espressioni della gravità sulla superficie di un pianeta di forma ellissoïdica triassica e considerazioni relative [Expressions for gravity on the surface of a planet of triaxial ellipsoidal form and relative considerations (with French, German, and English summaries)]: Boll. Geodesia e Sci. Aff., v. 16, no. 1, p. 1-16, 1957.

Boaga reviews the conditions on the basis of which the external potential function of a rotating planet of known angular velocity, mass, and external equilibrium surface can be calculated, and treats particularly the potential generated by a triaxial ellipsoidal planet. Expressions are derived for the value of gravity at the surface of the planet as a function of Cartesian and of geographic coordinates; some of the formulas obtained have been found by others. Finally he examines the special case of a triaxial ellipsoid that is almost an ellipsoid of rotation, and draws some conclusions concerning Clairaut's theorem. — D. B. V.

- 182-254. Thomas, Paul D. Use of near-earth satellite orbits for geodetic information: U. S. Coast and Geod. Survey Tech. Bull., no. 11, 36 p., 1960.

The principal geodetic uses of artificial satellites are to obtain better geodetic positioning in areas of the earth not connected to continental networks of horizontal control, such as islands and intercontinental connections of geodetic datums; to deduce from the nodal motion of the satellite orbit a more refined value for the flattening of the spheroidal representation of the earth; and to obtain data on regional gravity anomalies from a long-term program using many satellites.

The type of satellite most useful for geodetic purposes, a recommended geodetic satellite program, and satellite tracking methods are discussed. Mathematical calculations having to do with the escape of the rocket from the earth and the orbit of the satellite and calculations of geodetic data from observations of the satellite are given in an appendix. — V. S. N.

- 182-255. Veis, George. Geodetic uses of artificial satellites: Smithsonian Contr. Astrophysics, v. 3, no. 9, p. 95-161, 1960.

Previous geodetic methods applied to data provided by artificial satellites have used the perturbations in the motion of a satellite to determine the gravitational field of the earth and thus to obtain information on the shape of the geoid. A geometric method is presented which consists in performing a triangulation in space and determining the positions of a certain number of observing stations whose positions are unknown. In this method directions are determined directly in relation to a reference system defined by the stars. The relative positions of the stars will be the same for all observers on earth, and if the system of reference is connected to the stars it can then be defined by the equator and ecliptic of a certain epoch. For practical reasons a system of reference that is not fixed with relation to the stars may also be used, that is, a system defined by the instantaneous equator and ecliptic. This system is then connected to a reference system on the earth.

Terrestrial, astronomic, and geodetic systems of elliptical and rectangular coordinates are described and their applications discussed. Methods of measuring geometric quantities, that is, distances and angles or directions are given. Finally, three methods that can be used to obtain geodetic information from artificial satellites and their applications are described: by observations to objects of known positions, to objects of unknown positions, and to orbiting objects. — V. S. N.

- 182-256. Burkard, Richard K. Geodesy for the layman: St. Louis, Mo., U. S. Air Force, Aeronautical Chart and Inf. Center, 77 p., 1959.

The basic principles of geodesy and geodetic surveying are presented in an elementary form. The booklet is divided into five parts as follows: development of geodesy, figure of the earth, principles of geodetic surveying, geodetic systems, and developing a world geodetic system. Particular emphasis is placed on the role of the Air Force in developing a world geodetic system and on the importance to the military planner for accurate distance and direction information in order to guide long-range missiles to a target. — V. S. N.

Norinelli, Armando. Significance of Cassini's numbers as weights in the cabelle correction of gravity measurements. See Geophys. Abs. 182-285.

Arnold, Kurt. Rigorous theory of the absolute deflection of the vertical as a function of free air gravity anomalies. See Geophys. Abs. 182-288.

#### GEOTECTONICS

- 182-257. MacDonald, Gordon J. F. Tectonic theories: Am. Geophys. Union Trans., v. 41, no. 2, p. 168-169, 1960.

Recent experimental studies on the stability of minerals at high pressures and temperatures suggest a mechanism by which shallow water sediments can be deposited in great thicknesses in a geosyncline. The crust-mantle boundary is taken to be a phase transition. The equilibrium depth is fixed by the initial thermal state. Sediments are deposited on the upper surface of the crust. The increase in pressure caused by the loading of the sediments results initially in the conversion of low-density crustal material to the mantle phase of higher density. As a result of this conversion the phase boundary moves upward while the surface on which sedimentation takes place moves downward because of the density contrast between the crust and the mantle. The conversion of the low-density high-entropy phases to high-density low-entropy phases is accompanied by the generation of heat at the phase boundary. The generated heat will locally raise the temperatures and tend to displace the phase boundary downward in opposition to the effect of mechanical loading at the surface of sedimentation. Because of the low thermal conductivity of the sediments, the temperature at any fixed depth below the surface will be increased. The higher final equilibrium temperature in the crust results in a depth to the discontinuity greater than the initial depth. The greater depth to the discontinuity implies a thick crust and an elevation of the sediments above sealevel. — D. B. V.

- 182-258. Griggs, David T. Isostatic compensation, and origin of continents and mountains: Am. Geophys. Union Trans., v. 41, no. 2, p. 166-167, 1960.

During 1957-60, the controversy between the two major schools of thought in tectonophysics was heightened by several exciting new developments. The "immobile mantle" school has been supported by Clark's discovery that radiative heat transfer in the probable minerals of the mantle is substantial (see Geophys. Abs. 166-288, 171-192) and by new evidence of phase equilibria and the hypothesis that the M-discontinuity is a phase change (see Geophys. Abs. 168-188).

The "mobile earth" school on the other hand points to other developments to support its contentions: Von Herzen's heat flow measurements (see Geophys. Abs. 177-229) show a regional pattern, which may reflect subcrustal convec-

tion; and Mason (see *Geophys. Abs.* 176-285) and Vacquier (see *Geophys. Abs.* 176-171) discovered large strike-slip displacements in the Murray, Mendocino, and Pioneer fracture zones in the Pacific Ocean.

From seismic and gravity measurements at sea it has become increasingly apparent that much of the isostatic compensation must be below the M-discontinuity. Departures of the figure of the earth from hydrostatic equilibrium (see *Geophys. Abs.* 176-159) must mean either a finite strength at depth, or density differences maintained dynamically, as by convection. — D. B. V.

- 182-259. Lyustikh, Ye. N. O konvektsii v zemnoy obolochke [On convection in the earth's mantle]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 3-6, 1960.

An attempt is made to determine the heat energy required to produce and maintain the convection currents in the mantle of the earth that are assumed by Vening-Meinesz (see *Geophys. Abs.* 171-157) to be the cause of tectonism in the earth's crust. The conclusion reached is that less than  $10^{26}$  ergs per year can be transferred by convection currents to the crust, and that the convection currents should move intermittently. — A. J. S.

- 182-260. Kraus, Ernst C. Über die Ungleichseitigkeit der zweiseitigen Orogenie. Eine vergleichend-geotektonik Untersuchung [On the inequilateral nature of bilateral orogens. A comparative geotectonic investigation]: Freiberger Forschungshefte C 57 Geologie, p. 7-27, 1959.

The reasons for the formation of orogens that are bilateral but not equilateral are investigated by means of a comparative study of the major mountain systems of the earth. It is concluded that both primary events, which take place during compression and sedimentation in a downwarping geosyncline, and local secondary events take part in a chain reaction leading to such inequality.

Underlying the normal processes and products of the geosynclinal cycle, the influence of a foreign, predominantly varying current system can be detected. Its effect is felt far beyond the geosynclinal belt, which can alter events in the hyporheal level of convection currents and distort its products. A deeper, "bathyrheal" level must be postulated, the slower mass circulation of which governs crustal events on a regional scale, involving both continents and oceans. (See also *Geophys. Abs.* 164-144.) — D. B. V.

- 182-261. Hess, H. H. Caribbean research project, Progress report: Geol. Soc. America Bull., v. 71, no. 3, p. 235-240, 1960.

One major objective of the Caribbean Research Project is to interpret the available geophysical data in the light of the geologic history of the past 100 million years. Several episodes of mid-Cretaceous metamorphism are now recognized on the basis of field mapping.

The concept that island arcs represent an early stage of alpinotype mountain building is rejected. Alpinotype mountains are developed along the thin margin of continental crust, island arcs on an oceanic type of crust.

Germanotype mountains develop in areas of continental crust of normal thickness. All three types can be seen along a single tectonic axis from the Antilles (arc) into the coastal ranges (alpinotype) of Venezuela and thence to the Venezuelan Andes (germanotype).

Laboratory measurements of seismic velocities in fresh peridotite (8.4 km/s) through partially serpentinized peridotite to serpentine (5.7 km/s) indicate that the so-called basaltic crust of the oceans may be peridotite that

has been two-thirds serpentinized. If so, Mattson's basement rocks (serpentinites) may be altered mantle rocks exposed at the surface. On the other hand, MacKenzie has shown that true intrusive peridotites, emplaced at temperatures of at least 800°C, exist. — D. B. V.

- 182-262. Bishopp, D. W. The role of crustal energy in the origin of rift valleys: South Africa Geol. Soc. Trans. and Proc., v. 62, p. 151-159, with discussion, p. 161-165, 1959.

Various hypotheses of the origin of rift valleys and associated eruptives have taken insufficient notice of the changes of volume and energy involved. In the interplay of gravitational and thermal forces, the latter may entirely dominate the former and override all questions of isostatic equilibrium.

Rift valleys seem to be closely related to the Mohorovičić layer, which is here considered as the seat of the main transformations of energy and the source of enclaves of hot, gas-charged magma. The African and other rifts may have started with an original bulge upward due to magma pressure along a given line; then, either by release of lavas at the surface or by lateral migration at deep level, support was removed and the arches collapsed, leaving the flanking ramps intact but for the remanent faults. This is virtually a reversion to J. W. Gregory's original explanation. The genesis of geosynclines with associated vulcanism, and of basins and swells, is also attributed to transformations of energy and volume at or near the Mohorovičić level and to migrations of magma.

The scale of various crustal phenomena in contrast to the great size and stored energy of the earth, the question of rigidity, and the limits between which natural principles such as isostasy may be deemed effective are discussed. Various structural forms and their development in the thin skin at the earth's surface under the control of thermal and gravitational agencies are considered.

Discussions by B. B. Brock and T. W. Gevers and Bishopp's reply to the discussions follow the paper. — V. S. N.

- 182-263. Brock, B[yrion] B[rittton]. On orogenic evolution, with special reference to southern Africa: South Africa Geol. Soc. Trans. and Proc., v. 62, p. 325-365, with discussion, p. 367-372, 1959.

The search for a definition of orogeny applicable to the Archean in Africa has led to a search for demonstrable geologic constants applicable to all geologic time. Brock defines an orogeny as a linear mobile belt between two inert blocks or cratons of an appropriate relative size, that is, the ratio of the magnitude of a mobile belt to the diameter of its craton is roughly constant whatever the age, and the size of those units shows a progression with time. This ratio is well illustrated by graphs. Orogenic evolution is reflected inversely by the number of orogenic belts per era, ranging from 2 in the Tertiary through 30 in the Paleozoic, hundreds in the Proterozoic, and thousands in the Archean. In size the orogenies become progressively smaller going backward in time toward a zero point where there was no sedimentation. The crust existing when Archean sedimentation began is now largely granite; it may be primordial granite or it may be the product of granitization of an original basaltic crust. It seems certain that it was never intrusive, except where locally reactivated. Reactivation appears to account for the failure to recognize the First Unconformity which is believed to be just as widespread as the Archean. — V. S. N.

- 182-264. Fairbridge, Rhodes W. Statistics of non-folded basins: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 419-440, 1959.

Using a series of maps that show the fundamental structure divisions of shield, fold belt, and basin for every continent, the nonfolded basins (defined as those free from alpinotype folding and metamorphism, in which a clear interpretation of sedimentary characteristics may be obtained) have been analyzed statistically.

The results of the analysis show that the basins of each broad category tend to repeat the same dimensional characteristics. Categories identified in this way correspond fairly well to Stille's "parageosynclines" and to the subdivisions of this class recognized by Kay. It is suggested that each category corresponds to an underlying crust of specific thickness and mobility.

The total volume of nonpelagic sediments of the world outside of heavily folded belts is  $2.8 \times 10^8 \text{ km}^3$ ; this is the absolute finite ceiling of potential oil-bearing strata. However, this figure must be severely curtailed because an appreciable area near the continental shelf margins and slope is not at present commercially drillable, another enormous segment belongs to nonmarine continental basins almost devoid of oil, and certain basins lack the sedimentary or structural characteristics required for hydrocarbon accumulation. The evidence supports the view that most of the recoverable hydrocarbons of the world lie in pools scattered through only 20 percent of the total basin area. — D. B. V.

- 182-265. Kawai, Naoto, and Massé, Gerald W. Application of rock magnetism to the formation of mountains (Himalaya-Tibetan and circum-Pacific mountain chains): Kyoto Univ. Coll. Sci. Mem., ser. B, v. 26, no. 2, p. 229-234, 1959.

The remanent magnetization of the Miocene lava of the Deccan Traps of India is used to demonstrate quantitatively the hypothesis that the thick sediments of the Tethys geosyncline were squeezed out by compression resulting from movement of Gondwanaland relative to the Siberian and Baltic tablelands to form the mountain chains of the Himalaya-Tibetan zone. The northward drift of India since Late Cretaceous or Miocene time has amounted to about  $5.3^\circ$  or 590 km along the meridian to its present latitude. The volume of the sediments compressed upward ( $V_3$ ) plus the volume of the sediments compressed downward ( $V_2$ ) into the substratum is nearly equal to the volume shift of India ( $V_1$ ). Estimates are made for  $V_1$  from the amount of continental drift and from the thickness of the Indian continent as determined from seismological data, and for  $V_3$  from the present volume of the ranges plus an estimate of the volume eroded; however, more gravity data must be obtained in the Trans-Himalaya zone for a determination of  $V_2$ .

A similar analysis may be made for the circum-Pacific mountain chain and particularly for the Japanese Islands where known gravity data make it possible to estimate the shape of the continental base submerged in the substratum. Runcorn's estimate that the linear compression of the basement of the Pacific amounts to more than 1,000 km is now being examined by this method. — V. S. N.

- 182-266. Harrison, J. V. Aspects of orogens: Nature, v. 186, no. 4726, p. 689-690, 1960.

This is a report on the 50th anniversary meeting of the Geologische Vereinigung held in Würzburg, Germany, during March 12-14, 1960. The theme of the papers presented at the meeting was the orogen. Texts of the papers, reviewed briefly here, will be published in the *Geologische Rundschau*. — D. B. V.

Jobert, Georges, and La Mouël, Jean. Tensions generated in the earth by unequally distributed heat sources. See Geophys. Abs. 182-330.

Egyed, L[ászló]. Investigations on the interior of the earth. See Geophys. Abs. 182-339.

Fischer, G[eorge]. The earth lives. See Geophys. Abs. 182-340.

182-267. Egyed, L[ászló], and Stegema, L[ájos]. Physical background of a dynamical earth model: Zeitschr. Geophysik, v. 24, no. 4/5, p. 260-267, 1958.

Earlier investigations by Egyed have led to the conclusion that the earth's radius is increasing at a rate of 0.4 to 0.8 mm per yr (see Geophys. Abs. 167-164, -165; 171-203; 177-178; 178-215). The same conclusion can be reached by applying Gilbert's results (see Geophys. Abs. 182-281) to Ramsey's theory (see Geophys. Abs. 141-11985). Using Bullen's density values as recomputed by Bullard (see Geophys. Abs. 172-140), the rate of increase is calculated to be at least 0.3 mm per yr, with the upper limit depending on the density jump at the inner core boundary. It can be shown that density at the boundary of the inner core is less than 18 g per cm<sup>3</sup>, probably 14.5-16.5 g per cm<sup>3</sup>. — D. B. V.

182-268. Ferenczi, Istvan. Structural control of the North Carolina coastal plain: Southeastern Geology, v. 1, no. 3, p. 105-116, 1959.

The North Carolina coastal plain is not a simple homoclinal structure. The Great Carolina Ridge is an area of uplift and the Hatteras axis is one of subsidence; both are transverse to the Appalachian trend. Midway between these two features is the Cape Lookout-Neuse fault zone. It is suggested that the capes along the present shoreline have been controlled by these structural features.

The basement rock beneath the sedimentary cover has the character of a peniplained block mountain rather than that of a folded mountain chain. — J. W. C.

182-269. Whitten, C. A. Geodetic measurements related to crustal movements and particularly earthquakes: Am. Geophys. Union Trans., v. 41, no. 2, p. 153-154, 1960.

Releveling in the San Francisco Bay area after the earthquake of March 22, 1957, showed movement of points in the same direction as previously, but of a magnitude greater than anticipated (2-3 feet). There was no indication of any large displacement along the San Andreas fault. About 2,000 miles of releveling was undertaken in California in the region from the vicinity of Los Banos south to Wheeler Ridge in 1957, in the vicinity of Palmdale in 1958, and in the vicinity of Taft and Maricopa in 1959. Computation and adjustment of the 1959 survey had not been completed by the end of 1959.

In a leveling network along the San Andreas fault near Hollister, Calif., results from surveys made at 20-year intervals indicated an annual angular rate of deformation of 0.1 second and an annual slippage of 10 mm. In another network near Cholame, Calif., the angular rate of deformation was about the same but the slippage was only 2 mm per yr. — D. B. V.

182-270. Salvioni, Guido. I movimenti del suolo nell'Italia centro-settentrionale [Ground movements in north central Italy (with French, German, and English summaries)]: Boll. Geodesia e Sci. Aff., v. 16, no. 3, p. 325-366, 1957.

This is a preliminary report on the results of precise leveling surveys in Italy. Data from the old grid established in 1877-1903 and from the new survey of 1950-56 have been standardized with respect to method of calculation, reference surface, and measurement times. The results of comparison of the old and new values are summarized in a map showing lines of equal movement (contour interval 5 cm). The survey procedures are described in some detail, and complete results are tabulated for each line in the network. — D. B. V.

- 182-271. Meshcherikov, J. A. [Meshcheryakov, Yu. A.]. Secular crustal movements of the East-European plain and associated problems: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 261-275, 1959.

Secular tectonic movements in the U. S. S. R. have been studied since 1950. On the basis of leveling surveys made from 1913 to 1932 and from 1945 to 1950, coordinated with tide gauge observations on the coasts of the Baltic, Azov, and Black Seas, absolute values of crustal movement rates (in millimeters per year) were calculated for 250 points and plotted on a map. Comparison of geologic and physiographic data with the geodetic materials served to check the latter and provided reliable and fully substantiated conclusions on secular movements.

Within the east European plain several zones of uplift separated by zones of absolute or relative subsidence have been established. The average rate of uplift or subsidence is estimated at 2-4 mm per yr; the maximum (uplift) is 7-10 mm per yr. The transition between positive and negative movements is usually a narrow flexure. No area is completely stable.

The distribution of areas of uplift and subsidence cannot be explained adequately on the basis of postglacial isostatic readjustment. The sign of present movement is largely determined by geologic structure; the east European platform is rising, sedimentary basins are sinking. These present manifestations, therefore, should be regarded as a regular continuation of major tectonic processes in the crust. The observed facts are best explained by oscillations of predominantly north-south trend superposed on larger block movements. The present rate of movement is apparently more rapid than that in the recent past. This also is explained by the complex oscillatory nature of the movement; the geodetic data reveal elementary oscillations that are superposed on the more general tendencies established by geologic observations.

A correlation between seismicity and secular ground movement is additional confirmation of the fact that secular movements are controlled by endogenetic processes within the crust. — D. B. V.

Nesteroff, Vladimir D. Age of the last movements of the Red Sea graben determined by the carbon-14 method applied to fossil reefs. See Geophys. Abs. 182-47.

- 182-272. Ehara, Shingo. Geotectonics of the Pacific: Geotectonics of the Ryukiu arcuate Is. and its influence upon the western part of southwestern Japan: Geol. Soc. Japan Jour., v. 66, no. 775, p. 229-241, 1960.

An understanding of the geotectonics of the Ryukyu Island arc, as part of the boundary of the Asiatic Continent, is important in determining the influence of the Asiatic Continent on the Japanese islands and also in understanding the origin of the Ryukyu Trench and the tectonics of the Shikoku Sea.

Geologically the Ryukyu arc may be divided into 3 zones (outer to inner-Tertiary, Paleozoic, volcanic) limited by imaginary tectonic lines paralleling the arcs and forming a lattice to the north and south with the original struc-

tures of Kyushu and Taiwan. In Kyushu the longitudinal lines are more active tectonically than are the original structural lines, and as the outward thrusting forces from the East China Sea have concentrated upon the Okinawa and Saki-shima island groups thrusting them toward the Pacific, Kyushu has been pulled away from Honshu and Shikoku. Previous to the formation of the Shichito-Ogasawara submarine ridge and the Marianas Island arc barriers during Tertiary time, the western Pacific extended across the Shikoku and Philippine Seas, and southwestern Japan extended along the Paleo-Cathaysia massif to Taiwan and possibly even to Borneo, judging from similarities in stratigraphy. With the formation of these barriers the tectonic line paralleling the Nippon-Mariana Trench became the line limiting the western Pacific from the east Asiatic continental islands.—V. S. N.

- 182-273. Biq, Chingchang. Is the Pacific basin rotating counter-clockwise? (in Chinese with English summary): Chinese Assoc. Adv. Sci. Trans., v. 2, no. 1, p. 16-19, 1958.

Brief descriptions are given of some significant faults in the coastal areas of the western Pacific and of the stress field with which these faults are genetically related in order to examine the theory, proposed by Benioff (1958) and also St. Amand (1957), that the Pacific basin from at least Baja, Calif., to the Kurile Islands and probably the rest of the basin also is rotating counter-clockwise. Biq observes that the sector of the Pacific basin between Japan and the equator is rotating in a clockwise direction and concludes that if the transcurrent-faulted areas of the circum-pacific belt are considered altogether, it may be seen that this oceanic basin is expanding towards both poles thus causing its northern and southern parts to move apart from each other near the equator. —V. S. N.

- 182-274. Geyl, W. F. Geophysical speculations on the origin of stepped erosion surfaces: Jour. Geology, v. 68, no. 2, p. 154-176, 1960.

Stepped erosion surfaces are a widespread feature in Australia (as in other parts of the world) and suggest a phased lowering of relative sea level without deformation of the land during the later Cenozoic.

It is proposed that stepped erosion surfaces are ultimately caused by continental shift induced by deep convection currents. New ocean capacity is created in the oceanogenic zone and is lost in the orogenic zone causing an eustatic drop of sea level. There is consequently a rejuvenation of erosion in the nonorogenic land masses, which tend to rise isostatically. As compression ceases the young folded mountains also rise isostatically and suffer extreme erosion. The resulting sedimentation in the oceans leads to an eustatic rise of sea level. The isostatic adjustment of loaded ocean floor and unloaded land leads to a long continued drop of relative sea level, eustatic insofar as sea level drops with the sinking floor, epeirogenic insofar as the land rises. In older and higher erosion surfaces the epeirogenic component predominates; in lower and younger erosion surfaces the eustatic component may be more significant but can never account for more than about 800 feet of their elevation above present sea level. Adjustment is spasmodic and operation of other factors gives periods of stability of relative sea level that allow initiation of erosion surfaces. These surfaces continue to work upstream long after removal from direct control by sea level/base level, and will continue to do so today even though initiated millions of years ago.

It is not claimed that the hypothesis of shift as a cause of stepped erosion surfaces has been adequately proved, but quantitative estimations of the effects of shift on relative sea level show results in reasonable agreement with

elevations of actual erosion surfaces and so give some support to the hypothesis. The work of Baulig (1935) and De Toit (1937) foreshadowed the present hypothesis. — V. S. N.

#### GLACIERS

- 182-275. Rigsby, George P. Crystal orientation in glacier and in experimentally deformed ice: *Jour. Glaciology*, v. 3, no. 27, p. 589-606, 1960.

More than 8,000 ice crystals from widely separated temperate and polar glaciers were oriented and measured for crystal fabric studies. Fabrics showing very strongly preferred orientations were found. A number of laboratory experiments on deformation and recrystallization of ice were conducted in an attempt to solve certain problems concerning glacier flow.

In polar glaciers the c or optic axes of the ice crystals tend to be perpendicular to the foliation plane; in temperate glaciers the optic axes tend to form three or four strong maximums, which also appear related to the foliation. Patterns from ice deformed in the laboratory resemble some of the fabric patterns found in polar glaciers. Ice appears to be very sensitive to shearing forces, and the fact that glide planes are found parallel to foliation in polar glaciers indicates that crystals under stress assume a preferred orientation in order to yield easily to that stress; the strength of the pattern is more or less proportional to the strength of the shearing forces. The laboratory experiments indicate that preferred orientations may be lost completely when ice is recrystallized under melting conditions in a stress-free environment. It is safe to conclude that proper orientation of the crystal in order to glide on the basal plane is very important in the "flow" of polar glacier ice, and that in temperate glaciers, gliding plus recrystallization or continual boundary migration is important to the flow. — V. S. N.

- 182-276. Griffiths, T. M. Glaciological investigations of the TUTO area of Greenland: U. S. Army Snow, Ice, and Permafrost Research Establishment Tech. Rept. 47, 63 p., 1960.

This report summarizes the results of glaciological investigations in the TUTO area of Greenland during the 1956 field season. It includes discussion of the accumulation and the ablation data on the Thule Ramp, on the P-Mountain Glacier, and at stations along the TUTO-Whitehorse Trail; determination of ice movement velocities on the Thule Ramp; measurements of the ice velocity network established in 1955 in the Blue Ice region; firn and ice temperature data from installed thermocouples in the Blue Ice area and along the TUTO-Whitehorse Trail; observations of ice-margin geomorphological phenomena and examination of the crevasse pattern in the Blue Ice and adjacent areas; measurement of a triangulation network and establishment of photographic control stations for compilation of an ice-edge map; and recommendations for further work.

Figures for the average annual movement of selected stakes on the Thule Ramp, based on measurements for the summer of 1954 and the years 1954-55 and 1955-56, show that ice velocity during the summer season is 2 to 3 times as great as it is for the year as a whole and that movement gradually decreases toward the edge of the ramp. Surface velocity decreases quite uniformly from a little over 4 m per year 3,500 m inland to zero at about 500 m inland.

Results of the resurvey of the net of movement stakes and reading of the crevasse thermocouples established in the Blue Ice area in the summer of 1955 are shown in tables and isotherm maps. — V. S. N.

- 182-277. Butkovich, T. R. Some physical properties of ice from the TUTO tunnel and ramp, Thule, Greenland: U. S. Army Snow, Ice, and Permafrost Research Establishment, Research Rept. 47, 17 p., 1959.

An ice tunnel in the Greenland Ice Cap was begun in 1955 and extended 1,167 feet into the ice by 1957. Results of unconfined compressive strength, ring tensile strength, and flexural strength tests are presented in tables. Photomicrographs and petrofabric diagrams are given for the six types of ice tested. The differences in strength between horizontal and vertical cores from the tunnel are not significant; there are differences between types of ice, however. Crushing strength values found for the tunnel ice generally fit the empirical equation that relates crushing strength to density. The values for ramp ice, however, do not fit the equation when average density values are used; this is probably due to the layering. The empirical equation relating ring tensile strength to density of high-density snows gives results approximately 20 percent greater than those obtained for tunnel ice; the grain size appears to be the controlling factor here.

Temperature curves as a function of depth into the wall and along the length of the tunnel are presented. A 30-day study of deformation of a room 100 feet by 30 feet at 650 feet into the tunnel indicates that the room is closing primarily by a block action. — J. W. C.

- 182-278. Fristrup, Børge. Recent investigations of the Greenland Ice Cap: Geog. Tidsskr., v. 58, p. 1-29, 1959.

Glacial studies on the Greenland Ice Cap, especially during the 1950's, are reviewed. The first part of the review describes the various research expeditions. The second part deals with the topography and areal extent of the icecap and the temperature and density of the ice. A list of 113 references is given. — J. W. C.

- 182-279. Robin, G. de Q. Progress on the Antarctic ice sheet: Polar Rec., v. 10, no. 64, p. 3-10, 1960.

This is a brief review of the main characteristics of the Antarctic continent and its ice mantle as determined by recent traverses across the continent. Major surface features discovered as a result of International Geophysical Year activities include the dome shaped nature of East Antarctica (the Atlantic-Indian Ocean side of a line joining the south end of the Ross Ice Shelf to the south end of the Filchner Ice Shelf), which rises to a maximum elevation of 4,000 m. The thicker the ice, the less is the surface modified by underlying relief; thus, the pattern of the ice in coastal areas indicates the underlying relief most clearly.

Preliminary ice thickness measurements indicate that the mean thickness of the Antarctic ice sheet, aside from coastal areas and ice shelves, may exceed 2,000 m. Determination of the areas where the subglacial floor is above or below present sea level coupled with knowledge of areas of exposed rock clearly indicate that the bulk of East Antarctica is of continental proportions. The structure of West Antarctica is still not clear. A deep trough probably connects the southern Ross Ice Shelf with the Bellingshausen Sea. West of this, volcanic rocks are believed to be typical of an island zone, whereas to the east geological similarities between the Sentinel and the Horlick Mountains make a link between them probable.

Love and Rayleigh waves travel across much of Antarctica more rapidly than across other continents. This indicates that the earth's crust is thinner over a moderate proportion of the wave path.

The state of the present mass balance of the ice sheet needs much more investigation. It is not known whether or not the total amount of ice stored on the Antarctic continent is increasing or decreasing; however, in view of the low rates of accumulation and great ice thicknesses near the central regions, the ice cover must have been building up for at least 20,000 years and possibly many times longer. — D. B. V.

- 182-280. Cailleux, André. Altitude du continent antarctique et loi des altitudes de Matschinski [Altitude of the Antarctic continent and Matschinski's law of altitudes]: Acad. Royale Belge Bull. Cl. Sci., ser. 5, v. 45, no. 3, p. 251-255, 1959.

Results of measurements of the Antarctic icecap made during the International Geophysical Year confirm the conclusions reached independently by Matschinski (see *Geophys. Abs.* 148-13419) and Cailleux (see *Geophys. Abs.* 164-208) that the icecap is thicker than formerly believed. Three levels must be distinguished at each point: the altitude of the névé, where the ice is in contact with air (measured by leveling); the altitude of the bedrock bottom under the ice (measured by geophysical methods); and the theoretical altitude of the deglaciated bedrock, that is, its elevation if the ice were removed and isostatic equilibrium were established.

The mean altitude of the ice surface is of the order of 2,100 m and the mean ice thickness is probably between 1,800 and 2,500 m. Using Matschinski's figure of 480 m for the altitude of the deglaciated, isostatically compensated continent the ice thickness is calculated to be 2,150-2,250 m, which is in good agreement with the measured values. — D. B. V.

#### GRAVITY

- 182-281. Gilbert, C. Dirac's cosmology and the general theory of relativity: Royal Astron. Soc. Monthly Notices, v. 116, no. 6, p. 684-690, 1956.

An explanation is given, according to the principles of the general theory of relativity, of some results previously obtained by Dirac. It is assumed that the unit of distance for electromagnetic phenomena is different from the unit of distance used for describing gravitational phenomena. The ratio of these units varies with time. The former unit gives the usual "cosmic" distance and a Newtonian law of gravitation which is independent of the time; the latter unit leads to a Newtonian law of gravitation for which the gravitational power of matter varies inversely as the epoch.

Formulas are derived which enable the age of the universe ( $t$ ), Hubble's constant ( $H$ ), and the mean density of matter in the universe ( $\omega$ ) to be calculated from the values of the constants of atomic theory and the present observed value of the gravitational "constant." It is found that  $t=4.1 \times 10^9$  yr,  $H=160$  km per sec per megaparsec, and  $\omega=4.8 \times 10^{-29}$  g per  $\text{cm}^3$ . — Author's summary

- 182-282. Munk, W[alter] H., and MacDonald, Gordon J. F. Continentality and the gravitational field of the earth: Jour. Geophys. Research, v. 65, no. 7, p. 2169-2172, 1960.

Satellite observations provide some information about zonal harmonics  $J_2$ ,  $J_3, \dots, J_6$  of the gravitational field. For a hydrostatic earth (all surfaces of equal density are level), odd harmonics vanish and even harmonics can be computed from precession and geophysical data. We have compared the non-

hydrostatic (observed minus hydrostatic) harmonics with those calculated for the known distribution of continents and some reasonable assumptions about density in the crust. The two sets of values do not agree, and this raises the possibility that density variations in the mantle, perhaps unrelated to the distribution of continents, are the important factor in determining the gravitational coefficients of low order. — Authors' abstract

- 182-283. Arnold, Kurt. Schwerewerte in grossen Höhen über der Erdoberfläche [Gravity values at great heights above the earth's surface]: Potsdam Geod. Inst. Veröffentl., no. 12, p. 51-69, 1959.

This paper presents a spherical harmonic development for determination of gravity values at points far above the earth's surface from values at the earth's surface. — D. B. V.

- Boaga, Giovanni. Expressions for gravity on the surface of a planet of tri-axial ellipsoidal form and relative considerations. See Geophys. Abs. 182-253.

- 182-284. Gavrilov, L. I. Gravitatsionnyy potentsial ellipticheskogo paraboloida [Gravity potential of an elliptic paraboloid]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 733-735, 1960.

A mathematical analysis of the gravitational potential of an elliptic paraboloid  $(X^2/p)+(y^2/q)+2z_1=0$  is given. In this equation  $p$  is equal to  $a^2/c$ ,  $q=b^2/c$ , where  $a$  and  $b$  are parameters of the paraboloid, and  $c \rightarrow \infty$ ,  $a \rightarrow \infty$ , and  $b \rightarrow \infty$ . Formulas derived for such a paraboloid indicate that only the value of  $\sigma(pq)^{1/2}$  can be found from observations and that the Macloren's theorem of confocal ellipsoids is applicable to the case of elliptic paraboloids. — A. J. S.

- 182-285. Norinelli, Armando. Significato ponderale dei numeri di Cassinis nella riduzione per la calotta delle misure di gravità [Significance of Cassinis' numbers as weights in the calotte correction of gravity measurements (with English, French, German, and Spanish summaries)]: Boll. Geodesia e Sci. Aff., v. 18, no. 4, p. 471-484, 1959.

The expression  $\Delta g = -\delta_m[f]$  is derived analytically for the gravity reduction for the spherical calotte, where  $[f]$  is the sum of Cassinis' numbers relating to station height and  $\delta_m = \frac{\delta f}{[f]}$  is the mean density of the spherical calotte de-

duced from the mean densities of the successive Hayford zones, taking Cassinis' numbers as weights. Simplifications of these computations are presented, and the coefficients for calculation of mean density of the calotte are tabulated. — D. B. V.

- 182-286. Kántás, Karl. The gravitational potential and its vertical derivatives [with German summary]: Geofisica Pura e Appl., v. 44, p. 20-24, 1959.

The vertical gradient of the gravity field is derived from the gravitational potential as a corollary of Green's theorem. A simple approximation is applied to the solution of the integral defining the vertical gradient. Numerical values of the coefficients are given for practical calculations. — Author's summary, D. B. V.

- 182-287. Cook, A[lan] H[uugh]. Determination of the Earth's gravitational potential from observations of Sputnik 2 (1957β): Royal Astron. Soc. Geophys. Jour., v. 1, no. 4, p. 341-345, 1958.

Observations of the rate of rotation of the orbital plane of Sputnik 2 are combined with Jeffreys' equation for the coefficients J and D in the spherical harmonic expansion of the earth's gravitational field to give revised estimates of J and D. The relative uncertainties of the results emphasize the great value of satellite observations and the need for a revision of the spherical harmonic analysis of surface gravity. Comparison of the value of  $e^{-1}$  with that deduced from the constant state of precession indicates that the earth is not in a hydrostatic state.

The solutions of the observation equations give the following values: weight-ed- $\delta J = -9.4 \times 10^{-6}$ ,  $\delta D = +5.1 \times 10^{-6}$ ,  $e^{-1} = 298.24 \pm 0.36$ ; unweighted— $\delta J = -4.92 \times 10^{-6}$ ,  $\delta D = -4.3 \times 10^{-6}$ ,  $e^{-1} = 297.88$  ( $\delta J$  and  $\delta D$  are the differences from Jeffrey's values of  $J = 1.632 \times 10^{-3}$  and  $D = 10.6 \times 10^{-6}$ ). — D. B. V.

- 182-288. Arnold, Kurt. Strenge Theorie der absoluten Lotabweichungen als Funktionen der Freiluftanomalien der Schwere [Rigorous theory of the absolute deflection of the vertical as a function of free air gravity anomalies]: Potsdam Geod. Inst. Veröffentl., no. 13, 46 p., 1959.

The formula for calculation of gravimetric plumline deflections from free air anomalies that was derived in a previous paper (see Geophys. Abs. 174-190) is given in a more rigorous form, analogous to that derived for gravimetric geoid undulations. — D. B. V.

Arnold, Kurt. On the determination of geoid undulations from free-air anomalies. See Geophys. Abs. 182-251.

Uotila, Urho A. [K.]. Determination of the shape of the geoid. See Geophys. Abs. 182-247.

Boaga, Giovanni. On the determination of the figure of the earth by means of gravimetric measurements. See Geophys. Abs. 182-249.

Uotila, Urho A. K. Investigations on the gravity field and shape of the earth. See Geophys. Abs. 182-246.

- 182-289. Halushko [Galushko], P. Ya. Pro vídpovidnist' znachen' anomalii izostatichnykh i anomaly Buhe [On the correspondence of values of isostatic anomalies and Bouguer anomalies (with Russian summary)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 19, no. 1, p. 57-67, 1959.

As a basis for drawing conclusions from gravity data concerning the earth's internal constitution it is necessary to combine analysis of both isostatic and Bouguer anomalies.

Bouguer and isostatic anomalies obtained from gravity observations at sea do not correspond. Inasmuch as the Bouguer correction is taken into account in calculating isostatic anomalies, this must mean that the assumptions of mass compensation are unrealistic. Bands of negative isostatic anomalies at sea do not reflect real quantitative mass distribution, but are the result of a distortion of the gravitational field in the isostatic reduction. Geotectonic structures and hypotheses based on analysis of isostatic anomalies at sea are thus based on unreal assumptions and lose scientific interest.

New methods should be developed either for accounting for the effect of mass compensation or for interpreting present isostatic anomalies to eliminate the discrepancy between Bouguer and isostatic anomalies. — D. B. V.

- 182-290. Válek, Rostislav. Nomogramme zur Berechnung der Schwerewirkung  $V_{xz}$  und  $V_\Delta$  einer Kugel und eines Zylinders [Nomograms for the calculation of the gravity effect  $V_{xz}$  and  $V_\Delta$  of a sphere and of a cylinder (with Czech and Russian summaries)]: Československá Akad. Věd Geofys. Sborník, no. 74, p. 57-62, 1958.

Four nomograms with transparent overlays are presented for the determination of the gravity effect  $V_{xz}$  and  $V_\Delta$  of a sphere and of a cylinder. The complete equations for these nomograms are derived, and the procedure for their use is outlined. Accuracy is  $\pm 10$  percent. — D. B. V.

- 182-291. Beránek, Břetislav. Diagrams for the graphical determination of the values of higher derivatives of gravity for the case of two-dimensional bodies: Československá Akad. Věd Geofys. Sborník, no. 75, p. 63-71, 1958.

The theory and method of construction of diagrams for determining the higher derivatives of gravity for the case of two-dimensional bodies are presented, and diagrams are given for the second and third derivatives. Use of the second derivative diagram is illustrated by an example from the Czechoslovakian part of the Vienna Basin. — D. B. V.

- 182-292. Pola, Ivan. Kolichestvennaya interpretatsiya gravimetriceskikh izmereniy v sluchaye nalichi dvukh plotnostnykh granits razdela [Quantitative interpretation of gravimetric measurements in the case of the presence of two density discontinuities (with Czech and English summaries)]: Československá Akad. Věd Geofys. Sborník, no. 76, p. 73-81, 1958.

The effect of a lower, regional density discontinuity can be distinguished from that of a higher, more local discontinuity by quantitative interpretation along a suitably chosen gravity profile. The gradient produced by the gravity effect of the lower discontinuity must be determined and subtracted from the anomaly along the profile; the result is essentially the gravity effect of the higher discontinuity.

The first part of this paper derives the formula  $\Delta g = \sigma_2 k x + \sigma_1 f(x)$ , where  $\Delta g$  is the gravity anomaly,  $\sigma_1$  is the density contrast at the upper discontinuity and  $\sigma_2$  that at the lower discontinuity,  $k$  is a constant, and  $x$  is the axis along which the profile is taken, coinciding with the direction of the gradient. The second part describes the types of cases encountered in petroleum prospecting, and the third part gives an example from the Czechoslovakian part of the Vienna Basin. — D. B. V.

- 182-293. Pola, Ivan. Úprava redukce na bouguerovu desku v okolí hustotních rozhraní povrchových hornin [Form of reduction to a Bouguer plate in the vicinity of density discontinuities of surface rocks (with English and Russian summaries)]: Československá Akad. Věd Geofys. Sborník, no. 77, p. 83-89, 1958.

In reducing gravity measurements to a Bouguer plate the error introduced when the surface rocks are not of equal density may be several times larger than the measurement error because the usual formula is based on the assumption of uniform density. This paper evaluates the magnitude of such er-

rors and proposes a simple method of eliminating them. This is accomplished by introducing a variable density in the neighborhood of density boundaries at the surface. A nomogram has been constructed for practical use, and an example is given. — D. B. V.

- 182-294. Pola, Ivan, and Růžička, Jaroslav. The error in determining density boundary depth in relation to the accuracy in determining contact rocks density in the quantitative interpretation of gravity measurements: Československá Akad. Věd Geofys. Sborník, no. 78, p. 91-99, 1958.

The accuracy of determining the dimensions and depth of anomalous bodies from gravity measurements depends on the accuracy of the observations and on the correct determination of the density contrast between the bodies and the surrounding medium. This paper examines the accuracy of determination of depth of the boundary between two rocks of different densities as a function of the accuracy of determination of their densities.

Nomograms are presented for practical use in determining the mean error due to this source. A solution is derived for a basin that is also valid for other anomalous bodies. An example is given for a Neogene basin. — D. B. V.

Henderson, Roland G. A comprehensive system of automatic computation in magnetic and gravity interpretation. See Geophys. Abs. 182-

- 182-295. Bancroft, A. M. Gravity anomalies over a buried step: Jour. Geophys. Research, v. 65, no. 5, p. 1630-1631, 1960.

The expression  $d = \frac{t}{\exp(t/d_0)-1}$  is derived for the case of a semi-infinite step of depth  $d$  and thickness  $t$ . As  $t$  decreases to very small values,  $d$  increases and tends to the value  $d_0$ . The maximum depth to the step is therefore  $d_0$ ; the actual depth is likely to be considerably less than  $d_0$  for reasonable values of density. The advantage of the formula for a step is that in cases where it is applicable it gives a smaller value of  $d_0$  than either of the formulas of Bott and Smith (see Geophys. Abs. 173-194), and the relation between actual depth and  $d_0$  is very easily applied.

The expressions for  $d$  and  $d_0$  were originally derived for use in the interpretation of the Bouguer anomalies near Holleford, Ontario, where a circular depression in the Precambrian basement is thought to represent a meteor crater. The maximum depth to and thickness of the material filling the depression (shown by the negative anomaly to be lighter than the rocks exposed at the surface) were estimated to be 300 feet and 650-1,600 feet, respectively; subsequent drilling to 1,100 feet failed to reach the undisturbed Precambrian. — D. B. V.

- 182-296. Fajkiewicz, Z[bigniew]. A rapid method for disentanglement of local gravity anomalies from the regional gravity field: Acad. Polonaise Sci. Bull., cl. 3, v. 5, no. 9, p. 911-915, 1957.

By proving the existence, for three-dimensional anomalies, of a diagram radius  $r=R$  in which the residual gravity  $\Delta g$  is approximately equal to the local anomaly  $\Delta g_L$ , a simple and rapid method of separating local anomalies from the regional gravity field is obtained. The point of departure is Griffin's definition of residual gravity (see Geophys. Abs. 136-10751).

The method is outlined. Results obtained for the "Miawa" anomaly in Poland using both the new method (8-points method) and the Tikhonov-Bulanzhe

method (38-points method) (see Geophys. Abs. 128-8978) are compared. The extremaums of local anomalies differ by about 2 mgal, owing to a certain freedom in choosing the first ring of the diagram plotted by Tikhonov. The most essential difference is in the character of the regional gravity field; in this respect the results obtained by the new method are in satisfactory agreement with the regional magnetic anomaly of the area. — D. B. V.

- 182-297. Butakov, G. S. Nekotoryye soobrazheniya po rabotam s krutil'nymi vesami [Some considerations on work with torsion balances]: Razvedochnaya i Promyslovaya Geofizika, no. 17, p. 67-71, 1957.

Macover's method of smoothing a variometric network results in nonalignment of the network due to measurement errors in the second derivatives and errors of integration. Butakov analyzes the causes of the lack of closure and proposes a formula for the reliability of variometric observations. As an example the formula shows that the distance between adjacent points in variometric survey networks should not be more than 2,000 m for the model z-40(30) variometer, and 201,050 m for the model S-20 when the survey is done for a 2-mgal map. — A. J. S.

- 182-298. Uspenskiy, D. G. Puti razvitiya gravitatsionnogo metoda poiskov i razvedki rudnykh mestorozhdeniy [Ways of development of the gravity method of exploration and prospecting of ore deposits (with English summary)]: Sovetskaya Geologiya, no. 2, p. 90-98, 1958.

Gravity exploration in the U. S. S. R. is reviewed. It has been successful in prospecting for massive sulfide ore, particularly in direct mapping of ore bodies. Many problems are yet to be solved in connection with direct exploration of iron deposits of the Krivoy Rog and Kursk types. As the accuracy of gravity exploration increases, its use can be extended to the search for pegmatites, quartz veins, bauxite, barite, and manganese. New gravity apparatus is required. American models have an accuracy of  $\pm 0.01\text{-}0.03$  mgal, whereas the Russian models are accurate to only  $\pm 0.1\text{-}0.3$  mgal. Desirable improvements are listed. — J. W. C.

- 182-299. Tsuboi, Chuji. Application of  $\sin x/x$  and other similar functions to computing gravity anomalies at higher elevations starting from given surface anomalies: Ohio State Univ. Inst. Geodesy, Photogrammetry, and Cartography Repts., no. 3, 18 p., 1959.

Gravity-anomaly distributions have been computed for an elevation of 46.7 km above Vening Meinesz' gravity profile 17 across Indonesia using three different interpolation methods. The distributions deduced by the  $\sin x/x$ ,  $(\sin x/x)^2$ , and linear interpolation methods agree within several milligals. — D. B. V.

- 182-300. Seya, Kiyoshi [Kiyoshi]. A new method of analysis in gravity prospecting (running average method) I [in Japanese with English summary]: Butsuri-Tanko, v. 12, no. 2, p. 65-73, 1959.

The theory and practical application of the "running average method" for analysis of gravity survey results and the interpretation of one dimensional anomalies obtained by this method are discussed. The Bouguer anomaly on a line is expanded by using a Fourier series and by plotting the excess of the observed value over the average of a selected number of readings at the midpoint of the points of observation along the line. By using two sets of averages, anomalies can be associated with subsurface masses and structures. — V. S. N.

- 182-301. Harrison, J[ohn] C. Gravity at sea: Am. Geophys. Union Trans., v. 41, no. 2, p. 271-273, 1960.

The technique of measuring gravity at sea has been revolutionized in the last three years by the development of the Graf (see Geophys. Abs. 171-168) and LaCoste (see Geophys. Abs. 177-205) gravity meters for use on surface ships. The rate of accumulation of data has been increased by an order of magnitude and the potentialities are even greater. The requirements of sea gravimeters and the construction of the two types now in use are outlined briefly. Tests of the LaCoste-Romberg meter in aircraft have been very promising (see Geophys. Abs. 177-204, 181-268); the value of airborne measurements for rapid regional gravity surveying of the oceans depends on the development of a suitable navigation system. — D. B. V.

- 182-302. Thompson, L[loyd] G. D. An improved bronze pendulum apparatus for relative gravity determinations: Dominion Observatory Ottawa Pubs., v. 21, no. 3, p. 145-176, 1959.

A bipendulum apparatus which uses bronze half-second pendulums has been developed by the Dominion Observatory for relative gravity measurements. Variable factors such as temperature, pressure, arc, and time are controlled precisely so that all observations are made under identical conditions and no corrections need be applied to the observed periods. Results show that repeated swings with one pair of pendulums give observed periods that are consistent to about  $\pm 8 \times 10^{-8}$  seconds. For repeat occupations of the same site the mean period for 3 or more swings with 1 pair is consistent to about  $\pm 5 \times 10^{-8}$  seconds ( $\pm 0.2$  mgal). Observations with several pairs give gravity differences that are accurate to the order of  $\pm 0.2$  mgal.

Gravity values obtained with this apparatus in 1957 are in close agreement with other pendulum and gravimeter values. Relative to the adopted value of 980.62200 cm per sec<sup>2</sup> for the Ottawa reference pier, the following gravity values have been obtained for important sites in the United States and Canada: Washington (Commerce pier),  $g=980.12050$  cm per sec<sup>2</sup>; Vancouver (U. B. C. Physics Bldg.),  $g=980.93676$  cm per sec<sup>2</sup>; and Winnipeg (Dominion Public Bldg.),  $g=980.99483$  cm per sec<sup>2</sup>. — V. S. N.

- 182-303. Burša, Milan. Etalonierung des Nörgaardschen Gravimeters TNK 310 und Massstabskorrektion des tschechoslowakischen gravimetrischen Netzes [Calibration of the Nörgaard gravimeter TNK 310 and scale correction of the Czechoslovakian gravimetric network (with Czech and Russian summaries)]: Československá Akad. Věd Geofys. Sborník, no. 72, p. 11-26, 1958.

Methods of determining the scale value of a gravimeter are reviewed and applied to the Nörgaard TNK 310 instrument. Twofold calibration by the Molodenskiy-Boulanger method gives a scale value of 0.9974 with a probable error of not more than  $3 \times 10^{-4}$ . For this value the maximum correction that can be applied to the Czechoslovakian gravity network is -0.9 mgal. For practical purposes the value 0.9974 is constant for all parts of the micrometer screw. The vertical component of the angle between the quartz fiber and the axis of rotation of the gravimeter is about 13 minutes, and its effect on the measurement can be neglected. The instrument should be recalibrated periodically to determine whether the scale value is constant with time. — D. B. V.

- 182-304. Jobert, Georges. Théorie du pendule de Zöllner et du pendule de Lettau [Theory of the Zöllner pendulum and of the Lettau pendulum (with English and Esperanto summaries)]: Geofisica Pura e Appl., v. 44, p. 25-73, 1959.

The mathematical theory of the motions of the Zöllner horizontal pendulum and of the Lettau double pendulum are examined at some length. It is concluded that the double pendulum has no advantage over the simple pendulum except in the case of large drift. If ground inclinations are large enough to affect noticeably the sensitivity of a simple pendulum, the accompanying drift would be prohibitive for the double pendulum as well. After calibration of position only, the sensitivity of the double pendulum should not vary. If the simple pendulum does not show marked drift, its sensitivity should remain constant even for very small inclinations of its axis. — D. B. V.

- 182-305. Silva, Giovanni, and Norinelli, Armando. Teoria della Bilancia di Eötvös e procedimenti di calcolo delle grandezza che essa permette di determinare [Theory of the Eötvös balance and procedures for calculating the quantities that it can determine (with English summary)]: Boll. Geodesia e Sci. Aff., v. 16, no. 1, p. 49-67, 1957.

In the first part of this paper Silva gives an elementary but rigorous mathematical treatment of the theory of the Eötvös torsion balance, with special reference to the sign to be attributed to the observed data. In the second part Norinelli examines in detail different methods of calculating  $U_{xz}$ ,  $U_{yz}$ ,  $U_{xy}$ , and  $U_\Delta$  and presents a simple method based on the strict application of the least-squares method. — D. B. V.

- 182-306. Popov, Ye. I. O zavisimosti spolzaniya nul'punkta kvartzevykh gravimetrov ot tolshchiny nitey uprugoy sistemy [On the dependence of creep of the zero-point of quartz gravimeters on the thickness of the filaments of the elastic system]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 751-752, 1960.

Certain regularities of zero point creep in Nørgaard and CH-3 gravimeters were observed and studied. It was found that this creep is due to viscosity of the quartz filaments used in the gravimeters, and that the magnitude of the creep is a function of the filament thickness. A suggestion is made that the observed effect would be even greater in elastic systems that use quartz glass for springs. — A. J. S.

- 182-307. Barta, G[yörgy]. On the variations of gravity: Univ. Sci. Budapest. Eötvös Annales, Sec. Geol., v. 1, p. 13-19, 1957.

If long-period geomagnetic variations are related to displacements in the earth's core, the gravity field should also show a pulsation of similar period. This period should be of the order of 50 years, and should be discernable in mareographic observations (see Geophys. Abs. 179-197). Meteorological processes should also exert an influence on the earth's gravity field; their maximum effect, however, is calculated to be not more than  $\pm 1$  mgal.

Systematic worldwide collection of data on secular gravity variations should be made in the same manner as for magnetic variations. High-precision determinations of temporal changes of gravity were planned for the International Geophysical Year. — D. B. V.

- 182-308. Thulin, Åke. Une détermination absolue de  $g$ , au pavillon de Breteuil, par la méthode de la chute d'une règle divisée [An absolute determination of  $g$  at the Pavillon de Breteuil by the method of free fall of a graduated scale (with English summary)]: Annales Géophysique, v. 16, no. 1, p. 105-127, 1960.

The absolute value of gravity determined at the gravity station Sèvres A (in the laboratory of the International Bureau of Weights and Measures at Sèvres, France) by means of high-speed cinematography of a graduated scale falling freely in a chamber evacuated to  $5 \times 10^{-5}$  mm Hg, is  $980,928.0 \pm 1$  mgal. The value for the same point in the Potsdam system is  $980,940.8$  mgal. This result is in agreement with recent determinations by the reversible pendulum method, and confirms anew the necessity for revision of the Potsdam values. (See also Geophys. Abs. 174-199.) — D. B. V.

- 182-309. Mumme, I. A. Absolute gravity determinations in Adelaide, and the necessity for establishing a new permanent gravity base station: Australian Jour. Sci., v. 22, no. 8, p. 350-352, 1960.

Absolute gravity determinations have been made in Adelaide, South Australia, both by absolute gravity pendulum measurements and by gravimeter ties with absolute gravity stations elsewhere in Australia and overseas. Six different values have been obtained, ranging from 979.7218 to 979.7265 gals, and four of these values must be revised to correspond with the revised Cambridge value on which they are based.

A probable value of 979.7237 gals ( $\pm 3$  mgals) is obtained for the Adelaide New Observatory's gravity station by averaging some of these results. As the Old Observatory has been demolished and extensive building alterations have been made at the New Observatory, it is recommended that a new permanent gravity base station be established in Adelaide, possibly in the University grounds. — D. B. V.

- 182-310. Oldham, C. H. G. Gravity and magnetic investigations along the Alaska highway: Dominion Observatory Ottawa Pubs., v. 21, no. 1, 22 p., 1958.

A gravity and magnetic survey was made along the Alaska Highway between Dawson Creek, Alberta and Fairbanks, Alaska, and 296 gravimeter stations were occupied. Ties were made to 10 pendulum stations covering a gravity range of 1,486 mgal, and a calibration factor of 0.246804 mgal per scale division was derived for the gravimeters. A study of profiles of elevation, Bouguer anomaly, magnetic intensity and lithology leads to the following general interpretation. A 60-mgal negative anomaly across the Rocky Mountains has been attributed to a 16,000-foot crustal downwarp, while an anomaly of similar magnitude but with steeper gradients across the Cassiar Mountains is considered to be due to a mass of low-density granite occurring within the mountain system. — Author's abstract

- 182-311. Hespers, J., and Wijnen, J. C. van. The gravity field of the Venezuelan Andes and adjacent basins: Koninkl. Nederlandse Akad. Wetensch. Afd. Natuurkunde, ser. 1, v. 23, no. 1, 95 p., 1959.

After a geological introduction and summary of gravimetric work in Venezuela, the results of gravity studies are presented and analyzed, and the structure and development of the Venezuelan Andes and adjacent basins are interpreted in the light of the anomalies. The Maracaibo and Barinas-Apure Bas-

ins are lows reflecting crustal downwarps filled with light sediments. Mass distribution under the Andes is assymetrical, suggesting that the eastern part was thrust over the western part. The controlling factor in the origin of the mountains was the development of a shear fracture, as postulated by Gunn (see Geophys. Abs. 129-9282, 139-11617). The amount of crustal shortening due to lateral compression is estimated to be 50 km at most. — D. B. V.

Hales, A. L. Seismic and gravity research on crustal structure in South Africa. See Geophys. Abs. 182-352.

- 182-312. Heiskanen, W. [A.], Niskanen, E., and Kärki, P. Topographic-isostatic reduction maps for Europe and North Atlantic in the Hayford zones 18-1 for the Airy-Heiskanen system,  $T=30$  km and 20 km: Acad. Sci. Fennicae Annales, ser. A-3, no. 54, 4 p., 1959.

Isostatic reduction maps are presented for Europe and its surroundings (lat 30°-70° N., long 20° W.-40° E.) and for the northern Atlantic Ocean (lat 0°-40° N., long 15°-75° W.); each is calculated for two different depths of compensation, 20 and 30 km. The figures of the maps are to be added to observed gravity values. Accuracy is 1.5 mgal or better.

The terrain correction is large near coasts and oceanic islands—sometimes more than 20 mgal—and must be computed before the gravity anomalies can be interpreted properly. With these maps, mean elevations and depths for the zones A - O (that is, to 166.7 km from the computation point) can be estimated; the isostatic correction and, if necessary, the terrain correction can then be computed from these mean elevations. — D. B. V.

- 182-313. Beneo, Enzo. Petroleum exploration in southern Italy (with French abstract): World Petroleum Cong., 5th, New York, Proc., sec. 1, paper 53, p. 957-963, 1959.

Results from the completed gravimetric network of southern Italy show an important gravimetric depression located in the Flysch between the Apennine and the Gargano-Murge sectors. It is interrupted, however, by a positive local uplift centered in the volcanic zone of the Vulture. The relationship between the Flysch and the gravimetric depression is not absolute; that portion of the Apennine sector which includes the Maiella Mountain is a negative area interpreted as due to the deep position of the igneous substrata. The corresponding isoanomalies form a west-east dorsal with a gradual increase of values toward the positive maximums reached in the Gargano. A detailed gravimetric survey made later of this dorsal showed a maximum where seismic data have indicated an uplift in the calcareous substrata at about 2,000 m depth. Data from the most significant and deepest wells drilled in recent years seem to confirm a definite relationship between the areas of gravimetric depression and the Flysch.

Oil possibilities in the Flysch, Apennine, Gargano-Murge, and deeper basin areas are discussed. — V. S. N.

- 182-314. Salvioni, Guido. Determinazione di gravità relativa lungo la linea di livellazione N. 19 (Portomaggiore-Mestre) [Determination of relative gravity along the leveling line no. 19 (Portomaggiore-Mestre)]: Boll. Geodesia e Sci. Aff., v. 17, no. 1, p. 33-45, 1958.

Relative gravity measurements made along leveling line 19 between Portomaggiore and Mestre, one of the lines chosen for calculation of Italian geopotential elevations, are described. The gravimetric data are tabulated. Examination of the results shows that the variation in Bouguer anomaly values corresponds well with values of ground movement and of gravity. — D. B. V.

Poldini, E., Burri, J. -P., and Inagaki, M. Some results of geophysical studies carried out in the Eau Morte region (Geneva canton). See Geophys. Abs. 182-190.

- 182-315. Chudoba, Vratislav, and Šimon, Zdeněk. Československé vertikální tříhové zakladny, měřitko a posun gravimetrické sítě I. a II. řádu [Czechoslovakian vertical gravity calibration line, scale and level of the gravimetric networks of first and second order (with Russian and German summaries): Československá Akad. Věd Geofys. Sborník, no. 73, p. 27-56, 1958.]

Results of gravimetric measurements made in 1947-58 on 8 vertical component gravity calibration lines in Czechoslovakia are presented. Gravity differences measured with the Nörgaard TNK 310 instrument between 1947 and 1955 are tabulated chronologically and compared with results obtained with other gravimeters. Another table gives the gravity differences for individual sections of the calibration line, and a third summarizes the gravity data.

The adjusted Czechoslovakian first and second order networks are compared with the pendulum network of the Potsdam Geodetic Institute; the gravimeter network is  $0.23 \pm 0.12$  mgal too high, and its gravity differences are  $0.32 \pm 0.15$  mgal larger for each 100 mgal.

The method of determining the conversion relation between two gravimetric systems from gravity ties is explained and illustrated by an example. Finally, a method of guaranteeing the true scale of the Czechoslovakian gravimetric base network that involves remeasurement with a more accurate instrument is proposed. — D. B. V.

- 182-316. Doležal, Jindřich. Napojení gravimetrických měření v Československé části Vídeňské pánve na gravimetrickou síť I. a II. řádu [Joining of gravimetric measurements in the Czechoslovakian part of the Vienna Basin to the gravimetric network of the first and second order (with English and Russian summaries): Československá Akad. Věd Geofys. Sborník, no. 79, p. 101-111, 1958.]

Gravity measurements in the Czechoslovakian part of the Vienna Basin have been adjusted to the first and second order gravimetric network of the country; the results are presented in a Bouguer map of the area (contour interval 1 mgal). Density values used in the Bouguer reduction were obtained from laboratory measurements. Average accuracy is estimated as  $\pm 0.6$  mgal. Remapping is recommended for a portion of the northwest part of the area, where the mean error in measured gravity values is considerable. — D. B. V.

- 182-317. Ibrmajer, Jaroslav. Některé problémy interpretace gravimetrických materiálů ne Vídeňské pánvi [Some problems of interpretation of gravimetric data in the Vienna Basin (with English and Russian summaries): Československá Akad. Věd Geofys. Sborník, no. 80, p. 113-131, 1958.]

The geology of the Vienna Basin and density characteristics of the sedimentary and basement rocks are discussed; then the structure of the Czechoslovakian part of the basin is interpreted qualitatively from the Bouguer anomaly and seismic refraction results. The major structures are indicated on a map on which the Bouguer anomalies and isochrones are superposed. Accuracy of interpretation of the regional gravity measurements is estimated as  $\pm 3-5$  mgal. A map of local gravity anomalies constructed on the basis of second derivatives was also used in the interpretation. — D. B. V.

- 182-318. Ibrmajer, Jaroslav, and Doležal, Jindřich. Znodenocení gravimetrických měření, provedených v Československé části Vídeňské pánve [Evaluation of gravimetric measurements made in the Czechoslovakian part of the Vienna Basin (with English and Russian summaries)]: Československá Akad. Věd Geofys. Sborník, no. 81, p. 133-145, 1958.

Independent gravity measurements have been made by different organizations for both geodetic and geologic purposes, using gravimeters or torsion balances, in the Czechoslovakian part of the Vienna Basin through 1955. The results obtained by 10 different surveys are described and analyzed. The measurements in each area are evaluated from the point of view of their usefulness in present petroleum exploration and the possibility of their incorporation into a single gravity map.

The Bouguer anomaly maps of four of the regions are reproduced, also a map of gradients and curvatures for a fifth area. Four of the 10 surveys are considered to meet necessary standards, 3 are deemed unusable, and 3 require field checking before a definite evaluation can be made. — D. B. V.

- 182-319. Ibrmajer, Jaroslav, and Pola, Ivan. Interpretace charakteristických geologických řezů Vídeňské pánve na zakladě gravimetrických měření [Interpretation of typical geologic sections of the Vienna Basin on the basis of gravimetric measurements (with English and Russian summaries)]: Československá Akad. Věd Geofys. Sborník, no. 82, p. 147-154, 1958.

Gravity measurements are interpreted along typical geologic sections across the Czechoslovakian part of the Vienna Basin. As the geology is fairly well known, some of the rules governing quantitative interpretation in this area could be determined by comparing the geologic and gravity data. In some cases geologic assumptions were verified, but in others they were not supported by the gravity data.

The interpretation was based on the method of so-called difference curves; the difference between the measured gravity effects and those calculated from the assumed geology can be determined from these curves and their gradients. The curves for eight geologic sections are reproduced. — D. B. V.

- 182-320. Beránek, Břetislav. Lokale Zeitanomalien und lokale Schwerenanomalien im inneralpinen Wiener Becken [Local time anomalies and local gravity anomalies in the Inner Alpine Vienna basin (with Czech and Russian summaries)]: Československá Akad. Věd Geofys. Sborník, no. 83, p. 155-169, 1958.

The results of gravity and seismic refraction investigations in the Inner Alpine Vienna basin (Czechoslovakian part of the Vienna basin) are presented. It is shown that the method of time anomalies is useful for qualitative interpretation of geologic structure.

Local relative time anomalies are defined as areas in which traveltimes are lower (positive) or higher (negative) than in their surroundings. Comparison of the local time anomalies and gravity anomalies (second derivatives) shows very good correspondence, especially in the northern part of the area. A more thorough comparison indicates that local gravity anomalies represent the geologic units better in area and in detail. It is concluded that the results obtained by refraction fan-shooting can be achieved more cheaply and more quickly by means of gravity investigations using modern interpretation methods, at least in terrane similar to the area in question.

Six maps of the Inner Alpine Vienna basin show the structural units, isochrones, local time anomalies, Bouguer anomalies, second derivative gravity anomalies, and local time anomalies superposed on gravity anomalies. — D. B. V.

- 182-321. Szilárd, József. As országos gravitációs alaphálózat néhány különleges problémája [Some special problems of the national gravity base network]: Geofiz. Közlemények, v. 8, no. 3, p. 97-104, 1959.

The principal problems involved in the homogeneous processing of available gravity data for Hungary in preparation of the gravity maps of the country are discussed. More than 100,000 gravity stations have been occupied, some by torsion balance and some by gravimeter, and the results have been reduced according to different methods. Three maps are being constructed, one based on torsion balance data, one on gravimetric data, and the third combining the two. — D. B. V.

- 182-322. Renner, János. A magyar országos gravitációs alaphálózat végeges feldolozása [The final processing of the Hungarian national gravity base network]: Geofiz. Közlemények, v. 8, no. 3, p. 105-119, 1959.

An English version of this paper has been published by Renner and Szilárd in Acad. Sci. Hungaricae Acta Tech., v. 23, no. 4, p. 365-395, 1959 (see Geophys. Abs. 181-282). — D. B. V.

- 182-323. Airinei, Ștefan. Asupra unui efect gravimetric major în zona colinară a munteniei orientale [On the typical gravity effect in the hilly zone of eastern Muntenia]: Acad. Romne Bul. Științ, Sec. Geologie-Geographie, v. 1, no. 1-2, p. 123-131, 1956.

Gravity studies in the hilly region of eastern Muntenia (Greater Walachia) have revealed a steep gravity gradient (4-2.5 mgal per km), which forms a narrow elongate belt 45 km in length. It is shown on a map. The gravity effect is interpreted as the result of the presence of a fault. — J. W. C.

- 182-324. Organisyan, Sh. S. Opyt primeneniya gravimetrovoy s"emki pri poiskakh i razvedke slepykh kolchedannikh rud alaverdskogo tipa [Experiments in application of gravimetric survey in prospecting and exploration of blind pyrite ores of the Alaverd type]: Akad. Nauk Armyan. SSR Doklady, v. 29, no. 4, p. 175-180, 1959.

Results are reported of an experimental gravity survey of blind pyrite ores in northern Armenia. The search for copper and polymetallic ore bodies was made with a gravimeter GAK-ZM for the purpose of checking its performance. It was found that the gravimeter used was accurate within the range from 0.3 to 0.5 mgal, and that this accuracy is insufficient for distinguishing gravity anomalies due to small lenses and nests of pyrite (up to 10 m thick and 100 m long) from topographic effects. An accuracy of 0.1-0.2 mgal is required. — A. J. S.

Agul'nuk, I. M., Zakashanskiy, M. S., Pudovkin, I. M., and Umantsev, D. F. Structure of the magnetic and gravity field of the lowland and its frame. See Geophys. Abs. 182-430.

Zakashanskiy, M. S., Pudovkin, I. M., and Umantsev, D. F. Comparison of the magnetic and gravity fields of the lowland and frame. See Geophys. Abs. 182-431.

- 182-325. Mumme, I. A. Determination of the absolute gravity values on the summits of a number of prominent hills in the Mount Lofty Ranges: Royal Soc. South Australia Trans., v. 83, p. 119-121, 1960.

Gravity observations at nine summit stations in the Mount Lofty Ranges in South Australia are presented in a table. Observations are based on an absolute gravity value of 979.7232 gals at the gravity base station in the New Observatory at the University of Adelaide. The methods used, the reduction of results, and the calculation of theoretical gravity values and Bouguer anomalies are discussed. — V.S.N.

- 182-326. Thyer, R. F., and Everingham, I. B. Gravity survey of the Perth Basin, Western Australia: Australia Bur. Mineral Resources, Geology and Geophysics Bull., no. 33, 11 p., 1956.

The results are presented of a gravity survey over an area of 43,000 sq mi extending along the Indian Ocean coast of Western Australia from Geraldton in the north to Cape Leeuwin in the south and inland for 100-150 miles. A negative gravity anomaly with a minimum of more than -130 mgals forms a trough about 400 miles long and up to 55 miles wide. Steep gravity gradients on the flanks of the anomaly suggest faults, which have brought relatively light sediments into juxtaposition with denser basement rocks. The major part of the anomaly is due apparently to these sediments, which at their maximum may be 30,000 feet thick. The results indicate several previously undetected faults and two minor synclines that diverge from the main synclinal axis; the importance of anticlinal axes associated with the synclines is stressed. In general, the gravity pattern indicates that the Perth Basin becomes narrower to the north between converging faults but continues in that direction to join the Carnarvon Basin. — V.S.N.

Seedsman, K. R. Gravity and magnetic traverses over aeromagnetic anomalies near Cowell. See Geophys. Abs. 182-434.

- 182-327. Robertson, E. I., and Reilly, W. I. The New Zealand Primary Gravity Network: New Zealand Jour. Geology and Geophysics, v. 3, no. 1, p. 41-68, 1960.

The New Zealand Primary Gravity Network, established between 1947 and 1955, consists of 437 stations. The gravity differences between 19 stations were measured with the Cambridge pendulum apparatus and between all stations with a North American gravimeter. Initially the observations were reduced separately in the North and South Islands; the resulting values constitute the New Zealand Provisional System, which has remained the basis for recording gravity results within New Zealand.

Subsequent adjustment of the network has resulted in a revised set of values, the New Zealand Potsdam System (1959), which differs by an average of +5.0 mgal from the provisional system. Values of gravity and of free-air and Bouguer anomalies in the New Zealand Potsdam System are tabulated for each of the 437 stations of the primary network. — D. B. V.

- 182-328. Verhoogen, John. Temperatures within the earth: Am. Scientist, v. 48, no. 2, p. 134-159, 1960.

This is a discussion of present thinking concerning temperature distribution within the earth as determined largely by the intensity and distribution of heat sources, the most important of which is radiogenic heat. The various methods used for determining the temperatures and their sources and distribution are discussed as follows: the rate of production of radiogenic heat as determined by recent analytical methods and an approximation of heat distribution as determined by the steady-state case, the data of surface heat flow for both continental and oceanic areas, transport of heat by convection, temperatures as inferred from seismic data and solid-state theory, and the adiabatic gradient in the mantle and outer core. In conclusion, Verhoogen discusses briefly the thermal history of the earth. — V.S.N.

- 182-329. Jobert, Georges. Perturbation du flux de chaleur dans la croûte terrestre due au relief [Disturbance of heat flow in the earth's crust due to the relief]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 19, p. 3209-3210, 1960.

A new general method of correcting calculations of heat flow from the crust for the effect of topography is presented. The crust is assumed to be homogeneous, nonradioactive, and bounded by a cylindrical surface on which temperature ( $T$ ) is known. The method also permits study of the effect of a change in any of the postulated conditions in different parts of the relief, as for example when  $T$  is zero under the ocean and varies on the continent as a function of altitude and distance from the ocean. — D.B.V.

- 182-330. Jobert, Georges, and Le Mouél, Jean. Tensions engendrées dans la Terre par des sources de chaleur inégalement réparties [Tensions generated in the earth by unequally distributed heat sources]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 13, p. 2400-2402, 1960.

Pericontinental orogenesis is sometimes explained by the action of horizontal tension between continental and oceanic blocks; this tension can be explained, in part, by a horizontal thermal gradient caused by unequal distribution of heat sources in the upper layers of the earth. This paper considers the simple case of an elastic homogeneous body that contains a semicircular cylinder, bounded by the same plane as the body, in which heat sources are uniformly distributed. The deformation in a cross section of the cylinder is analyzed mathematically.

The magnitude of the differential tension thus calculated is large enough to suggest that inequalities in heat sources and thermal coefficients should be taken into account in concepts of continental structure. — D.B.V.

- 182-331. Smyslov, A. A. Znacheniye dannykh o radioaktivnosti i teploprovodnosti gornykh porod pri metallogenicheskikh issledovaniyakh [Significance of data on the radioactivity and heat conductivity of rocks in metallogenic investigations]: Akad. Nauk SSSR Izv. Ser. Geol., no. 7, p. 32-45, 1960.

Temperatures deep in the earth's crust were calculated on the basis of results of measurements of the radioactivity and heat conductivity of rocks. Results are tabulated, giving temperatures computed for depths of 2, 4, 6, 10, 15, 25, 50, 100, 140, 150, 160, 180, and  $> 180$  km in six different types of

areas—primary ocean basins, geosynclines in the basaltic layer, geosynclines in a thin granitic layer, geosynclines in a thick granitic layer, regions of shallow crystalline rocks, and regions where folded Precambrian and Paleozoic rocks are covered by platform sediments.

Smyslov concludes that the distribution of radioactive elements in igneous rocks and the thermal regime of the crust support Bilibin's (1955) scheme of the evolution of magmatism of mobile belts, and that the low thermal conductivity of sediments plays an important role in the evolution of magmatic activity, and therefore in metallogenesis, by substantially aiding the local accumulation of heat in the crust. — D. B. V.

MacDonald, Gordon J. F., and Ness, Norman, F. Stability of phase transitions within the earth. See Geophys. Abs. 182-358.

Valle, P[ao]la E[milio]. An estimate of the melting point in the mantle of the Earth. See Geophys. Abs. 182-375.

182-332. Electronics. Components and materials department—Blue diamonds make rugged thermistors: Electronics, v. 33, no. 35, p. 78, 1960.

Blue diamonds, type IIB, are extrinsic p-type semiconductors and have a high negative temperature coefficient from below 200°K up to approximately 500°K. A process for attaching suitable ohmic contacts has been developed. A Ti-Ag-Cu eutectic is used in a 1,200°C furnace, bathed in a stream of argon, to attach the contacts. These physical properties of the diamond make it an excellent thermistor material: low specific heat; high heat conductivity (more than that of copper at room temperature); high physical strength, as compared to sintered oxide thermistors; nonhygroscopic; and resistant to corrosive fluids and high temperatures. The diamond thermistor can be placed in actual contact with the medium to be measured, thus increasing the heat dissipation constant and reducing the thermal time constant.

Prototype thermistors used diamond cylinders measuring 2.5-5 mm in length, and 1-1.5 mm in diameter. No crystal orientation is required as diamond is an electrically isotropic material. Cost of the devices would depend on the availability of IIB diamonds and on the wastage in preparing suitable shapes for thermistors. — H. C. S.

182-333. Boldizsár, T[ibor]. Computation of terrestrial heat flow in a well near Colorado Springs: Nehézipari Műszaki Egyetem Sopron, Bányamérnöki és Földmérőmérnöki Karok, Közleményei, Pub. 20, p. 21-26, 1959.

By solving the differential equation of heat conduction in cylindrical coordinates it is possible to compute the temperature distribution of fluid flowing upward in boreholes. The solution given is suitable for determination of the virgin rock temperature and conductivity at depth from the temperature of the outflowing fluid at the well head. Terrestrial heat flow can be determined if the conductivity of the rocks is known. The value of the terrestrial heat flow near Colorado Springs, Colo., based on measurements in a borehole, is  $0.995 \times 10^{-6}$  cal/cm<sup>2</sup>, sec. — J. W. C.

182-334. Stegna, L[ajos]. Praktische geothermische Untersuchungen in Ungarn [Practical geothermal investigations in Hungary]: Univ. Sci. Budapest. Eötvös Annales, Sec. Geol., v. 1, p. 79-87, 1957.

In regions that are complex structurally and hydrologically, such as the Trans-Danube area of Hungary, near-surface geothermal measurements may be unreliable. This is illustrated by three profiles in the vicinity of Pécs. Isothermal maps based on temperature measurements on karst waters in the Tatabanya coal mining district and on thermal waters in the vicinity of the main Budapest fault are reproduced. Other measurements, made in the Recsk mining district, show the geothermal effect of oxidation of sulfide ores. The results of these are plotted on two graphs of water temperature versus distance from an ore body. — D. B. V.

- 182-335. Boldizsár, T[ibor]. Terrestrial heat flow in the Nagylengyel oil-field: Nehézipari Műszaki Egyetem Sopron, Bányamernöki es Földmérőmernöki Karok, Közleményei, Pub. 20, p. 27-34, 1959.

Rock temperatures were measured in two boreholes in the Nagylengyel oil-field of Hungary. The geothermal gradient is  $4.56^{\circ}\text{C}$  per 100 m, and the heat flow is  $2.0 \times 10^{-6} \text{ cal/cm}^2$ , sec. An approximate linear relationship is found to exist between the ratio of heat conductivity of wet and dry core samples and the porosity as determined from logging data. — J. W. C.

- 182-336. Koshlyak, V. A. Termal'nyye issledovaniya otlozheniy Meso-kaynozoya vostochnoy chasti zapadno-sibirskoy nizmennosti [Thermal investigations of sediments of the Meso-Cenozoic of the eastern part of West Siberian Lowland]: Sovetskaya Geologiya, no. 5, p. 97-106, 1960.

The results are reported of temperature studies of 14 research and exploration drill holes in the vicinity of Kolpashevo in the eastern part of the West Siberian Lowland. The geothermal gradient ranges from  $3.7^{\circ}\text{C}$  to  $2.2^{\circ}\text{C}$  per 100 m. The maximum values occur in an area of high occurrence of the basement; this is illustrated on a contour map and in a geologic profile. The occurrence of steeper geothermal gradients above projections on the basement should be a useful criterion in oil and gas exploration. — J. W. C.

- 182-337. Ryabukhin, G. E., and Nesterov, I. I. Geotermicheskiye nabлюдения по глубоким скважинам Омской области [Geothermal observations in deep wells of the Omsk area]: Sovetskaya Geologiya, no. 1, p. 129-134, 1960.

The geothermal gradient of the Omsk region in the southern part of the West Siberian Lowland was studied using data obtained from four deep drill holes. The temperature at 100 m intervals is presented in a table, and a geothermal profile is drawn. The average geothermal gradient ranges from  $1.9^{\circ}\text{C}$  to  $3.26^{\circ}\text{C}$  per 100 m.

Movement of the ground water is reflected in the geothermal gradient. Rocks with stagnant water regimens are characterized by similar geothermal conditions at the various depths; the geothermal gradient is normal and not dependent on the hypsometric position of the water-bearing horizons. For rocks with dynamic water regimens, however, the geothermal gradient decreases in areas of subsidence and increases in areas of uplift.

A change in the geothermal gradient is an indicator of the movement of ground water. The direction in which its value increases indicates the direction of movement of the water. — J. W. C.

## INTERNAL CONSTITUTION OF THE EARTH

- 182-338. Birch, Francis. Internal constitution of the earth; physics of the interior: Am. Geophys. Union Trans., v. 41, no. 2, p. 173-176, 1960.

A bibliography is presented to serve as an index of activity during 1957-60, mainly in the United States, concerning the internal constitution of the earth. Items are listed under the following headings: books; seismology; equation of state (experimental); equation of state (theoretical); polymorphism, phase changes; melting curves (experimental); melting curves (theoretical); radiation, radiative transfer, conductivity, temperature distributions; geochemistry, heat production, and heat flow. — D.B.V.

- 182-339. Egyed, L[ászló]. Investigations on the interior of the earth: Univ. Sci. Budapest. Eötvös Annales, Sec. Geol., v. 1, p. 47-77, 1957.

This is the complete statement of Egyed's theory of the constitution and development of the earth, based on the hypothesis of an expanding earth (see Geophys. Abs. 167-165, 171-203, 173-236). — D. B. V.

- 182-340. Fischer, G[eorg]. Die Erde lebt [The earth lives]: Deutsch. Geol. Gesell. Zeitscher., v. 111, pt. 3, p. 579-598, 1959.

This is a review of evidence and theories concerning the constitution and evolution of the earth, mainly from a petrochemical point of view. — D. B. V.

- 182-341. Jeffreys, Harold. The structure of the earth: Royal Soc. New South Wales Jour. and Proc., v. 93, pt. 4, p. 137-139, 1960.

This lecture, sponsored by the Royal Society of New South Wales and the University of Sydney, reviews the methods of determining the nature of the density distribution within the earth. — V.S.N.

- Woollard, G[eorge] P[rior]. Current developments in seismological research. See Geophys. Abs. 182-83.

- 182-342. Kennedy, George C. Phase relations of some rocks and minerals at high temperatures and high pressures: Am. Geophys. Union Trans., v. 41, no. 2, p. 283-286, 1960.

Recent results of high-pressure studies of minerals fall into four general categories: melting points of minerals under high confining pressures, melting curves for minerals under high water pressure, vapor pressures of hydrous-anhydrous mineral assemblages at high water pressures, and equilibrium curves for solid-solid phase changes at high temperatures and pressures.

The most startling result from the geological point of view is that high-pressure polymorphism of common silicate phases known at the surface of the earth appears to be the rule rather than the exception. In general, however, the depth at which common polymorphs are formed appears to be greater than current thinking would admit. Of particular pertinence are the great depths in the crust needed to form grossularite, zoisite, lawsonite, kyanite, and jadeite; the presence of impurities, however, might modify the stability fields of these minerals so that they would be stable at lower pressures than those indicated by the experiments. — D. B. V.

- 182-343. Lucke, O. Über den physikalischen Zustand der Materie im Erdinneren [On the physical state of matter in the earth's interior]: Zeitschr. Geophysik, v. 24, no. 4/5, p. 240-259, 1958.

If the phase diagrams of the apparently most abundant constituents of the earth—fayalite, forsterite, and metallic iron—are extrapolated on the basis of the theory of finite elastic displacements to obtain the earth's chemical composition, the relative abundance of iron is larger by 50 percent than that in the cosmos. The discrepancy is examined in the light of a number of theories on the composition of the earth's interior; that of Egyed (see Geophys. Abs. 165-172), which postulates an "ultraphase" in addition to metallic bonds, is found to be the most promising.—D. B. V.

- 182-344. Weizman (Veytsman), P. S., Kosminskaja (Kosminskaya), I. P., and Riznichenko, J. V. (Riznichenko, Yu. V.). New deep seismic sounding data on the structure of the earth's crust and on mountain roots: Bur. Central Séismol. Internat. Pubs., Sér. A, Traavaux Sci., no. 20, p. 97-112, 1959.

In its present form the method of deep seismic sounding is similar to the correlation refraction method; however, it investigates greater depths, using shot-point distances up to 300 km or more and charges of the order of 50-300 kg (in water) or up to 800 kg (in shothole groups). Recording is done by special portable low-frequency (5-15 cycles per second) multichannel stations. Sensitivity is enhanced not only by the use of low frequencies but by suitable grouping of shot points and receivers and choice of a quiet time and place for observations.

Results of investigations in different parts of central Asia and other parts of the U.S.S.R. show that this method has a higher resolving power than other methods of investigating crustal structure; it permits detailed study of mountain, foothill, and platform regions. In all areas investigated the boundaries of the granitic, basaltic, and subcrustal layers could be distinguished. The observed wave groups are complex, indicating that the transitions between layers are complex.

Crustal thickness was found to be greater under the mountainous areas of central Asia than under platforms and plains, showing that the mountains have roots. The roots of the folded systems of the Tien Shan, Pamir, and Turkmen S.S.R. appear to be a general downbuckling of the M-discontinuity. This boundary and the top of the basaltic layer show local elevations and depressions that do not conform to the present surface relief. The roots of Hercynian structures appear to consist of a thickening of the basaltic layer, those of Alpine structures of the granitic.

Comparison of deep seismic sounding data with gravity data shows that the negative gravity anomalies of the mountains reflect mainly the depth and shape of the M-discontinuity.—D. B. V.

- 182-345. Afanas'yev, G. D. O petrograficheskoy interpretatsii geofizicheskikh dannykh o stroyenii zemnoy kory [On the petrographic interpretation of geophysical data on the constitution of the earth's crust]: Akad. Nauk SSSR Izv. Ser. Geol., no. 7, p. 3-31, 1960.

This is essentially a summary of current information and hypotheses on the thickness and petrographic constitution of the earth's crust obtained from geophysical data, mainly seismological. Directions for future research aimed at clarifying problems concerning the nature of the deep crust and of the magmatic and tectonic processes that take place in it are outlined.—D. B. V.

- 182-346. Woppard, George P[rior]. The crust and core of the earth, in *The undiscovered earth: Southern Research Inst. Conf. Proc.*, Birmingham, Ala., p. 39-44, 1959.

This is one of a group of papers on various technical aspects of earth science presented at the annual conference for laymen of the Southern Research Institute. The internal structure of the earth is described, and the methods by which this structure is determined are outlined. The discussion includes methods of seismic and gravity measurements to determine crustal structure, with some typical results shown in tables; theories of the origin of the crustal structure and their relationship to crustal stability; and the nature of the core of the earth as deduced from seismic measurements. — V. S. N.

Carey, S. Warren. The strength of the earth's crust. See *Geophys. Abs.* 182-514.

- 182-347. Ewing, Maurice. Earth's crust below the oceans and in continents: *Am. Geophys. Union Trans.*, v. 41, no. 2, p. 172-173, 1960.

In 1957-60 the crust beneath the oceans was studied by a variety of geophysical methods including seismic reflection and refraction, surface-wave dispersion, and gravity, magnetic, and heat flow measurements. The seismic refraction technique provided most extensive and detailed data; measurements were made in previously unexplored parts of the North and South Atlantic, North and South Pacific, and Indian Oceans. The continental crust was studied primarily by refraction and reflection techniques, surface-wave dispersion, and gravity and magnetic measurements. Results are summarized briefly. — D. B. V.

- 182-348. Macdonald, Gordon A. Dissimilarity of continental and oceanic rock types: *Jour. Petrology*, v. 1, no. 2, p. 172-177, 1960.

Recent papers cite the similarity of rocks, particularly andesites, in continental and oceanic regions, but the similarity is primarily one of name. The oceanic "andesites" belong to the alkaline suite, whereas the typical continental andesites are calc alkaline and hypersthene or hornblende bearing. To avoid further confusion it is suggested that the name "andesite" for the oceanic rocks be replaced by the names hawaiite and mugearite. Whatever name is used, it is essential to emphasize the difference between the oceanic "andesites" and andesites of continental orogenic regions.

All members of the oceanic suite are present also in continental regions, but the calc alkaline rocks characteristic of orogenic regions on the continents are absent within the true ocean basins, except in island arcs near the continents that were formerly regarded as the continental border. — Author's abstract

- 182-349. Mason, R. G. Geophysical investigations of the sea floor: Liverpool and Manchester Geol. Jour., v. 2, pt. 3, p. 389-410, 1960.

Seismic refraction measurements show that the earth's crust thins from about 35 km under the continents to 6 km under the oceans, also that the oceanic crust has a layered structure. The sediments that cover it are much thinner than expected, which suggests that the oceans are perhaps younger than was thought, or perhaps the sediments have become engulfed in lavas. Great fracture zones cross the floor of the northeast Pacific, and there is evidence for strike-slip movements of more than 200 km along them. The dis-

covery that heat flow rates for continents and oceans are approximately equal upsets previous ideas about radioactive heat sources. A pattern has been observed in the heat flow associated with an oceanic rise. It has been suggested that both are related to convection in the mantle. Subcrustal drag by convection currents may explain the fracture zones. — Author's abstract

182-350. International Geophysical Year Bulletin (No. 34). Seismic crustal studies during the IGY. Pt. 2: Continental program: Am. Geophys. Union Trans., v. 41, no. 2, p. 351-355, 1960.

Measurements of continental crustal structure were carried out in five areas during the International Geophysical Year: the central shield region in the Great Lakes area (2 profiles), the buried shield area near the head of the Mississippi embayment in Arkansas, the high plateau of central Mexico, the Andean high plateau of South America, and the adjacent Andean foothill region. Both quarry blasts and special shots were used.

In the Keweenaw Peninsula the profile is parallel to the strike. There the crustal structure consists of about 1.5 km of material with a velocity of 4.7 km/s, overlying material with a velocity of 6.3 km/s that extends to a depth of 36 km; under this is the mantle with a velocity of 8.05 km/s. No intermediate layer was detected. The Apostle Island profile crosses a major structural dome in the surface rocks. At the north end 2 km of material having a velocity of 3.5 km/s (Precambrian sediment) overlies 3 km of material with a velocity of 5.2 km/s; beneath this, in turn, a layer with a velocity of 6.15 km/s extends down to the mantle, lying at a depth of 37 km and having a velocity of 8.15 km/s. At the south end of the profile the surface material (granite) has a velocity of 5.2 km/s and a depth of 1 km; beneath this is a layer having a velocity of 6.15 km/s extending down to the mantle (8.15 km/s) at 36.6 km depth. No intermediate layer is evident.

The Arkansas profile indicates an upper layer 2 km thick of material with a velocity of 4.65 km/s, underlain by 10 km of 5.5-km/s material; beneath this is crustal material having a velocity of 6.9 km/s to a depth of 43 km where the mantle (8.15 km/s) appears. The high density implied by the 6.9-km/s velocity explains the positive gravity anomaly of this area. The thick crust in this area of low elevation is significant.

The Mexican profile shows a surface layer 0.5 km thick with a velocity of 3.0 km/s, underlain by a 3.5-km layer with a velocity of 4.9 km/s; this in turn is underlain by a layer of 6.0 km/s. Two interpretations of crustal thickness are possible here. The 6.0-km/s layer may be 28.9 km thick, underlain by an 11-km layer with a velocity of 7.6 km/s underlain in turn by mantle rock with a velocity of 8.2 km/s, for a total crustal thickness of 43.8 km. Alternatively, the 6.0-km/s layer may be 16.2 km thick and may be underlain by 2 basal layers, the upper with a velocity of 6.4 km/s and thickness of 15.3 km and the lower with a velocity of 7.6 km/s and thickness of 8.8 km, for a total crustal thickness of 44.2 km.

Profiles based on mine blasts at Toquepala, Peru, show an apparent velocity layering in the flank area of the altiplano of 5.3 km/s, 6.2 km/s, a suggestion of a 6.7-km/s layer, and the mantle with 8.2 km/s; on this basis the crust is 46 km thick. If second arrivals are used in the altiplano region proper where first arrivals were not obtained, a depth of the order of 65 km is suggested: 4.1 km of 5.3-km/s material, 21.2 km of 6.2-km/s material, 39.6 km of 6.7-km/s material, and then the mantle.

A profile based on mine explosions at Chuquicamata, Chile, showed surface material with a velocity of 5.5 km/s overlying a layer with velocities of 6.0 km/s to, possibly, 6.4 km/s; and indicated definitely by first arrivals, and a 7.0 km/s basal layer overlying the mantle (8.0 km/s). On the basis of this struc-

ture the crustal thickness is 56 km for the mountain flank. If second arrivals are used, a thickness of 70 km is found beneath the altiplano: 6 km of 5.5-kmps material, 28.4 km of 6.35-kmps material, 35.9 km of 7.0-kmps material, and then the mantle. — D. B. V.

- 182-351. Neumann, Frank. Crustal structure in the Puget Sound area: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 153-167, 1959.

Seismological investigations in the Puget Sound area to date have shed little or no light on the nature of the crustal layering in the region. Three layer velocities (5.8 km/psec, 6.4 km/psec, and 7.0 km/psec) have yielded most consistent results in preliminary studies, but there is no evidence that subcrustal velocities (8 km/psec or more) have ever been registered; so far as instrumental readings are concerned, the M-discontinuity does not exist here.

Consistent results have been obtained by using three sets of purely hypothetical traveltimes in interpreting the observed values. The validity of these curves is discussed at some length. More than one combination of structure and velocity may satisfy any one of the curves within the limits of observational error. Analysis of the data of 37 earthquakes in the area using these curves shows that the crustal layers are probably not parallel to one another. Higher velocity layers always underlie lower velocity layers, but their depths vary from place to place. There is a broad correlation between seismic results and the broader scale features of the gravity picture. Further data and additional seismic stations are needed to reveal any weaknesses in the interpretation given here. — D. B. V.

Hess, H. H. Caribbean research project, Progress report. See Geophys. Abs. 182-261.

- 182-352. Hales, A. L. Seismic and gravity research on crustal structure in South Africa: Jour. Geophys. Research, v. 65, no. 7, p. 2155-2168, 1960.

Crustal structure in the Eastern Transvaal has been studied by means of recordings of Witwatersrand earth tremors and by local surveys using the continuous ground excitation method. The instrumentation and techniques used are described. The results indicate that there is an intermediate layer in the region, and that the  $P_n$  traveltimes are shorter for the coastal plain than for the high plateau as should be expected if the plateau were isostatically compensated. The relation between crustal structure and isostatic equilibrium is discussed at some length.

A crustal thickness of 30 to 40 km is consistent with the isostatic anomaly field in South Africa. The anomalies on the seaward side of the escarpment bounding the interior plateau are predominantly negative. It is suggested that in some areas the negative anomalies are due to the still existing roots of the former topography, and inferences are made concerning the strength of the mantle and crust. Heat generated by plastic deformation may account for the association of volcanism with regions of high stress. — D. B. V.

- 182-353. Gane, P. G. Seismic work on crustal structure in South Africa: Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 151-152, 1959.

Seismic observations of Witwatersrand earth tremors were observed by means of the well-established radio triggering technique between a master

station in Johannesburg and a single mobile field station situated from 50 to 500 km away. Traverses were made to the south-southwest, east, and north-northeast of Johannesburg, and the results are compared with those of an earlier work to the west. No significant differences in crustal thickness exist in any of these directions, nor does the Mohorovičić surface have any appreciable dip.

Compilation of the results from more than 500 seismograms gives the following values for depths and velocities: superficial layer—1.3 km from both P (5.40 km/s) and S phases (3.20 km/s); continental crust—33.8 km from P (6.18 km/s) and 32.0 km from S (3.66 km/s); velocity at top of mantle—P=8.27 km/s, S=4.73 km/s. There were only vague indications of phases corresponding to an intermediate layer; apparently the crust here is generally uniform for a large part of its extent. — D. B. V.

- 182-354. Båth, Markus. Crustal structure of Iceland: *Jour. Geophys. Research*, v. 65, no. 6, p. 1793-1807, 1960.

The crustal structure of Iceland was investigated by means of explosions at a depth of 30 m in the Graenavatn crater lake, recorded with a 12-channel refraction apparatus at a number of stations along two profiles (one across the center of the island and the other in the western part). A three-layer crust was found—a top layer of lava and volcanic ash and two basaltic layers. The longitudinal wave velocities in these layers are 2.69, 6.71, and 7.38 km/s, and the thicknesses are 2.1, 15.7, and 10.0 km, respectively. The total crustal thickness is 27.8 km. Both direct and reflected waves were used in the study.

Longitudinal guided waves propagated by multiple reflections in the lava layer were recorded to distances of more than 100 km. The large velocity contrast between the lava layer and the first basaltic layer results in more than 83.5 percent of the original seismic energy remaining in the lava layer, leaving only a few percent to penetrate deeper. Amplitude attenuation coefficients are about twice as large for the central profile as for the western profile, mainly because of scattering of the waves in the inhomogeneous and heavily fractured crust along the former. The seismic efficiency of the explosions varies on the average from 20 to 25 percent, according to the records of the Reykjavik seismograph station. — D. B. V.

- 182-355. Closs, H[ans]. Über Erfahrungen mit Sprengungen zur Untersuchung der höheren Teile der Erdkruste in Deutschland [On experiences with explosions for investigation of the upper parts of the earth's crust in Germany (with English and Italian summaries)]: *Annali Geofisica*, v. 12, no. 3, p. 257-270, 1959.

This is a review of the results of recent explosion-seismology research in West Germany. Quarry explosions with charges ranging from 1 to 10 tons were used for reflection and refraction measurements, and normal reflection surveys were also used to some extent. Observations were made as far as 200 km from the shot points. Chamber blasts were found to be preferable to shots in deep wells. Electric four-channel refraction instruments with strong total amplification are now used instead of portable mechanical seismographs.

The refraction records obtained in the Rhenish Schiefergebirge, Kassel-Frankfurt area, and Alps foreland are discussed. Combined with gravity observations, such results have thrown light on the nature of the root of the Alps. Layer velocities and depths to the Förtsch (top of basement), Conrad, and M-discontinuities determined for four regions by reflection surveys are tabulated. — D. B. V.

- 182-356. Gal'perin, Ye. I., and Kosminskaya, I. P. On seismic investigations of the deep crustal structure according to the International Geophysical Year: *Annali Geofisica*, v. 12, no. 3, p. 283-295, 1959.

Preliminary work with deep seismic sounding in the Caspian Sea area in 1956 showed the method of point profiles with movable shot points to be the most effective. In the epi-Hercynian platform of the Turkmen S. S. R. the crust consists of a sedimentary layer 2-3 km thick, a granitic layer 10-15 km thick, and a basaltic layer 20-25 km thick; total thickness is 30-35 km. In the transition zone to the Caucasus geosyncline area the thickness of the sedimentary layer increases abruptly and that of the granitic layer decreases. In the trough proper the sedimentary layer is more than 20 km thick and is underlain by the basaltic layer (waves corresponding to the granitic layer were not observed); total thickness is of the order of 40-45 km.

The transition zone from the Asian continent to the Pacific Ocean was studied in 1957-58 as part of the International Geophysical Year program of the U.S.S.R. Preliminary results suggest a complex crustal structure. The traveltimes curves show three types of crust: continental in the Kurile Island arc and northern Sea of Okhotsk, intermediate in the deep part of the Sea of Okhotsk, and oceanic in the region of the oceanic plateau.

The deep seismic sounding investigations were conducted in conjunction with seismic observations of weak local earthquakes (Hurup Island), gravity and aeromagnetic observations at sea, and geologic investigations of the coastal areas. — D. B. V.

- 182-357. Utsu, T[okuji]. Observations of the  $L_g$  waves and crustal structure in the vicinity of Japan: *Geophys. Mag. [Tokyo]*, v. 29, no. 4, p. 499-508, 1960.

$L_g$  surface waves, which travel purely continental paths, have been recorded at Japanese stations on Kyushu and Hokkaido for earthquakes originating in Siberia, Outer Mongolia, and China. This distribution indicates that the crust beneath the central part of the Sea of Japan is oceanic whereas that beneath the Yellow Sea and the northwestern part of the East China Sea is continental. — D. B. V.

- 182-358. MacDonald, Gordon J. F., and Ness, Norman, F. Stability of phase transitions within the earth: *Jour. Geophys. Research*, v. 65, no. 7, p. 2173-2190, 1960.

Assuming that the M-discontinuity is a phase transition separating basalt from eclogite, the movement of such a phase transition resulting from changing mechanical and thermal conditions associated with sedimentation and erosion is examined. The equilibrium states of crusts having a wide range of thermal properties are calculated on the assumptions that isostatic equilibrium is maintained and that thermal equilibrium is attained. For example, the deposition of 10 km of low-conductivity sediments on a crust initially 35 km thick will result in the conversion of 5 km of the crust to mantle material and the elevation of the initial surface of sedimentation to 2 km above sea level, provided that the phase boundary is approximated by the pyrope-garnet transition. The time required for the deposition and subsequent elevation of the sediments is of the order of  $10^6$  yr.

The one-dimensional field equations describing the heat flow in the mantle and crust, together with appropriate boundary conditions, have been approximated by finite difference equations that have been solved on an IBM 704 computer for various sedimentation models (neglecting isostatic compensation).

For example, a basin initially 3 km deep receives sediments at a rate inversely proportional to the depth of sedimentation; after  $4 \times 10^6$  yr the basin is filled with 4 km of sediments and the phase boundary moves upward from an initial 30 km to 24 km; the sediments then rise above sea level and the phase boundary moves downward; the maximum uplift of the sediments above sea level is 610 m, and this level is maintained for more than  $40 \times 10^6$  yr. The amplitudes and time scales of the motion of the phase boundary and outer surface are in general agreement with geological observations. — D. B. V.

- 182-359. Harris, P. G., and Rowell, J. A. Some geochemical aspects of the Mohorovičić discontinuity: *Jour. Geophys. Research*, v. 65, no. 8, p. 2443-2459, 1960.

Hypotheses of mantle composition and of the nature of the Mohorovičić discontinuity are discussed.

It is considered (a) that there is no evidence for the assumption that meteorite compositions can be applied in their entirety to the composition of the earth; (b) that even assuming the earth to have a chondritic composition does not permit any calculation of the composition of earth layers; and (c) that any analogy between achrondites and the earth cannot be applied quantitatively and is of no relevance to problems of the Mohorovičić discontinuity.

Geological evidence indicated that the upper mantle is of peridotitic composition. Though conditions for eclogite stability do exist within the earth, there is no evidence for the hypothesis that the Mohorovičić discontinuity coincides with a phase transformation to eclogite. — Authors' abstract

- 182-360. Hess, H. H. The AMSOC hole to the earth's mantle: *Am. Geophys. Union Trans.*, v. 40, no. 4, p. 340-345, 1959; *Am. Scientist*, v. 48, no. 2, p. 254-263, 1960.

The history of the "Mohole" project to drill to the earth's mantle is reviewed, and the choice of site is discussed. This has been narrowed down to two locations, one about 120 miles north of San Juan, Puerto Rico, and the other south of Los Angeles from Guadelupe Island toward Clipperton Island; seismic work is now under way to find places in these areas where depth to the M-discontinuity is favorable and heat flow is comparatively low. The scientific objectives of the project are also discussed.

It is predicted that the uppermost layer will be found to consist of unconsolidated sediments and the second of consolidated sediments with or without volcanics; the section of these layers will be very incomplete. The third layer, the so-called basalt layer, will be serpentinized peridotite such as has been dredged from the mid-Atlantic Ridge. The mantle will be peridotitic and of the same composition as St. Paul's rock; Ringwood's model (see *Geophys. Abs.* 176-224) will be substantially correct. — D. B. V.

- 182-361. Vesalanen, E. [E.], Nurmia, M., and Porkka, M. T. New evidence for the existence of Gutenberg's asthenosphere channel: *Geophysica [Helsinki]*, v. 7, no. 1, p. 1-11, 1959.

New evidence for the existence of Gutenberg's asthenosphere channel based on the data of distant earthquakes is presented. The depth of the channel is different for different earthquake regions, and the critical depth obtained in this paper might correspond to the trough or minimum velocity level of Gutenberg's channel. For Alaska it is 45 km, for north Japan 80 km, for Tonga 95 km, and for South America 120 km.

It is generally assumed that the horizontal strain in the mantle gradually changes from compressive to tensile type at a depth of about 100 km; this change should have an effect on the elastic properties of the material and might provide a contributory cause for the existence of the asthenosphere channel in addition to the temperature effects suggested by Gutenberg. If the level of no horizontal strain did lie somewhat below the critical depth, the abrupt decrease in earthquake frequency at this depth and the changes in seismogram type occurring at this depth could be explained.

The results demonstrate the importance of regional study of seismograms. The possibility of misinterpretation of the focal depth of earthquakes above 150 km is indicated, and the need to develop an accurate method for calculating the depth is emphasized. — V. S. N.

- 182-362. Valle, P[ao]la E[milio]. Una stima del punto di fusione nel mantello della Terra [An estimate of the melting point in the mantle of the earth (with English abstract)]: Annali Geofisica, v. 13, no. 1, p. 79-84, 1960.

Melting temperatures at 15 different depths in the mantle, calculated on the basis of transverse wave velocities, are tabulated and compared with Uffen's values (see Geophys. Abs. 151-14070). The new values are considerably lower. Examples are: 1,517°K at 100 km, 3,100°K at 1,000 km, 4,083°K at 2,898 km as against 1,800°K, 3,726°K, and 5,256°K obtained by Uffen for corresponding depths. — D. B. V.

- 182-363. Lehmann, I[nge]. Structure of the upper mantle as derived from the travel times of seismic P and S waves: Nature, v. 186, no. 4729, p. 956, 1960.

On the basis of P-wave data it has been shown that the mantle consists of an upper layer, extending down to about 220 km, characterized by a small velocity gradient, and a lower layer with considerable velocity gradient; there is an abrupt increase in velocity at the boundary. S-wave data from northeastern North America also show the change to a higher velocity and higher velocity gradient at 220 km, and in addition indicate the existence of a low-velocity layer at 150-220 km.

The  $S_d$  phase, usually poorly observed in Europe, has been recorded there in a few shallow earthquakes well enough to show that the traveltimes are very nearly the same as in northeastern North America; a European structure similar to that adopted in northeastern North America will give rise to S-phases having traveltimes in fair agreement with those of the observed late S-phases. The S-phases of six Rumanian intermediate earthquakes are also in agreement with such a structure.

It is likely that P-wave velocities are somewhat affected in the layer in which S-wave velocities are low. The velocity distribution for P-waves, therefore, has been adjusted to include a layer of slightly lower velocity at 150-220 km; this can be done without altering the traveltimes appreciably. — D. B. V.

- 182-364. Kishimoto, Yoshimichi. Seismometric investigation of the earth's interior, pt. 3. On the structure of the earth's mantle, pt. 1: Kyoto Univ. Coll. Sci. Mem., ser. A, v. 28, no. 2, p. 117-149, 1956. On the structure of the earth's mantle, pt. 2: ibid., v. 28, no. 4, p. 391-399, 1958.

In part 1, an investigation of the shallow-focus earthquakes of Kamchatka-Kurile Islands and of Formosa is reported to clarify the structure and proper-

ties of the upper mantle. The time-distance graphs of these earthquakes were found to fit fairly well with the Jeffrey-Bullen 1939 table in the range from about  $9^{\circ}$  to  $26^{\circ}$ . This suggests that except for the uppermost 100 km, the structure of the upper mantle near Japan is in accordance with that to be deduced from the Jeffrey-Bullen table.

In part 2, seven normal, shallow-focus Japanese earthquakes were analyzed in order to investigate the structure of the uppermost part of the mantle, including the problem of the existence of the low-velocity layer. The following conclusions were reached: The P-velocity at the mantle's surface is 8.0 km/s in accord with earlier findings of Gutenberg, Jeffrey, and others; it seems possible that the low-velocity layer also exists in Japan but, if it does exist there, it differs somewhat from that in North America and Europe; the structure in the part of the mantle deeper than about 100 km seems to coincide with that of Jeffrey-Bullen; and the regional difference in the mantle's structure continues down to a considerable depth and includes the low-velocity layer. — V.S.N.

Lyustikh, Ye. N. On convection in the earth's mantle. See Geophys. Abs. 182-259.

182-365. David, E. Dynamische Kompressibilitätsmessungen für hohe Drücke [Dynamic compressibility measurements for high pressures (with English abstract)]: Zeitschr. Geophysik, v. 25, no. 5, p. 239-252, 1959.

The results of recent measurements of pressure, density, and energy content of shock waves can be extended to a general equation of state giving density as a function of pressure and temperature, from which conclusions can be drawn concerning the nature of the earth's interior. A transformation involving a density jump, shown by gabbro at 150 kilobars pressure, corresponds well with the seismically determined inhomogeneity between 400 and 700 km depth. On the other hand olivine does not show the expected transformation from tetrahedral to spinel form.

The density jump from about 5.6 g per  $\text{cm}^3$  to 9.9 g per  $\text{cm}^3$  at the core-mantle boundary at 2,900 km is much too great to be a phase transformation. The density of the outer core is about 1.3 g per  $\text{cm}^3$  lower than the density of nickel-iron at corresponding pressures and probable temperatures; therefore, other substances such as silicates must be dissolved in it.

The density jump between the outer and inner core could represent either a transition to pure nickel-iron or precipitation of all "impurities" as crystals, or a liquid-solid phase transition without unmixing. In either case secular displacement of the boundary is a possibility.

The limits for the absolute values of density in the interior are now fixed within about 1.5 g per  $\text{cm}^3$  for the inner core, 0.1 g per  $\text{cm}^3$  for the outer core, and 0.01 g per  $\text{cm}^3$  for the mantle. (See also Geophys. Abs. 181-322.)— D.B.V.

182-366. Strong, H. M. Melting temperatures of metals at very high pressures: Am. Scientist, v. 48, no. 1, p. 58-79, 1960.

Experimental evidence is reviewed to show how pressures influence the temperature at which phase transitions in metals occur, especially the transition of solid to liquid. Until recently, most measurements on transitions that occur at elevated temperatures were limited to pressures of the order of 10,000 atm. As a result, it was proposed that the melting curves would pass through a maximum in temperature and end at a solid-liquid critical point or continue to rise indefinitely. With the extension of several fusion curves to

one order of magnitude higher pressure, no solid-liquid critical temperature has yet been discovered. Only the fusion curve of rubidium appears to have a maximum. The fusion curve of germanium continues up to 160,000-180,000 atm without the appearance of a new solid phase with a rising fusion curve. It is now important to progress to another order of magnitude in order that the properties of matter exposed to conditions prevailing at the center of the earth may be explored. This should remove present uncertainties regarding the extrapolation of the melting point of iron and the physical properties of the substances composing the mantle. Direct experimental observations are needed to determine how fusion curves eventually terminate. — V. S. N.

- 182-367. Wada, Tatsuhiko. On the possibility of the metallic transition of MgO crystal at the boundary of the earth's core: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 31, 12 p., 1960.

Ramsey's hypothesis (see Geophys. Abs. 141-11985) that the density jump at the boundary of the earth's core is due to a phase transition under pressure and not to the appearance of a new material such as iron is applied to a model in which the D-layer and the core are composed of the molecular and the metallic phases of MgO, respectively. An approximation of the tight-binding method is employed to investigate the electronic band structure of an MgO crystal. Results show that the pressure-induced transition of MgO to the metallic phase occurs at a pressure of about  $1.2 \times 10^6$  bars, which is the pressure at a depth of about 2,600 km in the earth according to Bullen's table. In terms of the electronic band structure of an MgO crystal, these results mean that the energy gap between the conduction band and the valence band of a crystal disappears at  $r=1.87$  Å. At this point the valence electrons in the ordinary ionic state are made free, and the electronic band structure becomes metallic. A new model in which the electric conductivity increases abruptly in the deeper part of the D-layer and a transition from a molecular (or ionic) to a metallic phase occurs at the boundary of the earth's core with a large density jump is suggested. — V. S. N.

- 182-368. Wada, Tatsuhiko. An equation of state of periclase (MgO) and the D-layer [in Japanese with English abstract]: Zisin, v. 12, no. 4, p. 171-181, 1959.

This is virtually the same as the paper published in Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 31, 12 p., 1960 (see Geophys. Abs. 182-367). — V. S. N.

#### ISOTOPE GEOLOGY

- 182-369. Compston, W. The carbon isotopic compositions of certain invertebrates and coals from the Australian Permian: Geochim. et Cosmochim. Acta, v. 18, no. 1/2, p. 1-22, 1960.

Permian deviations of carbon-13 ( $\delta C^{13}$ ) are reported for Permian and Devonian brachiopods, Permian crinoids, and Permian coals from Australia; permil deviations of oxygen-18 ( $\delta O^{18}$ ) are also given for the marine invertebrates. Only the Permian brachiopods are isotopically preserved; their mean  $\delta C^{13}$  value is significantly more positive than that of Cretaceous and Recent brachiopods and mollusks measured elsewhere (Urey and others, see Geophys. Abs. 145-12778). If there are no appreciable generic effects in carbon isotopic fractionation within the brachiopods, it might be concluded that the sea water in which these specimens lived was isotopically heavier than at present;

this would indicate either an age effect, in which the entire Permian exchange reservoir was enriched in carbon-13 relative to the present, or a comparatively local effect not attained in recent seas. More work is necessary before an empirical age effect can be regarded as established.

A single coal seam was very constant in  $\delta\text{C}^{13}$ , and a trend toward values some 2.5 permil more negative from Lower to Upper Permian was observed for a sequence of seams. The Lower Permian coal  $\delta\text{C}^{13}$  was approximately the same as that for Upper Carboniferous coal measured elsewhere (Wickman, see Geophys. Abs. 154-14723). It is believed that the coal  $\delta\text{C}^{13}$  values represent the average isotopic composition of the original plant constituents. It is suggested that this trend may be due directly to the general climatic amelioration which reputedly occurred in Australia at this time. — D. B. V.

- 182-370. Skougaardt, M. W., and Horr, C. A. Occurrence of strontium in natural water: U.S. Geol. Survey Circ. 420, 6 p., 1960.

A survey was started in 1957 to determine the occurrence and distribution of stable strontium in natural waters of the United States because of the lack of data on the distribution and because of the current interest in nonradioactive strontium isotopes as possible diluents for the harmful, radioactive strontium-90 when ingested by animals and man.

Results of the survey show that the stable strontium content of surface water is low, less than 0.50 ppm, in the Pacific Northwest, in the Northeastern United States, and in the Central Lowlands; is moderate, 0.50-1.5 ppm, in the Southeastern United States, in most of the Great Plains region, in the Western Mountain and Plateau regions, and in California; and is relatively high in northern and western Texas and in southern New Mexico and Arizona. Exceptions to this distribution are due to local geologic conditions. — V. S. N.

- 182-371. Broecker, Wallace [S.]. Geochemistry of ocean water: Am. Geophys. Union Trans., v. 41, no. 2, p. 259-260, 1960.

During 1957-60 much attention was focused on the isotope geochemistry of the ocean. Progress in this and in other research on ocean chemistry is summarized briefly. — D. B. V.

- 182-372. Östlund, [H.] Göte. Isotopic composition of sulfur in precipitation and sea-water: Tellus, v. 11, no. 4, p. 478-480, 1959.

The  $\text{S}^{32}/\text{S}^{34}$  ratio and the sulfur content of 16 samples of snow, rainwater, lake water, and sea water from different parts of the world were measured in an attempt to determine the origin of airborne sulfur. The sulfur isotopic ratio in precipitation was found to be remarkably constant (22.15-22.26, mean 22.20) regardless of location, or season, or large differences in sulfur concentration. The average ratio for sea-water sulfate was 21.91; the ratio in the one lake-water sample was unexpectedly high, probably due to local geographic conditions.

It is concluded that sulfate sulfur in precipitation probably does not originate principally from ocean spray. Possible sources of airborne sulfur, in which the sulfur isotopic ratios are closer to the values observed in precipitation, are volcanic gases, industrial coal and petroleum, and biogenic hydrogen sulfide from marshes and swamps. Further work is necessary to determine which source is the most important. — D. B. V.

- 182-373. Singer, S. F. Production of tritium in nuclear spallations: Geochim. et Cosmochim. Acta, v. 19, no. 3, p. 216-217, 1960.

Production cross sections for tritium have been measured in cyclotron targets and have been quoted as 53, 62, and 130 millibarns. These are compared with values deduced from cosmic-ray bombardment of iron meteorites, where a direct tritium measurement leads to 280 millibarns, while  $\text{He}^3/\text{He}^4$  ratio measurements lead to at least 215 millibarns possibly as high as 410 millibarns. Hence, application of cyclotron cross sections may lead to too high values for the cosmic-ray ages of meteorites. — Author's abstract

Hoffman, J[ohn] H., and Nier, A[lfred] O. Cosmic-ray-produced helium in the Keen Mountain and Casas Grandes meteorites. See Geophys. Abs. 182-72.

Anders, E. The record in the meteorites-II. On the presence of aluminium-26 in meteorites and tektites. See Geophys. Abs. 182-66.

Schaeffer, O[liver] A., and Zähringer, J. Helium and argon production in iron targets by high-energy protons. See Geophys. Abs. 182-69.

#### MAGNETIC FIELD OF THE EARTH

182-374. Cole, K. D. Solar terrestrial relationships: Nature, v. 186, no. 4728, p. 874, 1960.

Considerable evidence exists in favor of much lower proton densities in interplanetary space than commonly assumed. If this density is as low as 1 proton per  $\text{cm}^3$  and the resident magnetic field is of the order of  $10^{-4}$  gauss, hydromagnetic waves may be propagated from sun to earth all the time. Some such constant source of energy is required to explain the quasi-permanence of magnetic disturbance and auroras in high latitudes.

The earth would present a large capture cross section to these waves. Moreover, these waves can cause corpuscular bombardment of the atmosphere. In this way energy could be transmitted from sun to earth without actual transit of particles. Assuming a perturbation magnetic field of a few gammas in interplanetary space, Alfvén speed of  $10^8$  cm per sec, and a capture cross section of 10 earth diameters, the rate of delivery of energy to the earth would be  $10^{18}$  ergs per sec. This is adequate to explain magnetic disturbance. — D. B. V.

182-375. Valle, P[aolo] E[milio]. Sulla dispersione anomale delle onde magneto-idrodinamiche [On the abnormal dispersion of magneto-hydromagnetic waves (with English abstract)]: Annali Geofisica, v. 12, no. 3, p. 377-387, 1959.

The effect of anomalous dispersion on the propagation of magnetohydromagnetic waves is treated mathematically. It is shown that the phase velocity of such waves may be considerably higher than that envisaged by Alfvén. — D. B. V.

182-376. Kolbenheyer, Tibor. Über gewisse Integralmittelwerte der magnetischen Induktion im Erdinnern [On certain integral mean values of magnetic induction in the earth's interior (with Russian summary)]: Československá Akad. Věd Studia Geophys. et Geod., v. 3, no. 4, p. 369-375, 1959.

It is shown that the integral mean values of the vector of magnetic induction in the earth's interior can be calculated on the basis of the distribution of the vertical component of geomagnetic intensity at the surface and the known pro-

perties of this vector, both from the equation for this component in the direction of the polar axis and from similar equations for the components in the direction of any two mutually perpendicular equatorial axes. If the weak external field is neglected the mean value of the vector  $\vec{B}$  is proportional to the magnetic moment of the solid earth, and the calculation can be simplified.

Similarly, the integral mean value of some expressions in which there enter the rectangular coordinates  $x$ ,  $y$ , and  $z$  of points in the interior, and consequently  $B_x$ ,  $B_y$ , and  $B_z$ , can also be calculated. Equations suitable for several linear combinations are given. — D. B. V.

- 182-377. Fukushima, Naoshi. Three-dimensional consideration for current-system of geomagnetic variations (I). Current flow for polar elementary storm within a spherical conducting shell-pt. 1: [Japan] Rept. Ionosphere Research, v. 12, no. 4, p. 437-447, 1958; reprinted in Tokyo Univ. Geophys. Inst. Geophys. Notes, v. 12, no. 1, contr. no. 5, 1959.

For the study of current system for geomagnetic variations, the three-dimensional consideration of current distribution in the ionosphere is desirable. As a first step the current distribution in a stationary state produced by an electric dipole in a conducting shell bounded by two concentric spherical surfaces is considered, which may correspond to the case of a polar elementary storm. The result shows that the effect of the distribution of electrostatic charges at the boundary surfaces makes the electric current flow nearly along the spherical surfaces almost everywhere within the conducting shell except near the dipole, and a two-dimensional calculation hitherto made is approximately applicable. — Author's abstract

- 182-378. Nelson, J. H. General geomagnetism: Am. Geophys. Union Trans., v. 41, no. 2, p. 221-223, 1960.  
Knapp, David G. Bibliography on general geomagnetism: *ibid*, p. 223-226, 1960.

The general geomagnetic program of the United States during 1957-60 has been carried on by a number of agencies and organizations. The largest single element of the program was the International Geophysical Year, followed by International Geophysical Cooperation-1959. The work of the latter consisted of operation of the Guam Magnetic Observatory as a permanent installation and the continuation of 7 permanent observatories (Fredericksburg, Va.; Tucson, Ariz.; San Juan, P. R.; Sitka, College, and Barrow, Alaska; and Honolulu, Hawaii); continuation of Wilkes and Hallett stations in Antarctica in cooperation with Australia and New Zealand, respectively, and over snow traverse measurements in Antarctica.

The U. S. Navy Hydrographic Office announced Project MAGNET, a plan for an extensive airborne magnetic survey of most of the ocean areas of the world. Numerous geomagnetic measurements were made from rockets in Arctic, equatorial, and Antarctic regions. The U. S. Geological Survey flew 150,000 traverse miles of airborne magnetic surveys in the United States, including Alaska, and it is estimated that private companies flew more than a million traverse miles throughout the world.

New developments include the use of electronic computers for data processing; new exploration techniques, especially airborne; the AFMAG instrument; and the rubidium-vapor magnetometer. Interest in paleomagnetism has increased.

The bibliography compiled by Knapp is essentially a part of Nelson's report. It includes 97 entries, representing the more important contributions to the literature originating in the United States. — D. B. V.

- 182-379. Kautzleben, H. Über das geomagnetische Normalfeld nach Fanselau [On the geomagnetic normal field according to Fanselau (with English summary)]: Zeitschr. Geophysik, v. 25, no. 3, p. 143-157, 1959.

Fanselau's suggestion (see Geophys. Abs. 174-249) concerning the derivation of a normal field from potential calculations is considered from the point of view of four conditions to be fulfilled by a normal field. The principal advantage of this method cannot be realized in the present state of the analytical description of the earth's field. To facilitate the numerical analysis, nomograms were constructed for the territory of East Germany for determining the whole system of the elements X, Y, Z, H, T, D, and J; the entire range of these variables is covered. Examples are given of normal fields for East Germany, Northeastern United States, and Tibet, derived from the potential calculations of the Potsdam Geomagnetic Institute for epoch 1945.0. — Author's summary, D. B. V.

- 182-380. Bucha, Václav, and Kočí, Alois. Ubyazka osnovnykh geomagnitnykh setey CSR i PNR [Tying of the geomagnetic base networks of Czechoslovakia and Poland (with Czech and English summaries)]: Československá Akad. Věd Geofys. Sborník, no. 90, p. 263-275, 1958.

The base networks of the horizontal and vertical geomagnetic components were linked between Czechoslovakia and Poland in 1957 as a contribution to the world adjustment of geomagnetic networks. Measurements of both components were carried out simultaneously in both countries with QHM and BMZ instruments and a knife-edge and torsion fiber balance, at 23 stations fairly evenly distributed along the frontiers. Each station is described briefly.

The measurements were reduced according to the readings of the Průhonice, Hurbanova, and Šwider observatories. Results, reduced to epoch 1957.0, are given in two tables. — D. B. V.

- 182-381. Boushka, Ya., Bucha, V[áclav], and Kočí, A[lois]. Geomagnitnyye karty Chekhoslovakii dlya epokhi 1958,0 [Geomagnetic maps of Czechoslovakia for epoch 1958.0]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 798-808, 1960.

The 1946-53 geomagnetic survey of Czechoslovakia resulted in a new geomagnetic network of the first order for the territory surveyed; it is presented in 7 geomagnetic maps at a scale of 1:1,250,000 referred to epoch 1958.0. The secular variation of the geomagnetic field in Czechoslovakia is given for the period of 1948-58. — A. J. S.

Schmucker, Ulrich. Geomagnetic deep sounding in Germany in 1957-59—magnetograms and preliminary interpretation. See Geophys. Abs. 182-82.

- 182-382. Kopecký, Miloslav. Note on secular variation of characteristics of external magnetic field of earth [with Russian summary]: Československá Akad. Věd Studia Geophys. et Geod., v. 4, no. 1, p. 94-96, 1960.

Analysis of the daily variation of declination ( $\Delta D$ ) at Greenwich and of the U-index leads to the conclusion that secular variations of these characteristics of the external geomagnetic field are caused by the 80-year period of solar activity. — D. B. V.

- 182-383. Alaska University. High latitude geophysical data for July 1959: Alaska Univ. Geophys. Inst., UAG-C 1, 13 p., 1959.

This is the first in a continuing series of publications that present in tables current geophysical data related to polar ionospheric activity. The methods used for recording the data are described in sufficient detail to assure correct interpretation and the text is repeated every three issues or whenever changes are made in procedures. Supplementary issues summarize data for 6-month periods, the most recent of which (UAG-C7 May, 1960) summarizes earth current amplitude activity and rapid fluctuations, College K-indices, whole-day character, and equivalent daily amplitudes for January through June, 1959. — V. S. N.

- 182-384. Hutton, Rosemary. Regular micropulsations of the earth's field at the equator: *Nature*, v. 186, no. 4729, p. 955-956, 1960.

Analysis of earth current records obtained at Legon, Ghana, indicated that regular pulsations (pc) of earth currents occur during the night as well as during the day at this station; in fact, the maximum frequency of occurrence was at about 18<sup>h</sup>-20<sup>h</sup> Gmt. More recently, analysis of magnetic records of dH/dt at the same station shows a similar nighttime occurrence of regular pulsations in addition to the normally expected daytime occurrences.

Graphs of the telluric and magnetic pulsations during May, June, and July 1958 show three maximums, at 6<sup>h</sup>, 12<sup>h</sup>, and 20<sup>h</sup>; in each case the nighttime maximum is the greatest. Comparison with records obtained at Tamanrasset, Algeria, shows that frequency of occurrence of regular pulsations at night is greater at Legon, and that for quiet days in the interval 0<sup>h</sup>-14<sup>h</sup> the frequency of occurrence of regular pulsations is almost the same at both stations. — D. B. V.

- 182-385. Onwumechilli, A. Fluctuations in the geomagnetic horizontal field near the magnetic equator: *Jour. Atmos. Terrest. Physics*, v. 17, no. 4, p. 286-294, 1960.

Analysis of 600 fluctuations in the geomagnetic horizontal component (H) and vertical component (Z) recorded at Ibadan, Nigeria, in April and May 1958 shows that (1) the frequency of occurrence varies with local time in the same way as Sq; (2) the amplitude of fluctuations increases in a general way with Sq; (3) the amplitude of fluctuations in both H and Z tends to increase linearly with period (T), with some evidence of a decrease in slope at T=33 min; (4) fluctuations under quiet conditions occur mostly in the daytime and are most frequent when Sq is high; and (5) nighttime fluctuations are of long duration and occur mostly during disturbance of ( $K_p > 3+$ ) type. Fluctuations under quiet conditions have the characteristics of solar flare effects; it is suggested that both arise from similar causes. — D. B. V.

- 182-386. Onwumechilli, C. A., and Alexander, N. S. Variations in the geomagnetic field at Ibadan, Nigeria—I. Solar variations: *Jour. Atmos. Terrest. Physics*, v. 16, no. 1/2, p. 106-114, 1959.

Onwumechilli, C. A., and Alexander, N. S. Variations in the geomagnetic field at Ibadan, Nigeria—II. Lunar and luni-solar variations in H and Z: *ibid.*, v. 16, no. 1/2, p. 115-123, 1959.

Records of the magnetic observatory at Ibadan in equatorial Africa from November 1955 to June 1957 have been analyzed harmonically for solar, lunar, and luni-solar variations. The amplitude of solar variation of H is very large

(similar to that observed at Huancayo); that of Z is larger by a factor of 3 than any previously reported; and that of D is small but has its phase completely reversed between the June and December solstices. The solar variations in H and Z are explained as the result of the equatorial electrojet; the D-variation shows no obvious effect of the electrojet.

The lunar variations in H and Z are abnormally large. That of H is comparable to that at Huancayo and about 3 times greater than at other observatories of comparable geographic latitude; that in Z is larger than any previously reported. These results are also explained as the effect of the equatorial electrojet. The ratio of solar to lunar variations in H is small, as at Huancayo; this ratio in Z is equally small. The Chapman expression for L, derived from dynamo theory, is fully confirmed in all aspects. — D. B. V.

- 182-387. Benoit, Réné, and The Hien, Tran. Étude du champ géomagnétique dans la bande 5-50 c/s [Study of the geomagnetic field in the 5-50 cps band]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 5, p. 893-895, 1960.

The geomagnetic measurements reported in this paper were made at Saigon, under very different climatic conditions from earlier measurements made at Beni-Abbès (Algeria), for the purpose of clarifying some aspects of the problem of rapid micropulsations. The 5-50 cycles per second band was used to avoid interference of industrial origin. The apparatus is described briefly, and typical results presented graphically. A relationship between the low-frequency signals and local meteorologic disturbances is evident. — D. B. V.

- 182-388. Kazmi, S. A. A. On the geomagnetic Sq-variation of horizontal force in middle latitudes: Geophysica [Helsinki], v. 7, no. 1, p. 31-42, 1959.

The quiet-day diurnal variation of horizontal force at 12 observatories near middle latitudes is analyzed for the time of sunspot minimum. The longitudinal influence on the Sq field is much more pronounced than was expected. The center of the current vortex of the Sq field is found to lie between  $\pm 30^\circ$  and  $\pm 35^\circ$  in the Eastern Hemisphere and moves approximately parallel to the magnetic equator during its 24 hour passage round the earth; lines of equal Sq variation in middle latitudes are believed to run parallel to this track. The seasonal upward and downward shift of the current vortex follows a pattern relative to the seasonal latitudinal movement of the sun. The center reaches its extreme southward position in the Northern Hemisphere in September and its extreme northward position in the Southern Hemisphere in March, not at local solstice.

The activity of the Sq field in middle latitudes on either side of the center of the current vortex seems to be predominant during the Equinoxes but it is not symmetrical during the two seasons, that is, spring activity is considerably different from autumn activity. — V. S. N.

- Garland, G. D. Magnetic disturbances and electric logging. See Geophys. Abs. 182-198.

- 182-389. Campbell, Wallace H. Magnetic micropulsations accompanying meteor activity: Jour. Geophys. Research, v. 65, no. 8, p. 2241-2245, 1960.

Increased activity of magnetic micropulsations with periods of 5 to 30 seconds and magnetic flux densities of 20 to 320 m $\gamma$  was found to accompany the  $\eta$  Aquarid,  $\delta$  Aquarid, and Perseid meteor showers in 1958. Conflicting reports are discussed. It is concluded that there is good reason to believe that

ultra-low frequency magnetic effects of meteors have been observed. Further observations may be of value not only for the study of meteors but also for an understanding of the physical processes giving rise to magnetic micro-pulsations. — D. B. V.

- 182-390. Singer, S. F. Geophysical effects of solar corpuscular radiation: *Jour. Atmos. Terrest. Physics*, v. 15, no. 1/2, p. 48-50, 1959.

A magnetohydrodynamic model gives a natural explanation of the geophysical effects produced by emission of solar gas with high velocity, including SC\*. — D. B. V.

- 182-391. Halenka, Jaroslav, and Pěčová, Jana. Beitrag zur Frage des Zusammenhanges der Pulsationen des elektromagnetischen Feldes der Erde und der Sonnentätigkeit [Contribution to the problem of the relation of the pulsations of the electromagnetic field of the earth and solar activity (with Russian summary)]: *Československá Akad. Věd Studia Geophys. et Geod.*, v. 4, no. 1, p. 42-51, 1960.

Analysis of geomagnetic pulsations of the pc and pt type and sunspot activity leads to the conclusion that the appearance of pc and pt type pulsations depends exclusively on geomagnetic and solar activity; eruptive activity on the sun favors the appearance of the pc type, whereas the presence of filaments outside the floccular field favors the appearance of the pt type.

It is further concluded that analysis of more abundant material might clarify the nature of these relationships. — D. B. V.

- 182-392. Bednářová-Nováková, Bohumila. Solnechnye volokna-protuberantsy i ikh svyaz' s geomagnitnymi buryami [Solar filaments and their relation to geomagnetic activity (with French summary)]: *Československá Akad. Věd. Studia Geophys. et Geod.*, v. 4, no. 1, p. 52-58, 1960.

The relation between "free filaments" on the sun and recurrent geomagnetic storms has been investigated for the period April 1952-February 1954. The passage of free filaments across the central meridian of the sun may precede magnetic storms, depending on the surroundings of the filament, on its isolation, and on whether there is another electromagnetic field in the space between the filament and the solar equator. According to the diagrams of H. W. and H. D. Babcock, the passage of these filaments across the central meridian coincides with the passage of UM regions. — D. B. V.

- 182-393. Mariani, F., and Molina, F. Perturbazioni geomagnetiche, aurorali, ionosferiche e dei raggi cosmici: interdipendenze e relazioni con l'attività solare [Geomagnetic, auroral, ionospheric and cosmic ray disturbances: interdependences and relations with solar activity (with English abstract)]: *Annali Geofisica*, v. 12, no. 3, p. 297-368, 1959.

This is the first chapter of part 1 of a very comprehensive review of all the phenomena that are caused by or influenced by solar events and thus may be regarded as different terrestrial effects of a more general, single electromagnetic disturbance on the sun.

This chapter concerns magnetic storms. The morphology of geomagnetic storms is discussed. The two components of the perturbation field,  $D_{st}$  and  $S_D$ , are described in terms of electric current systems flowing in the ionosphere, and the meaning of  $S_D$  is illustrated. Sudden commencements and their geographic distribution and diurnal variation are described briefly. Finally, the correlation between magnetic storms and solar activity is treated. — D. B. V.

- 182-394. Mariani, F., and Molina, F. Perturbazioni geomagnetiche, aurorali, ionosferiche e dei raggi cosmici: interdipendenze e relazioni con l'attività solare, Parte 1 - 2. L'aurora polare [Geomagnetic, auroral, ionospheric and cosmic ray disturbances: interdependences and relations with solar activity, Part 1 - 2. The polar aurora (with English abstract)]: Annali Geofisica, v. 12, no. 3, p. 389-435, 1959.

The second chapter of part 1 of this paper (see also Geophys. Abs. 182-393) is a detailed discussion of the visual appearance, geographic distribution, and time variations of polar auroras, the physical structure of their spectra, their causes, and their correlation with solar and geomagnetic activity. — D. B. V.

- 182-395. Bachelet, F., Balata, P., Conforto, A. M., and Marini, G. Cosmic ray and geomagnetic disturbances from July 1957 to July 1958. Pt. 1—The cosmic ray events and their correlation with the geomagnetic events: Nuovo Cimento, v. 16, no. 2, p. 292-319; Pt. 2—The geomagnetic events: ibid., p. 320-331, 1960.

In the first part of the work, the relations between cosmic-ray storms (CRS) and magnetic storms (MS) were investigated systematically for the period July 1957 to July 1958. For some aspects of the problem a statistical approach was used.

The time-correlation of CRS → MS is particularly high (21 out of 24) but the correlation of MS → CRS is not as close (21 out of 71). It seems important if not determinant for the association of a magnetic storm with a true cosmic-ray storm that the magnetic storm be "free"—that is, it does not start while a cosmic-ray storm is in progress. The worldwide sudden commencement of a magnetic storm seems to favor the association with a cosmic-ray storm. Neither the range of the magnetic event nor its degree of small time-scale disturbance ( $a_p$  or  $K_p$ ) play an important part in the association. In general the magnetic storm precedes an associated cosmic ray storm by a very short interval.

The second part of the work identifies and classifies the 72 worldwide magnetic storms that occurred in the period studied in order to determine what characteristics systematically appear in those associated with cosmic-ray storms. The magnetic storms are divided into 5 groups,  $\bar{A}$ ,  $\bar{B}$ ,  $\bar{C}$ , A, and  $\bar{C}$ .  $\bar{A}$ ,  $\bar{B}$ , and  $\bar{C}$  have sudden commencements and A and C do not; these are further differentiated on the basis of the behavior of the H field. Results of the analysis are listed in tables giving data, onset time, type, deviation, and a valuation of importance. The order of importance appears to be  $\bar{A}$  (maximum, A,  $\bar{C}$ , C, and  $\bar{B}$  (minimum). — D. B. V.

- 182-396. Matsushita, S. Geomagnetic and geoelectric variations: Am. Geophys. Union Trans., v. 41, no. 2, p. 226-229, 1960.

Results of recent observation of magnetic storms and variations and of the magnetic effects of high altitude nuclear explosions are reported. Rocket, satellite, and balloon measurements of the upper atmospheric phenomena are al-

so summarized. Developments in theories of the origin of magnetic storms and other features of the geomagnetic field are outlined. A bibliography of 45 items is given. — D. B. V.

- 182-397. Maeda, H[iroshi], and Yamamoto, M. A note on daytime enhancement of the amplitude of geomagnetic-storm sudden commencements in the equatorial region: *Jour. Geophys. Research*, v. 65, no. 8, p. 2538-2539, 1960.

Data on 50 SC's recorded during the International Geophysical Year at 11 equatorial stations other than Huancayo, Peru, have been analyzed in order to determine whether the daytime enhancements noted at Huancayo were also seen at the other stations. It was found that the daytime enhancement occurs at stations less than about  $20^{\circ}$  in dip, and that an abnormally large amplitude appears at stations very close to the dip equator (within about  $3^{\circ}$ ). No appreciable diurnal variation is seen at stations higher than  $20^{\circ}$  in dip, and the magnitude of SC's at night is almost the same for all equatorial stations.

These results suggest that the sudden commencement of geomagnetic storms consists of two parts, one of atmospheric and the other of outer-atmospheric origin. The separation of the two parts may be possible by using nighttime values of SC's. Detailed studies are in progress. — D. B. V.

- 182-398. Srinivasamurthy, B. The diurnal variation of sizes of sudden commencements and impulses in the Kodaikanal magnetograms: *Indian Jour. Meteorology and Geophysics*, v. 11, no. 1, p. 64-68, 1960.

Combined data of 398 sudden commencements (SC's) and sudden impulses (SI's) recorded at Kodaikanal, India, during 1949-57 have been analyzed in order to study the relationship between the diurnal variation (DV) in amplitudes of the impulses and the DV in the horizontal component of the geomagnetic field (Sq variations in H). A correlation between day-time SC amplitudes and the range of DV in H at Kodaikanal is established beyond doubt. The enhancement, however, is small compared to that found at Huancayo, Peru, by Forbush and Vestine (1955). The two phenomena may have the same source, possibly currents flowing in the E-region of the ionosphere; the enhancement in both cases may be due to the locally enhanced conductivity of the E-region near the geomagnetic equator. — D. B. V.

- 182-399. Kato, Yoshio; Saito, Takao; and Kondo, Minoru. Geomagnetic rapid variations observed at the Onagawa Magnetic Observatory during the International Geophysical Year, pt. 1: *Tohoku Univ. Sci. Repts., ser. 5*, v. 11, supp., 49 p., 1960.

This is a compilation of data on geomagnetic rapid variations observed at the Onagawa observatory in Japan during the period from July 1 to December 1, 1957. The 6 tables list data on sudden commencements and bays, solar flare effects, pt pulsations, occurrence frequency of individual series of pt, pc pulsations, and duration of pc and stormtime pulsations. Photographs and diagrams of the physical plant and instrumentation of the observatory are given and 49 magnetograms are reproduced. — D. B. V.

- 182-400. Chinburg, Dale L. Great magnetic storm of March 31-April 3, 1960: *Jour. Geophys. Research*, v. 65, no. 7, p. 2206-2208, 1960.

Measurements of the scalar magnitude of the geomagnetic field vector F during the geomagnetic storm of March 31-April 3, 1960, made at 1-minute intervals with the proton precession magnetometer at the State University of Iowa, are summarized in four graphs. — D. B. V.

- 182-401. Cecchini, André; Dupouy, Georges; Roquet, Juliette; and Selzer, Édouard. Mise en évidence au moyen du "concentrateur-magnétophone" de l'Observatoire de Chambon-la-Forêt, de signaux magnétiques précurseurs, lors des orages du 11 fevrier 1958 et du 16 août 1959 [Detection of precursory magnetic signals at the time of the storms of February 11, 1958, and August 16, 1959, by means of the "magnetophone concentrator" of the Chambon-la-Forêt Observatory]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 24, p. 4023-4025, 1960.

A variometer of "magnetophone concentrator" type has been developed at the Chambon-la-Forêt magnetic observatory in France to record geomagnetic variations directly on a magnetophone band without intermediate electrical devices. The apparatus is described very briefly.

Results obtained for two worldwide magnetic storms with sudden commencements reveal precursory signals never before detected. Thirty hours before the beginning of the storm of February 11, 1958, there was an increase in level in frequencies between 220 and 1,100 cycles per second. Large chromospheric eruptions were observed February 8-12. About 20 hours before the storm of August 16, 1959, a similar increase was noted in the 440-1,100 cycles per second range and was particularly marked around 500 cycles per second. This was followed shortly by a new increase in the 800-1,000 cycles per second range, and finally a general reinforcement of all frequencies below 900 cycles per second began about 6 hours before the sudden commencement. Chromospheric eruptions were observed during August 10-14, 1959. — D. B. V.

- 182-402. Miguel [y Gonzales Miranda], Luis de. Bobina de inducción para el estudio de las variaciones rápidas del campo magnético terrestre [Induction coil for the study of the rapid variations of the geomagnetic field (with English summary)]: Rev. Geofísica, v. 18, no. 72, p. 339-355, 1959.

A new induction coil developed at the geophysical observatory in Toledo, Spain, for the study of rapid geomagnetic variations is described. The coil can detect pulsations of less than 1 minute that are also shown in earth currents; this proves that earth currents are induced by geomagnetic variations.

On the other hand the slower variations such as bays are not detected by the coil, although they are reflected in earth currents. The larger and more rapid the pulsation accompanying it, the more intense the bay appears. It is concluded that earth currents are not due entirely to induction. The slower variations might owe their origin to the accumulation of charges at a given instant and point, made possible by the large capacitance and volume of the earth. — D. B. V.

#### MAGNETIC PROPERTIES AND PALEOMAGNETISM

- 182-403. Stacey, F. D. Magnetic anisotropy of igneous rocks: Jour. Geophys. Research, v. 65, no. 8, p. 2429-2442, 1960.

A torque-meter method of measuring the magnetic anisotropy of rocks has been used in a study of a 1,050-foot bore core from a Tasmanian dolerite sill.

Each cylindrical specimen was suspended in a uniform field of 10.6 kilo-oersteds perpendicular to its axis, and the torque  $T$  exerted on it was measured at  $10^\circ$  intervals of the angle  $\theta$  between a mark on the specimen and the direction of the field. Fourier analyses of the torque curves  $T(\theta)$  yielded terms in  $\sin 2\theta$  and  $\sin 4\theta$ , of which the first was due principally to shape alinement of the magnetic grains and the second to alinement of cubic crystallographic axes. The anisotropy of the bore core was found to be due to a slight but regular alinement of grain elongations with no regular alinement of crystallographic axes. Superimposed upon the pattern of anisotropy, statistical deviations from isotropy were observed in individual rock samples owing to the finite numbers of magnetic grains which they contained. The statistical effects were used to confirm the interpretation of the Fourier components of the torque curves and to estimate the mean elongation of the magnetic grains.

If the criterion of acceptability of a rock for paleomagnetic work is taken to be a maximum possible anisotropic deflection of remanent magnetism of  $3^\circ$ , then it is required that its anisotropy be less than 10 percent. Equations are given expressing this criterion in terms of susceptibility anisotropy as well as torque-meter measurements. The anisotropy of the bore core, as well as of a few specimens of basalt and porphyry, is much too small to have influenced the paleomagnetic work which has been carried out on these rocks. —

Author's abstract

- 182-404. Fuller, M. C. Anisotropy of susceptibility and the natural remanent magnetization of some Welsh slates: *Nature*, v. 186, no. 4727, p. 791-792, 1960.

To investigate the effect of the deformation associated with mountain building on the anisotropy of susceptibility and the natural remanent magnetization of rocks, about 100 specimens were prepared for measurement from some 50 samples of Lower Paleozoic slates from Wales that developed cleavage during the Caledonian orogeny. The anisotropy in fields of less than 2 oersteds was determined with a transformer bridge and the remanent magnetization with an astatic magnetometer.

The results show that the cleavage is a plane of high susceptibility and that the remanent vector is parallel to it. In some of the slates the direction of remanent magnetization appears to have been controlled by the anisotropic susceptibility, and in others the pattern of anisotropy and the remanent magnetization have been alined with the cleavage independently.

It is concluded that the pattern of anisotropy and the remanent magnetization were determined either directly or indirectly by the stress environment during metamorphism. — D. B. V.

- 182-405. Rao, B. S. R., and Bhimasankaram, V. L. S. Studies on magnetic properties in relation to magnetic prospecting of the Kodur manganese belt, pt. 1: India Natl. Inst. Sci. Bull., no. 11, p. 32, 1958; Magnetic properties of manganese ores, pt. 2: India Natl. Inst. Sci. Proc., v. 26, pt. A, no. 1, p. 16-30, 1960.

In part 1 of this paper the results from the field study of the vertical magnetic field of the Kodur manganese belt are presented. Some ore bodies produce high positive and negative anomalies whereas other large deposits produce little or no magnetic anomalies; furthermore, both types of results are obtained over manganese ore deposits containing similar percentages of manganese and iron. In view of these anomalous observations, an extensive study of the magnetic properties of ore samples from these deposits was begun. In part 2 the various techniques employed in the measurement of magnetic properties and some of the results obtained are discussed.

An apparatus was designed to measure susceptibilities in the earth's field and their variation with field strength up to 50 oersteds; another apparatus covered the range from 50 to 250 oersteds; and a third apparatus was designed to study hysteresis properties of manganese ores between field strengths of 250 and 1,000 oersteds. Most of the 37 specimens tested possess high remanence and coercivity showing that manganese ores are susceptible to high permanent magnetism. All the samples exhibit ferromagnetism possibly due to a single ferromagnetic mineral. The nature of the ferromagnetic mineral present and the correlation of laboratory with field data will be presented in part 3. — V. S. N.

Neumann, W. New investigations of the irregular geomagnetic anomalies near Berggiesshübel in Saxony. See Geophys. Abs. 182-425.

182-406. Cox, Allan, and Doel, Richard R. Review of paleomagnetism: Geol. Soc. America Bull., v. 71, no. 6, p. 645-768, 1960.

This review is an attempt to bring together and discuss relevant information concerning the magnetization of rocks, especially that having paleomagnetic significance. All paleomagnetic measurements available to the authors are here compiled and evaluated, with a key to the summary table and illustrations in English and Russian. The principles upon which the evaluation of paleomagnetic measurements is based are summarized, with special emphasis on statistical methods and on the evidence and tests for magnetic stability and paleomagnetic applicability.

Evaluation of the data summarized leads to the following general conclusions:

1. The earth's average magnetic field, throughout Oligocene to Recent time, has very closely approximated that due to a dipole at the center of the earth oriented parallel to the present axis of rotation.
2. Paleomagnetic results for the Mesozoic and early Tertiary might be explained more plausibly by a relatively rapidly changing magnetic field, with or without wandering of the rotational pole, than by large-scale continental drift.
3. The Carboniferous and especially the Permian magnetic fields were relatively very "steady" and were vastly different from the present configuration of the field.
4. The Precambrian magnetic field was different from the present field configuration and, considering the time spanned, was remarkably consistent for all continents. — Authors' abstract

182-407. Stott, P. M., and Stacey, F. D. Magnetostriction and paleomagnetism of igneous rocks: Jour. Geophys. Research, v. 65, no. 8, p. 2419-2424, 1960.

Disk specimens from a number of igneous rock specimens were cooled from temperatures above the Curie points of their magnetic minerals under directed stresses of 500 and 1,000 kg per cm<sup>2</sup>. In all cases the thermoremanent magnetizations measured after unloading coincided with the direction of the earth's field to which they were exposed during cooling, which was either at 66° or 46° to the axis of compression. A duplicate set of specimens given the same heat treatment but without the stress was magnetized in the same direction. The scatter of measured directions was the same for both sets, showing that any magnetostrictive deflections of magnetization must have been less than the experimental error of about 3 percent.

Another set of specimens was given isothermal remanent magnetization by exposure to a field of 140 oersteds at an angle of 49° to the axis of directed stress; these as well as a duplicate set of unstressed specimens were also magnetized in the direction of the inducing field.

These results show that the application of directed stresses up to 1,000 kg per cm<sup>2</sup> during magnetization of igneous rocks does not deflect their magnetic moments. The same result was obtained with a rock in which the magnetic mineral was changed by heating in air while under directed stress. It is concluded that the natural magnetic moments of isotropic igneous rocks are not normally deflected by magnetostrictive effects. — D. B. V.

- 182-408. Kruglyakova, G. I., and Kruglyakov, V. V. Vliyaniye karaktera dvizheniya lavy na obrazovaniye ostatochnoy namagnichennosti gornykh porod [The effect of the character of the movement of lava on the formation of remanent magnetism in rocks]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 158-160, 1960.

The magnitude and direction of remanent magnetization vectors in extrusive rocks are studied with respect to the movement, viscosity, composition, and temperature of the lava, in addition to the topography of the area of extrusion. Magnetization of ferromagnetic elements takes place when the lava loses its mobility prior to its cooling to the Curie point. The magnetization of the lava under such conditions will be oriented in the direction of the earth's magnetic field regardless of the direction in which the lava flowed. If, however, the lava ceases its movement at a temperature lower than the Curie point temperature, then the direction of magnetization of the rock formed will depend on the direction in which the lava flowed and on the characteristics of the flow (laminar, turbulent). The crystals will have been already magnetized and will be oriented according to the direction of the flow or character of the turbulence. In case of a laminar flow, the magnitude of the remanent magnetization vector will correspond to the intensity of the earth's magnetic field at the time of magnetization, but the vector's direction may be different from the earth's magnetic field direction of the time. In case of a turbulent motion, the orientation of magnetic elements in the solidified lava will have a random character. — A. J. S.

- 182-409. Kawai, Naoto; Ito, Haruaki; Yasukawa, Katsumi; and Kume, Shiochi. Chemical-pressure remanent magnetism in sedimentary and metamorphic rocks: Kyoto Univ. Coll. Sci. Mem., ser. B, v. 26, no. 2, p. 235-239, 1959.

An experimental study was made of the effect of dehydration upon the remanent magnetism of goethite and lepidocrocite under vertical pressure. Magnetization was produced by a chemical reaction in which ferrous hydroxide was transformed to  $\alpha$ - and  $\gamma$ -hematites. The remanent magnetism produced has a large component perpendicular to the direction of pressure, and shows a great deviation in direction from that of an applied field. In horizontal sediments, vertical pressure due to the gravity load of overlying strata may act as a "uniaxial" pressure and, where rock samples contain hematites derived from dehydration of ferrous hydroxide, this uniaxial pressure should be taken into account in the interpretation of paleomagnetic data. — V. S. N.

- 182-410. Baldwin, Brewster, and Muehlberger, William R. Paleomagnetism, in Geologic studies of Union County, New Mexico: New Mexico Bur. Mines and Mineral Resources Bull. 63, p. 143-145, 1959.

In an earlier study (see Geophys. Abs. 174-281) of the paleomagnetism of the undifferentiated Clayton basalts of Union County, New Mexico, highly inconsistent results were obtained. These are possibly explainable on the ba-

sis of the presence of ilmenitic magnetite which may self-reverse during cooling. Results of recent paleomagnetic studies of the Apache and Seneca flows (part of the undifferentiated Clayton) in eastern Union County are in direct contrast to the earlier results; practically all samples taken from these two flows show intense reverse magnetization. A careful study to determine the reason for the inconsistency in magnetization direction in these basalts should aid in making paleomagnetism a useful tool in stratigraphic correlation and subdivision. — V. S. N.

- 182-411. Wilson, R. L. Remanent magnetism of Late Secondary and Early Tertiary British rocks: *Philos. Mag.*, v. 4, no. 42, p. 750-755, 1959.

The results of paleomagnetic measurements are given for the Tertiary basalts of northeast Ireland and for Cretaceous sediments in the south of England. The results for the basalts are reasonably consistent; all show reversed magnetization and indicate a deviation from the present earth's field of about  $8.4^\circ$  toward shallower inclinations. Assuming that the axis of the magnetic dipole field coincides roughly with the axis of rotation, this would indicate that Ireland has moved northward about  $11.5^\circ$  of latitude, or about 800 miles, since the eruption of the basalts.

The study shows that the results for the Cretaceous sediments are less likely to be reliable. They also indicate a shallower dip than that of the present dipole field. A simple and reliable statistical treatment is developed for evaluating paleomagnetic results. — D. B. V.

- 182-412. Roche, Alexandre. Sur l'aimantation de laves miocènes d'Auvergne [On the magnetization of the Miocene lavas of the Auvergne]: *Acad. Sci. [Paris] Comptes Rendus*, v. 250, no. 2, p. 377-379, 1960.

The direction of remanent magnetization was measured on three Upper Miocene basalt flows from the Cantal and two from the Limagne in the Auvergne, France. Those from the Cantal are normally magnetized, those from the Limagne inversely. The pole positions calculated from the mean directions are lat  $57^\circ$  N.; long  $119^\circ$  W. for the Cantal rocks, and lat  $57^\circ$  N.;  $133^\circ$  W. for those from the Limagne.

Nagata's results for rocks of similar age in Japan (see Geophys. Abs. 180-290) are discussed. Roche concludes that there is no necessity for invoking continental drift; departure of the axis of the geocentric dipole from the axis of rotation of the earth at certain times in the past can explain these and other paleomagnetic results. Such polar wandering could have been considerable in relatively short periods of geologic time; from this point of view, if no other, caution should be used in explaining the paleomagnetic results obtained on formations in widely separated areas, of which the relative ages moreover are often uncertain, in terms of horizontal crustal deformation. — D. B. V.

- 182-413. Pospelova, G. A. Prichiny obratnoy namagnichennosti vulkanogennykh porod Armenii i Kuril'skikh ostrovov [Causes of inverse magnetization of volcanic rocks of Armenia and the Kurile Islands]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 1, p. 37-49, 1960.

In the Kurile Islands and in Armenia the Lower Pliocene rocks exhibit normal magnetization, the Upper Pliocene and Lower Quaternary rocks exhibit

reversed magnetization, and later Quaternary rocks are again normally magnetized. A study was made of the magnetic properties, stability characteristics, composition of the ferromagnetic fraction, and thermal remanence of the directly magnetized Quaternary rocks and the inversely magnetized Upper Pliocene to Lower Quaternary rocks from both these areas. The directly magnetized samples do not differ in the above properties from the inversely magnetized samples. Since no evidence of local causes that could reverse the remanent magnetization was found either in Armenia or the Kuriles, the change in magnetic polarity of the Lower Quaternary and Upper Pliocene rocks in those regions should be attributed to a reversal of the earth's magnetic field as a whole during the Early Quaternary and Late Pliocene stage. — A. J. S.

- 182-414. Valiev, A. A. Paleomagnitnoye raschleneniye i korrelyatsiya Kazyozyskikh molass Chust-Papskoy antiklinali (Severnaya Fergana) [Paleomagnetic differentiation and correlation of the Cenozoic molasse of the Chust-Pap anticline (North Fergana)]: Uzbek. Geol. Zhur., no. 2, p. 8-16, 1960.

Differentiation and correlation of the Cenozoic molasse in central Asia is difficult because of a paucity of fossils and abrupt facies changes. Paleomagnetic measurements have overcome this difficulty to a considerable degree. The area of the Chust-Pap anticline has been studied extensively; measurements were made on 816 oriented specimens, which were 5 cm on an edge. The directions of the vectors of remanent magnetization are concentrated in two maximums, one that corresponds closely to the present field and one in the opposite direction. There is a definite rhythm in the reversal of direction with age, that is, with the vertical position in the section. This succession of rhythmically alternating direction of the magnetic field is used to correlate the geologic sections in several areas. — J. W. C.

- 182-415. Khramov, A. N. Rezul'taty paleomagnitnykh issledovaniy vo VNIGRI i ikh perspektivy [Results of paleomagnetic investigations in the VNIGRI and their prospects], in Issledovaniya VNIGRI v oblasti neftyanoy geologii: Vses. Neft. Nauchno-Issled. Geol.-Razved. Inst. Trudy, no. 132, p. 112-118, 1959.

Studies were made on the use of paleomagnetism for correlation of Pliocene and Pleistocene sedimentary rocks in western Turkmen S. S. R. Oriented 5-cm cubes were collected at 2-20 m intervals, and the vector of remanent magnetization was measured. Sections were constructed showing where the magnetization is normal or reversed; these sections were then compared. The Pliocene and Pleistocene of western Turkmen S. S. R. are subdivided into 10 paleomagnetic zones on the basis of these normal or reversed fields; the zones correspond to stratigraphic units.

The discussion is extended to the use of paleomagnetic measurements for resolving such problems as polar wandering and continental drift. The position of the north pole and the intensity of the components of the magnetic field for several localities in western Turkmen S. S. R. and in the Ural-Volga district at different geologic times back to the Ordovician are listed in a table. (See also Geophys. Abs. 169-234, 172-171.) — J. W. C.

- 182-416. Nagata, Takeshi, and Shimizu, Yoshio. Palaeomagnetic studies on Precambrian gneiss of Ongul Islands, Antarctica [with Japanese abstract]: Antarctic Rec., no. 10, p. 1-8, 1960.

This is virtually the same paper as previously published in Nature, v. 184, no. 4697, supp. no. 19, p. 1472-1473, 1959 (see Geophys. Abs. 180-291). — V. S. N.

## MAGNETIC SURVEYS

- 182-417. Henderson, Roland G. A comprehensive system of automatic computation in magnetic and gravity interpretation: *Geophysics*, v. 25, no. 3, p. 569-585, 1960.

In the interpretation of magnetic and gravity anomalies, downward continuation of fields and calculation of first and second vertical derivatives of fields have been recognized as effective means for bringing into focus the latent diagnostic features of the data. A comprehensive system has been devised for the calculation of any or all of these derived fields on modern electronic digital computing equipment. The integral for analytic continuation above the plane is used with a Lagrange extrapolation polynomial to derive a general determinantal expression from which the field at depth and the various derivatives on the surface and at depth can be obtained. It is shown that the general formula includes as special cases some of the formulas appearing in the literature. The process involves a "once for all depths" summing of grid values on a system of concentric circles about each point followed by application of the appropriate one or more of the 19 sets of coefficients derived for the purpose. Theoretical and observed multilevel data are used to illustrate the processes and to discuss the errors. The coefficients can be used for less extensive computations on a desk calculator. — Author's abstract

- 182-418. Kašpar, Milan. *Primeneniye pri geologicheskoy razvedke mikromagnitometrii so statisticheskoy obrabotkoy napravleniy* [Application of micromagnetometry in geological surveying, with statistical analysis of directions (with English summary)]: *Ceskoslovenská Akad. Věd Studia Geophys. et Geod.*, v. 3, no. 4, p. 376-391, 1959.

The use of the micromagnetic method for detailed geologic surveying of a limited area depends on the thickness of the overburden, constancy of the magnetic mineral content of the rocks, and limit of accuracy of measurement. Evaluation of the results is accomplished by statistical analysis of directions of magnetization. Three methods of analysis are compared: the graphic angular, numerical graphic triangular, and gradient methods. Agreement was found between the results of the angular and triangular methods if the microanomalies were characterized by large gradients and one or more pronounced directions, but not if the microanomalies were smooth and without pronounced trend. The angular method is considered to be preferable because the directional frequency is based on a much larger number of measurements. Data processing is facilitated by use of charts and simple instruments called devivometers.

The use of micromagnetometry is illustrated by examples from the Příbram ore district of Czechoslovakia. Over the diorite the direction of magnetization is prevailingly 150°-180° from north, whereas over the Algonkian rocks all directions are found but the more pronounced trends lie between 105° and 150°. Ordinary magnetic profiles could not show the boundary between these rocks. The micromagnetic method can also be applied to rocks usually regarded as nonmagnetic, and therefore should be of very great use in mapping thinly covered (up to 10 m) bedrock. — D. B. V.

- 182-419. Polonskiy, A. M. *Otsenka zapasov pryamymi metodami interpretatsii po dannym magnitorazvedki* [Estimation of reserves by direct methods of interpretation according to magnetic exploration data]: *Razvedka i Okhrana Nedr*, no. 6, p. 30-35, 1960.

Magnetic anomalies of two-dimensional bodies are interpreted by a direct method in which the values of the vertical component Z of the anomalous field are used and the residual integral is disregarded. It was found that errors in determination of the magnetic moment M of the bodies by this method does not exceed 6 percent. — A. J. S.

- 182-420. Mikhaylov, N. N. K voprosy postroyeniya strukturnykh skhem po materialam regional'nykh aeromagnitnykh nablyudeniy [Problem of the construction of structural diagrams according to data of regional aeromagnetic observations]: Sovetskaya Geologiya, no. 4, p. 85-91, 1960.

Problems connected with subdivision of the crust into structural layers on the basis of determinations of depths to disturbing magnetic masses are discussed. The treatment of depth determinations is as follows. Calculated depths are plotted on a grid for which distribution curves of calculated depths are obtained for each square. These curves are used to fix the boundary of the structural layers in each square. Bands formed by rows of squares are then examined. All calculated depths within such zones are projected on the vertical planes on which the averaged zone lines lie. Using these diagrams in conjunction with geologic data, structural layers in the crust can be detected.

This method has been used successfully in the West Siberian Lowland to determine the depth to the top of both the Paleozoic and the Precambrian. — J. W. C.

- 182-421. Karasik, A. M. O nekotorykh osobennostyakh izmereniy magnitnogo polya v Antarktide [Some features of measuring the magnetic field in Antarctica]: Inst. Geologii Arktiki Inf. Byull., no. 15, p. 51-55, 1959.

Aerial and ground magnetic measurements were carried out in 1956-57 in Antarctica during which several features of the magnetic field of the Southern Hemisphere were encountered. The airborne magnetometer measures  $\Delta T$  as increments of the modulus of the complete vector of the earth's magnetic field relative to a value compensated at the beginning of the measurements. The compensation has an opposite sign in the Southern Hemisphere in comparison with that in the northern; therefore, the compensating element in the instrument must be reversed. Calculations must also take into account reversals in the sign of parameters such as the normal inclination of the geomagnetic field. — J. W. C.

- 182-422. Wolf, H[elmut], and Olszak, G. Das Kernresonanzmagnetometer als Prospektionsgerät in der angewandten Geophysik [The nuclear-resonance magnetometer as a prospecting instrument in applied geophysics]: Zeitschr. Angew. Geologie, v. 5, no. 11, p. 554-555, 1959.

Construction of a nuclear-resonance magnetometer at the University in Leipzig has been commissioned by the VEB Geophysik. The principle and measuring technique are outlined briefly. The instrument is excellent technically and economically for both airborne regional surveying and for detailed ground prospecting. — D. B. V.

- 182-423. South African Mining Engineering Journal. Magnetic surveying: South African Mining and Eng. Jour., v. 71, pt. 1, no. 3493, p. 142-143, 1960.

The MZ-4, the latest model in a series of vertical variometers based on the torsion principle, is described. Two measuring ranges incorporated in the MZ-4 make the instrument useable anywhere in the world without addition of compensating magnets or without internal adjustment to the suspension system. The sensitivity range allows continuous readings over an interval of 20,000 $\gamma$ ; the super range has 20 built-in steps which give accurate base transfers and extend the continuous reading interval from +150,000 $\gamma$  to -150,000 $\gamma$ . An overall accuracy of about 3 $\gamma$  is obtainable when measurements at one field station are repeated. The instrument is fitted with a double temperature compensating arrangement, which ensures adequate compensation for all magnetic intensities at all latitudes. — V. S. N.

Nelson, J. H. General geomagnetism. See Geophys. Abs. 182-378.

Knapp, David G. Bibliography on general geomagnetism. See Geophys. Abs. 182-378.

Oldham, C. H. G. Gravity and magnetic investigations along the Alaska highway. See Geophys. Abs. 182-310.

182-424. Steenland, Nelson C., and Brod, Robert J. Basement mapping with aeromagnetic data—Blind River basin: Geophysics, v. 25, no. 3, p. 586-601, 1960.

A detailed aeromagnetic map at 1,700 ft of 16 sq mi of the uranium-producing Blind River basin in Ontario shows two types of anomalies, which are interpreted as originating from shallow mafic intrusives and from deeper basement rocks. The identification of a major basement fault from the anomalies is described. An aeromagnetic map computed upward to 2,630 ft and two second derivative maps confirm the existence of the two types of anomalies.

This small area contains the three principal components encountered in conventional large scale aeromagnetic surveys—intrabasement effects, effects of structure of basement surface, and effect of intrusive and extrusive rocks; the methods therefore should be applicable to larger surveys. — D. B. V.

182-425. Neumann, W. Neue Untersuchung der irregulären geomagnetischen Anomalien bei Berggiesshübel in Sachsen [New investigations of the irregular geomagnetic anomalies near Berggiesshübel in Saxony]: Zeitschr. Geophysik, v. 24, no. 4/5, p. 332-339, 1958.

A new interpretation of the abnormal magnetic anomalies near Berggiesshübel in the Schiefergebirge of the Elbe Valley (Elbtalschiefergebirge) is presented, based on new  $\Delta Z$  measurements and confirmed by subsequent drilling.

The main positive anomaly and the extensive negative anomaly accompanying it on the south edge of the schist mass are due mainly to induction. The negative anomalies (up to -1,000 $\gamma$  in intensity) directly over the outcrop of magnetite deposits show that the ore is magnetized in a direction opposite to that of the geomagnetic field. The form of the disturbing body is calculated from the shape of the anomalies. Its calculated intensity of magnetization is of the order of that of the magnetite-rich hornblende schist. An apparent susceptibility of 0.02-0.12 is inferred from the curves of the magnetic effect of the Martin-Zeicher deposit and one parallel to it on the southwest; this value is of the same order as the susceptibility of magnetite.

The reversal of magnetization of the ore is attributed to the effect of the hornblende schist. If the natural magnetization of the schist was stronger at the time of formation of the skarn ore than it is at present, its influence would have prevailed over that of the geomagnetic field on the cooling ore. It is demonstrated that this is quantitatively possible. — D. B. V.

- 182-426. Jelen, Miroslav. Detailní aeromagnetická měření okolí Šumperka (mapa profilů) [Detailed aeromagnetic measurements in the vicinity of Šumperk (profile map) (with English summary)]: [Czechoslovakia] Ustřed. Ústav Geol. Veštík, v. 25, no. 1, p. 71-72, 1960.

A detailed map based on aeromagnetic profiles spaced 500 m apart at an altitude of 50 m above the ground is presented for the area around Šumperk and Zábřeh in Moravia, Czechoslovakia. Accuracy is  $\pm 26\gamma$ . The anomalies correspond to known geological conditions, highs reflect granodiorite or metabasis rocks carrying a higher magnetite content. — D. B. V.

- 182-427. Arutyunyan, E. A. Opty primeneniya magnitorazvedki pri issledovanii zheleznorudnykh mestorozhdeniy Severnoy Armenii [Experience in the application of magnetic exploration to investigations of iron ore deposits in northern Armenia]: Akad. Nauk Artyan. SSR Izv., v. 12, no. 5, p. 45-65, 1959.

Results of magnetic exploration of known occurrences of iron ore in northern Armenia are reported. The purpose of the survey was to determine the economic value of the deposits from interpretation of their magnetic anomalies. Individual ore bodies were outlined sufficiently to initiate geological explorations. — A. J. S.

- 182-428. Stepanov, V. P. Magnitnoye anomal'noye pole Tatarskoy ASSR i ego svyaz' s geologicheskim stroyeniyem [Anomalistic magnetic field of the Tatar ASSR, and its relation to the geology]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 720-724, 1960.

A magnetometer survey of the Tatar A. S. S. R. and adjacent areas, completed at the end of 1957, has provided much data on the magnetic anomalies of the region. These data can be used to determine depth to basement in as much as all magnetic anomalies here are produced by the structure and petrographic composition of the crystalline basement rock. — A. J. S.

- 182-429. Pudovkin, I. M. Magnitnyye svoystva porod paleozoyskogo obrameniya [Magnetic properties of the rocks of the Paleozoic frame]: in Geologiya i neftenosnost' Zapado-Sibirs'koy nizmennosti: Vses. Neft. Nauchno-Issled. Geol.-Razved. Inst. Trudy, no. 114, p. 89-96, 1958.

The magnetic properties of the rocks of the belts marginal to the West Siberian Lowland are discussed, and their susceptibilities are listed in a table.

The susceptibilities of rocks of the Ural Mountains exhibit a great range, and single rock types have different properties from one geologic body to another. Anomalous magnetic fields with an intensity exceeding 500 gammas and even up to 2,000-3,000 gammas and more are distinctive of most gabbros and peridotites. Metamorphosed igneous rocks (serpentines, amphibolites) produce anomalies of an intensity similar to that of their nonmetamorphosed equivalents. Granitic rocks and sediments have very low susceptibilities.

The rocks of the North Caucasus as well as those of the Altay-Sayan are distinguished by properties similar to those of the Urals.

It is concluded that the parameters of the various rock types present a similar picture for the entire belt that frames the West Siberian Lowland as well as for the basement that underlies the sedimentary cover of this platform. — J. W. C.

- 182-430. Agul'nuk, I. M., Zakashanskiy, M. S., Pudovkin, I. M., and Umantsev, D. F. Stroyeniye magnitnogo i gravitatsionnogo poley nizmennosti i yeye obramleniya [Structure of the magnetic and gravity field of the lowland and its frame], in *Geologiya i neftenosnost' Zapadno-Sibirskoy nizmennosti: Vses. Neft. Nauchno-Issled. Geol.-Razved. Inst. Trudy*, no. 114, p. 153-167, 1958.

A map of magnetic anomalies of the West Siberian Lowland and of most of the framing orogenic belts is presented; it is on a scale of 1:2,500,000. This is the first map of so large an area obtained as a result of systematic aeromagnetic survey. Cursory examination of this map indicates a complex structure. The size of the anomalies ranges from very small to several hundred kilometers in length, and the intensity ranges in very broad limits from -500 to +3,000 gammas. The region has been divided into large areas with unifying characteristics. These have been designated with geographic names and are described briefly.

The gravity survey of this region is much less complete. Little work has been done in the vast central region except along the water courses. According to the data available the gravity field is very complex. The southern half of the lowland is in general distinguished by negative gravity anomalies and the northern half by positive. The direction of the trends of the anomalies in the various parts of the region is described. — J. W. C.

- 182-431. Zakashanskiy, M. S., Pudovkin, I. M., and Umantsev, D. F. So-postavleniye magnitnogo i gravitatsionnogo poley nizmennosti i obramleniya [Comparison of the magnetic and gravity fields of the lowland and frame], in *Geologiya i neftenosnost' Zapadno-Sibirskoy nizmennosti: Vses. Neft. Nauchno-Issled. Geol.-Razved. Inst. Trudy*, no. 114, p. 167-169, 1958.

In the south and central parts of the West Siberian Lowland the relationship of the magnetic and gravity fields is complex. In some places there is a direct relationship; in others it is reversed. The orientation of the anomalies, however, is parallel. In most of the northern and western parts of the lowland all magnetic anomalies have analogs in the gravity field.

The relation of the magnetic field to the gravity field in several areas marginal to the lowland is also described. — J. W. C.

- 182-432. Bernshteyn, V. A. K voprosu o magnitnom pole podnozhiya Klyuchevskogo vulkana [On the problem of the magnetic field under Klyuchevskaya volcano]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta., no. 28, p. 58-78, 1959.

Geomagnetic surveys were made of the vicinity of Klyuchevskaya volcano in Kamchatka in 1953 for the purpose of studying the underlying geologic structure. The vertical (Z) and horizontal (H) components and declination (D) were measured. The Z and H anomalies are shown on maps.

Interpretation of the deeper structure was considerably hampered by the presence of lava flows on the surface and other magnetic objects near the surface. It was established that the crystalline basement is not more than 4.4 km deep under the volcano. Some of the lava masses, for instance those to the east of the volcano, are magnetized in a direction that differs substantially from that of the present geomagnetic field. — D. B. V.

- 182-433. Whitten, G. F. Iron ore deposits and aeromagnetic anomalies near Tarcoola: South Australia Dept. Mines Mining Rev., no. 108, p. 22-27, 1959.

An examination was made of 3 taconite deposits near Tarcoola and of 25 aeromagnetic anomalies on the Tarcoola 1-mile sheet between September 1955 and March 1956. The taconite deposits are too low grade, too small, and too isolated to be of economic importance. No signs of iron mineralization were found in association with the aeromagnetic anomalies. Most anomalies were over granite or sand. — V. S. N.

- 182-434. Seedsman, K. R. Gravity and magnetic traverses over aeromagnetic anomalies near Cowell: South Australia Dept. Mines Mining Rev., no. 108, p. 28-37, 1959.

Vertical magnetometer and gravimeter traverses were made over two anomalies that were located by aeromagnetic surveys on the east side of the Eyre Peninsula near Cowell, South Australia. Results indicate the presence of a very large quantity of magnetic rock that is denser than the surrounding rocks and thus probably iron ore. The highest magnetic anomaly reading obtained is about 12,000 gammas above the general level, and the peak residual gravity anomaly is of the order of 3 mgals. The presence of magnetite is inferred because it is doubtful that any other mineral would produce such large magnetic anomalies. A preliminary testing program is recommended. — V. S. N.

#### MICROSEISMS

- 182-435. Carder, Dean S. Microseismic research: Am. Geophys. Union Trans., v. 41, no. 2, p. 151-153, 1960.

Microseismic work conducted by United States investigators during 1957-60 may be classified under three categories: review of old data, collection and evaluation of raw data from International Geophysical Year stations, and independent research. Progress in each category is reviewed briefly. — D. B. V.

- 182-436. Hieblot, James, and Rocard, Yves. Contribution à la théorie des microséismes [Contribution to the theory of microseisms]: Annales Géophysique, v. 15, no. 4, p. 539-546, 1959.

Standing waves at the surface of the ocean are known to transmit pressure variations to the seabed that are capable of generating microseisms. Variations are calculated both with and without taking into account water compressibility. In the latter case compressional waves are found to propagate vertically in the sea; the energy transmitted to the ground by microseisms lasting 100 sec and having a period of 8 sec is calculated as  $3 \times 10^{18} H^2$  ergs (H is a factor that takes into account partial reflection at the seabed).

It is concluded that a 100-km band of standing waves having a width equal to half the wavelength of the microseismic waves produced is capable of generating microseisms perceptible 2,000 km away. — D. B. V.

- 182-437. Due Rojo, Antonio. Prospección microsísmica [Microseismic prospecting]: [Spain] Inst. Geol. Min. Notas y Comun., no. 54, p. 139-157, 1959.

The results of research in various parts of the world on the origin and propagation of microseisms are summarized. The use of microseisms as a method of prospecting the earth's crust is a possibility for the distant future when their relation to local geologic structure is more fully understood. At present, however, they are a hindrance for no small part of the year to interpretation of seismological records. — D. B. V.

- 182-438. Schneider, Götz. Zum Wellencharakter der mikroseismischen Bodenunruhe [On the wave character of microseismic ground agitation (with English abstract)]: *Zeitschr. Geophysik*, v. 25, no. 4, p. 161-185, 1959.

The wave character of microseisms recorded at Stuttgart, Germany, by a set of Galitzin-Wilip seismographs has been investigated by means of analysis of amplitude-period diagrams, three-dimensional particle orbits over the whole range of microseism periods, and empirically determined local phase velocities. Short-period microseisms are interpreted as a superposition of higher mode surface waves of Rayleigh and Love type, whereas long-period microseisms appear to propagate as pure Rayleigh waves. — D. B. V.

- 182-439. Hollinderbäumer, J. Über die Ortung mikroseismischer Stürme [On the location of microseismic storms (with English abstract)]: *Zeitschr. Geophysik*, v. 25, no. 5, p. 209-238, 1959.

If it is assumed that microseisms consist of individual disturbances propagating discontinuously from their source, the direction of approach can be determined from the ratio of the maximum amplitude in one component to the amplitude recorded simultaneously in the other component ( $A_n/A_e$ ). The statistical distribution of the angles thus obtained indicates the direction of approach. If there is a single source, this direction is the same as that obtained by former methods; the new method, however, has the advantage that it can indicate two sources (shown by two distribution maximums) where the Menzel-Westerhausen method would show only the mean direction.

The method was applied to records obtained at Hamburg, Germany, Copenhagen, Denmark, and Kiruna, Sweden. The resulting angles intersected at two maximums, one on the coast of Norway and the other on the coast of Scotland.

From a second relative maximum in the Kiruna records, together with the vertical component and meteorological charts, it was possible to show that the microseisms were in the form of Love waves. — D. B. V.

- 182-440. Monakhov, F. I. Development of the microseismic method of tracing storms at sea: *Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci.*, no. 20, p. 181-191, 1959.

Microseisms have been investigated systematically in the U. S. S. R. since 1951 with the chief objective of developing a method of tracing storms at sea. Emphasis has been placed on determination of direction to the source of the microseisms; both tripartite observations and direction of particle oscillation have been used for this purpose.

To compare the efficiency of the two methods a tripartite and an azimuthal installation were set up at Yalta; these have been recording simultaneously since 1956-57. Additional observations have been made by a Gutenberg-type vector apparatus.

Analysis of the observations shows that Love waves are almost completely absent, and that the plane of polarization of the Rayleigh waves is generally inclined rather than vertical. Rayleigh waves inclined  $60^{\circ}$ - $90^{\circ}$  to the horizon comprise not more than 10-15 percent of the total number of waves. In general, therefore, the microseismic oscillation observed at Yalta is of a more complex nature than pure Love or Rayleigh waves. This makes the use of the vector installation unreliable for determination of direction of approach. Direction of propagation could be determined from Rayleigh waves for microseisms originating in the Atlantic but not for the closer ones originating in the Black Sea.

Maximum amplitude of microseisms was observed at Yalta a few hours after a cold front traveling across the Black Sea from west to east or from northwest to southeast had passed the station.

The accuracy of the tripartite method depends greatly on the distance between stations; for bases up to 500 m, accuracy is very low. The method using large bases is being developed in the U. S. S. R.; five tripartite stations were established for the International Geophysical Year, with seismograph spacing of 2-3 km, equipped with SVK seismographs tuned to 7-sec period with damping of about 1.5 and M-21 galvanometers with 4-sec period and damping of about 1.5. — D. B. V.

- 182-441. Okano, Kennosuke. Microseisms observed at Abuyama Seismological Observatory [in Japanese with English abstract]: *Zisin*, v. 12, no. 4, p. 182-190, 1959.

Following the routine and tripartite observations of microseisms made at Abuyama Seismological Observatory during the International Geophysical Year, particle motions of the ground were observed by vector seismographs in UD-NS, UD-EW, and EW-NS components. These observations show that microseisms are generated by sea waves and propagated from the disturbance source to the coast near the observatory. Amplitudes and periods of the microseisms depend on the scale of the disturbance source and the distance from source to coast. The earth-particle trajectories confirm that microseismic waves are Rayleigh type and that Love waves are rarely present. — V.S.N.

- 182-442. Newman, B. W. Microseisms associated with cyclones over northeast Australian waters: *Australian Meteorol. Mag.* no. 22, p. 24-25, 1958; also in *Queensland Univ. Dept. Geology Reprint*, new ser., no. 74, 12 p., 1959.

An examination was made at Brisbane, Australia, of microseisms related to four major cyclones during 1955, 1956, and 1957 and supplemented by data from Townsville, Australia, in 1957. A variation of amplitude of microseisms with pressure intensity of the storm is clearly shown, and a semilogarithmic function is derived that fits the data reasonably well. Ocean depth and locality appear to affect the amplitude, and while it is necessary to separate this from effects of change in pressure, it is evident that, dependent on locality, cyclones are associated with distinct microseism patterns. — V.S.N.

- 182-443. Malurkar, S. L. Microseisms and exploration of submarine anomalies: *Jour. Sci. Indus. Research [India]*, v. 19, no. 2, p. 60-61, 1960.

A broad classification of submarine strata can be made on the basis of microseisms. In regions where the seabed has produced microseisms, hard structure like that of granite may be assumed to exist; and in regions where microseisms are damped, soft material (even up to clay) is postulated. If data recorded at Madras, Bombay, Cochin, and other places in India were plotted on maps showing the sea bottom contours and the center and probable intensity of a cyclonic storm, the variations of amplitude and period of the microseisms along the storm track could be mapped. Over a number of years these tracks would provide a network on the basis of which the microseismically blind and active spots or areas could be mapped, thus distinguishing structural differences in the seabed. — D. B. V.

- 182-444. Rocard, Y[ves]. Petits mouvements de la terre dus aux fluctuations des vents [Small movements of the earth due to fluctuations of the wind]: *Annales Géophysique*, v. 15, no. 4, p. 551-554, 1959.

Very local, irregular, weak ground motion that cannot be attributed to microseisms or local earthquakes are observed with sensitive seismographs. The amplitude of this motion, of the order of 20 A on a meteorologically calm day, shows an abrupt sixfold or sevenfold increase several hours before a low pressure center arrives.

Calculations show that the dynamic pressure of wind against vertical obstacles on the earth, such as trees or buildings, cannot produce effects sufficient to explain this motion, but that variations in static pressure stemming simply from changes in wind velocity caused by such obstacles and by surface relief can produce the necessary effect. — D. B. V.

#### RADIOACTIVITY

- 182-445. Fiorentini-Potenza, M. Distribuzione delle principali facies petrografiche e della radioattività nel plutone "sienitico" di Biella (Valle del Cervo) [Distribution of the principal petrographic facies and of radioactivity in the Biella "syenitic" pluton (valley of the Cervo)]: *Soc. Mineralog. Italiana Rend.*, v. 15, p. 89-132, 1959.

About four pages of this paper are devoted to the radioactivity of the Biella granitic-syenitic pluton exposed in the Cervo Valley in Italy. The distribution of relative gamma activity in the pluton is shown on a 1:50,000-scale map with isorad contour interval of 300 impulses per minute. The survey was made with a scintillation counter; background count was measured at each point at a distance of 2 m above the rock.

In general, each petrographic facies has its characteristic mean value of radioactivity. The most noticeable negative anomaly in the interior of the body corresponds to the porphyritic or aplitic granites. Small local positive anomalies accompany vein concentrations of uranium minerals. — D. B. V.

- 182-446. Hayase, Kazuichi [Ichikazu]. Radioactivities of granitic feldspar and biotite of Misasa and Kurayoshi districts, Tottori Prefecture [in Japanese with English abstract]: *Japan Geol. Survey Bull.*, v. 10, no. 9, p. 801-807, 1959.

The order of radioactivity of feldspar and biotite in granitic rocks of the Misasa and Kurayoshi districts, Tottori Prefecture, Japan, was studied by the photo plate method. The feldspar from these granites is more radioactive than that from other places in Japan. In the same granitic rock, however, different constituents show different radioactivity. Fresh albite is less radioactive than altered plagioclase but more radioactive than potash feldspar; and biotite, commonly fairly radioactive, tends to be enfeebled by the presence of minute crystals of radioactive material. — V. S. N.

- 182-447. Tsutsumi, Tokudo. The radioactive accessory minerals and their distribution in some granites in Japan: *Kyoto Univ. Coll. Sci. Mem.*, ser. B, v. 26, no. 2, p. 111-151, 1959.

Microscopic and autoradiographic studies were made of the distribution of radioactive accessory minerals in specimens collected from 15 different granitic intrusives in Japan. The modes of distribution of the radioactive accessory minerals form characteristic types according to the locality and to the

degree of erosion of the intrusive bodies. The radioactive accessory minerals in fine-grained granite are more abundant, stronger in radioactivity, and smaller in size than those from coarse-grained granite. Of the radioactive accessory minerals contained in any one granite, more than 80 percent by volume occur on the boundaries or in the interstices of the major constituent minerals, and of the remaining 20 percent included within the major minerals, the individual grains are not always perfectly enclosed. It is concluded that the greater part of the radioactive accessory minerals crystallized later than the major constituent minerals (see also Geophys. Abs. 178-323). — V. S. N.

Smyslov, A. A. Significance of data on the radioactivity and heat conductivity of rocks in metallogenic investigations. See Geophys. Abs. 182-331.

- 182-448. Hayase, Ichikazu. The radioactivity of rocks and minerals studied with nuclear emulsion, VIII. The radioactive unequilibrium and the radiocolloid of Ogamo and Ningyotoge: Kyoto Univ. Coll. Sci. Mem., ser. B, v. 26, no. 2, p. 153-162, 1959.

The air in the gallery of the Ogamo mine, Tottori Prefecture, Japan, when measured with photographic plates was found to be anomalously high in radon. In the same gallery a radiocolloid with a high concentration of radium was found in the fault clay, whereas the uranium-bearing mineral of the mine, coffinite, was found to be deficient in radium, that is, it exhibits a disequilibrium condition. In the nearby Ningyotoge mine the same radiocolloid and the same disequilibrium condition of the uranium minerals is present; no measurements were made of the radon content of the air. It is believed that radium, leached from the coffinite or ningyoite, is being concentrated in the fault clay as a radiocolloid and that the radioactive gases come directly from the radiocolloid. — V. S. N.

- 182-449. Fergusson, G. J., and Knox, F. B. The possibilities of natural radiocarbon as a ground water tracer in thermal areas: New Zealand Jour. Sci., v. 2, no. 3, p. 431-441, 1959.

An evaluation of the factors that affect the carbon-14 concentration in the carbon dioxide coming to the surface with water and steam in the Wairakei thermal area of New Zealand shows that carbon-14 measurements can assist in the study of underground movement of water. Measurements at five locations in this area show that the time for travel from the surface to depths of 1,500 feet or more is less than 40,000 years. — D. B. V.

- 182-450. Cherdynsev, V. V., Shmonin, L. I., Ostapenko, V. F., Khaldeyev, O. D., and Kashkarov, L. L. Neytronnoye izlucheniye zemli [Neutron radiation of the earth]: Geokhimiya, no. 3, p. 261-267, 1960.

The neutron flux from the earth has been measured at different depths in mines and in boreholes. The ratio of fast to slow neutrons in the secondary neutrons of cosmic radiation, which predominate near the surface, is highest (28) in bedrock and decreases with increasing moisture content. In the neutron flux from the earth's crust the relative amount of fast neutrons is less than in mines and boreholes near the surface. An average neutron flux of 4 neutrons per  $\text{cm}^2$  per hr in bedrock was logged in boreholes in ore deposits. In areas enriched in the light elements (lithium, beryllium, and fluorine) the flux increased to 52 neutrons per  $\text{cm}^2$  per hr owing to ( $\alpha$ , n) reaction of these elements. — D. B. V.

- 182-451. Kogan, R. M., and Fridman, Sh. D. Raspredeleniye  $\gamma$ -kvantov po energii v prizemnom sloye atmosfery [Distribution of  $\gamma$ -quanta according to energies in the atmosphere near the ground]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 530-547, 1960.

The results of calculation of the energy composition of the gamma quanta in the lower several hundred meters of the earth's atmosphere is presented. The computation is based on a model of a layered medium. Radioactive elements of the uranium and thorium family, radioactive potassium evenly distributed in the upper layer of the rocks, or radioactive elements of given energy  $E_0$  of gamma quanta distributed over the rock-atmosphere interface in the form of a thin homogeneous film are taken as sources of radiation. An evaluation of the effect of gamma-field action on certain types of isotropic gamma-quanta detectors is given. — Authors' abstract, A.J.S.

- 182-452. Styro, B. I. Voprosy yadernoy meteorologii [Problems of nuclear meteorology]: Lietuvos TSR Moksly Akad., Geol. ir Geog. Inst. Moksliniai Pranešimai, Mono. Ser., no. 1, 418 p., 1959.

The radioactivity of the atmosphere is reviewed comprehensively. Chapter 1 deals with the nature of atmospheric radioactivity: the radioactivity penetrating into the atmosphere from the earth's surface, the radioactivity originating from the influence of radiation on the atmosphere, and radioactive isotopes entering the atmosphere as a result of man's activity. Chapter 2 describes the methods of measuring radioactivity in the air and in atmospheric precipitation. Chapters 3 through 9 deal successively with the concentration of radioactive materials in the atmosphere, aerosols and atmospheric activity, relation between atmospheric radioactivity and change in meteorological elements such as wind and temperature, temporal variations of atmospheric radioactivity, vertical distribution of atmospheric activity, cycle of radioactivity between the earth and the atmosphere, and atmospheric radioactivity and meteorological problems. — J. W. C.

- 182-453. Sastry, Ch. V., and Gill, P. S. Diurnal variation of cosmic ray neutron intensity: India Natl. Inst. Sci. Proc., pt. A, v. 26, no. 1, p. 41-48, 1960.

The study of diurnal variation of cosmic ray intensity is important as it is believed to be caused by anisotropy of primary cosmic radiation. It has been shown that diurnal amplitude is largely energy dependent, being larger when measured with a low energy detector, that is, a neutron monitor. The neutron monitor in operation at Gulmarg Research Observatory (9,000 ft, geomagnetic lat  $24.7^\circ$  N.) is described, and a preliminary report on the relation observed between the daily amplitude and geomagnetic activity is presented. It is shown that there is no apparent relation between the diurnal amplitude of neutron intensity and the geomagnetic planetary index  $K_p$ . The diurnal amplitude tends to be higher on days of low mean intensity and to be lower on days of high mean intensity. — V. S. N.

Rubin, Meyer, and Alexander, Corrinne. U. S. Geological Survey radiocarbon dates V. See Geophys. Abs. 182-29.

- 182-454. Vaughn, W[illiam] W., Wilson, E. E., and Ohm, J. M. A field instrument for quantitative determination of beryllium by activation analysis: U. S. Geol. Survey Circ. 427, 9 p., 1960.

A low-cost instrument has been developed for quantitative determinations of beryllium in the field by activation analysis. The instrument makes use of the gamma-neutron reaction between gammas emitted by an artificially radioactive source ( $Sb^{124}$ ) and beryllium as it occurs in nature. The instrument and power source are mounted in a panel-type vehicle. Samples are prepared by hand-crushing the rock to approximately 1/4-inch mesh size and smaller. Sample volumes are kept constant by means of a standard measuring cup. Instrument calibration, made by using standards of known BeO content, indicates the analyses are reproducible and accurate to within  $\pm 0.25$  percent BeO in the range from 1 to 20 percent BeO with a sample counting time of 5 minutes. Sensitivity of the instrument may be increased somewhat by increasing the source size, the sample size, or by enlarging the cross-sectional area of the neutron-sensitive phosphor normal to the neutron flux. — Authors' abstract

- 182-455. Cummins, D. O., Delaney, C. F. G., and McAulay, I. R. Light collection in liquid scintillator cells: Royal Dublin Soc. Sci. Proc., ser. A, v. 1, no. 2, p. 21-26, 1960.

The determination of the radioactivity of solutions by adding them directly to a liquid scintillator is common practice. The mixture is usually contained in a cylindrical quartz or glass cell. In all cases the shape and reflecting power of this cell have an important effect on the light collection and hence on the efficiency. The variation of the efficiency of collection over the volume of the cell was investigated for three types of cells — plain glass, glass with an aluminum foil reflector, and glass with a titanium dioxide diffuse reflector. The plain glass cell has an interesting property not shown by the others in that over a considerable part of its volume the efficiency is constant; the possible importance of this property in pulse height analysis is discussed. — V. S. N.

- 182-456. Gokhshtein, Ya. P., and Zhirova, V. V. Kolichestvennoye opredeleniye urana metodom ostsillograficheskoy polarizatsii [Quantitative determination of uranium by the method of oscilloscope polarography]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy, 5th sess., Trudy, p. 316-320, 1958.

Research on the quantitative determination of uranium by the method of oscilloscope polarography reported earlier (see Geophys. Abs. 181-6) is continued. The forms of polarograms and oscilloscopes indicate the amount of uranium present with an accuracy of  $\pm 7$  percent. The lead content can be determined from the same sample simultaneously with the uranium determination. The accuracy of lead determination is  $\pm 3$  percent. — A. J. S.

#### RADIOACTIVITY SURVEYING AND LOGGING

- 182-457. Mardock, Edwin S. Radioactivity logging and its future potential: Geophysics, v. 25, no. 4, p. 883-890, 1960.

The quantitative application of radioactivity logs for estimation of formation petrophysical properties is dependent on certain fundamental factors which are discussed. The full potential of radioactivity logging has not been realized, partly because some of the important factors have not yet been fully considered with respect to either the design of the equipment or the interpretation of the logs. The future of quantitative application of radioactivity logs will depend to a large extent on the development of single-component logging processes. Positive location of the sonde within the borehole for all types of

logs needs further development. These improvements plus future developments in gamma-ray spectral logs, neutron-gamma spectral logs, neutron activation logs, and neutron inelastic scattering logs promise a bright future for radioactivity logging. — D. B. V.

- 182-458. Pickell, J. J., and Heacock, J[ohn] G. Density logging: Geophysics, v. 25, no. 4, p. 891-904, 1960.

This review of density logging is primarily a compilation of information presented in the petroleum industry literature. It includes a brief discussion of some of the theory involved in gamma-ray density logging, various calibration curves, comparisons of density-log and core data, and comments on density-log interpretation.

Conclusions are that the density log, under good borehole conditions, provides an accurate means for measuring bulk density of the formation adjacent to the borehole. If grain density is known, valid estimates of porosity can also be made.

Because of the response characteristics of the system, accuracy in determining porosity is best when formation densities are low and porosities are high. — Authors' abstract

- 182-459. Stick, John C., Jr. New developments in nuclear logging: Petroleum Engineer, v. 32, no. 7, p. B31-B36, B38, B43, 1960.

The underlying principles and the types of radioactivity logs are discussed briefly and their current status is reviewed. Sources and detectors of radioactivity and typical modern tools for producing gamma ray and neutron curves, for detecting such elements as chlorine, oxygen, carbon, and silicon, and for measurement of density are described. The uses of radioactivity logs for location and identification of formations, structural correlation, depth checks, porosity determination, formation fluid evaluation, location of cement tops, radioactive tracer applications, liquid petroleum gas storage reservoir studies, and locating gas or water entry into producing wells are discussed. — V. S. N.

- 182-460. Holgate, M. M. The microlog as a porosity datum for the neutron log in the Swan Hills field, Alberta: Canadian Mining Metall. Bull., v. 53, no. 579, p. 502-506, 1960.

Porosity neutron deflection scales can be derived more easily by cumulative correlation than by the conventional method of plotting corresponding points on a graph.

The microlog can be used as a porosity datum for the neutron log by transforming the permeability cutoff it shows to a porosity cutoff by a permeability-porosity function obtained from core analysis. Porosity footage values calculated in this manner from the neutron log are within 20 percent of core analysis values. [See also Geophys. Abs. 163-173.] — Author's abstract

- 182-461. Nauta, H. Application of nuclear methods in oil-well logging: Geologie en Mijnbouw, v. 39, no. 2, p. 29-37, 1960.

A brief description of present day aspects of nuclear logging methods is given. Besides the well-known natural radioactivity log, which is a measurement of shale content in some cases, and the gamma-gamma log, indicative of the density of the material surrounding the borehole, the more sophisticated

methods of neutron logging are stressed. The interaction of gamma radiations and neutrons with matter is discussed, and the utility of gamma spectroscopy and the detection of gamma radiation at different time intervals after the neutron irradiation is explained. A measurement of the porosity and a chemical analysis of matter surrounding the borehole are the most salient features of neutron logging nowadays. — Author's abstract

- 182-462. Temkin, A. Ya. Nekotoryye metody resheniya zadach teorii neytronogo karotazha [Some methods of solution of problems of the theory of neutron logging]: Prikladnaya Geofizika, no. 23, p. 141-173, 1959.

An attempt is made to develop a method of interpretation of neutron-logging graphs by using an equation that describes the passage of neutrons through a medium containing hydrogen and by a group method which provides a solution to a system of equations for diffusion of neutron groups of different energies. The arbitrary constants in the equations of the latter method are determined by solving the equations for different homogeneous media and selecting appropriate values of the constants by comparing the values obtained for the same problems from kinetic equations. Some boundary problems of neutron logging can be solved only by using the kinetic-equations method. — A. J. S.

Dakhnov, V. N. Geophysical methods of study of reservoir properties of rocks. See Geophys. Abs. 182-208.

- 182-463. Homilius, Joachim, Lorch, Siegfried, and Seitz, Konrad. Radioaktive Dichtebestimmung mit der Gamma-Gamma-Sonde [Radioactive density determination with the gamma-gamma sonde]: Geol. Jahrb., v. 75, p. 183-196, 1958 (1959).

Systematic experimental and theoretical investigations were made of the method of determining density by means of gamma rays. Pointed tubes 1 m long and 25 and 13 mm in outer and inner diameter, respectively, were found to be practical; these were hammered into the ground to the desired depth. The measuring apparatus introduced into these tubes consisted of an 18 cm by 12 mm counting tube, 2 lead rods each 20 cm long, and a container at the lower end with a cobalt-60 preparation.

Sources of error are discussed, particularly the airspace between the tube and hole wall. Under optimum conditions, relative error should not exceed 2 percent. — D. B. V.

- 182-464. Itenberg, S. S. Ob ispol'zovanii dannykh gamma-karotazha dlya resheniya nekotorykh voprosov geologii [Use of data of gamma logging for solution of some geologic problems]: Sovetskaya Geologiya, no. 3, p. 106-112, 1960.

Detailed study of drill holes in the central and eastern Ciscaucasus areas by gamma logging has revealed intervals of increased gamma activity, some of which serve as stratigraphic marker horizons. The maximums on the logs are distinctive of fine clays enriched in organic matter; this material is regarded as having been deposited in a hydrogen sulfide-rich environment. Two examples of correlation of geologic sections of drill holes by their gamma logs are presented. — J. W. C.

- 182-465. Echagaray, Francisco Antunez. Manual para la exploracion del uranio [Manual for exploration of uranium]: Mexico, D. F., Com. Nac. de Energia Nuclear, 353 p., 1958.

Exploration for radioactive minerals is treated in simplified but detailed form. Subjects dealt with are the constitution of the atom, elementary geology, mineralogy, minerals that contain uranium, notable foreign uranium deposits, exploration for uranium and thorium deposits, zones for investigation in the Republic of Mexico, exploration for radioactive minerals using detectors, tests for determination of uranium, sampling, estimation of the economic value of uranium deposits, and mining engineering. A glossary of several hundred terms is included. — J. W. C.

- 182-466. Mumme, I. A. Prospecting for uranium mineralization in Australia: Queensland Govt. Mining Jour., v. 60, no. 692, p. 411-413, 1959.

The principles and techniques of aerial radioactivity surveys as practiced in Australia are summarized briefly. The following are discussed: the basis for the method of measuring gamma radiation of the earth's surface, instrumental adjustment, reduction of results, mathematical basis for analysis of radiometric anomalies, organization of aerial scintillometer surveys for uranium mineralization, and interpretation of aerial radiometric anomalies. — V. S. N.

- 182-467. Surazhskiy, D. Ya., and Tugarinov, A. I. Ob ispol'zovanii izotopnogo sostava svintsa diya poiskov uranovykh rud [On the use of the isotopic composition of lead in exploration for uranium ores]: Atomnaya Energiya, v. 9, no. 1, p. 21-26, 1960.

The causes of the development of anomalous leads and the possibility of using these anomalies for uranium exploration are examined. It is probable that leads with excessive radiogenic isotopes ( $Pb-207$ ,  $Pb-206$ ) develop by the following geologic processes: (1) rapid accumulation of young sediments due to intensive erosion of older uranium deposits; (2) assimilation of uranium-bearing rocks by magma and deep-seated granitization; (3) hydrothermal metamorphism of uranium ore bodies; and (4) supergene action in the zone of oxidation of ore bodies.

Modern methods of microanalysis makes it possible to determine the isotopic ratio in lead from nonlead minerals such as iron and copper sulfate. — J. W. C.

- 182-468. Owa, Eijiro. Report on the geological and radiometric survey of the Go River basin [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 10, no. 9, p. 737-740, 1959.

A geological and radiometric survey was made of the Go River basin as a step in the multiple purpose development of the area. The radioactivity count of some of the granitic rocks is more than 3 times that of the normal background count. — V. S. N.

- 182-469. Matsubara, Hideki. Report on the geology and radioactive anomaly in the multiple purpose development area of the Go River basin [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 10, no. 9, p. 741-747, 1959.

Slight radioactive anomalies were detected in the zone of hydrothermal alteration and in some granitic zones of the area. These anomalies are not indicative of mineralized areas of economic importance. — V. S. N.

- 182-470. Tokunaga, Shigemoto, and Kono, Michiya. Reconnaissance investigation for radioactivity in the Neogene sedimentary rocks of the Shinji and Tamatsukuri areas, Shimane Prefecture [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 10, no. 9, p. 809-815, 1959.

A surface examination with a portable Geiger counter indicated no significant abnormal radioactivity in the Neogene sedimentary rocks that unconformably overlie basement granites in this area in southwest Japan. The average anomalous radioactivity of the formations is from 0.19 to 1.35 times the normal background count. The conglomerate of the Tamatsukuri formation, however, is believed to have a possible ore reserve of radioactive minerals because the average radioactivity of this material, which consists largely of decomposed granite, is 1.70 times the normal background count, whereas the average count for the granite is 1.56 times the normal. — V. S. N.

- 182-471. Ukai, Yasuo. On the radioactive anomaly in the scheelite-molybdenite-chalcopyrite deposits of the Uchitomi mine, Fukui Prefecture [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 10, no. 9, p. 817-822, 1959.

An intense radioactivity anomaly has been detected in the scheelite-molybdenite-chalcopyrite deposits of the Uchitomi mine, Fukui Prefecture, Japan. Microscopic examination revealed numerous euhedral uraninite crystals in or near other accessory minerals, and chemical and X-ray examination of accessory heavy black minerals showed them to contain a large amount of uraninite and zircon and a small amount of allanite. — V. S. N.

- 182-472. Kinoshita, Yoshiro. On the radioactive anomalies in the Sakurago and Zomeki districts, Yamaguchi Prefecture [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 10, no. 9, p. 823-827, 1959.

The Sakurago and Zomeki districts are areas of high temperature replacement deposits of cupriferous pyrrhotite, galena, and sphalerite. A radioactivity survey of the main deposits and mine dumps detected no marked anomalies, and it was concluded that no deposits of radioactive minerals are present in these districts. — V. S. N.

- 182-473. Hiern, M. N. Exploration of the Western Prospect—Radium Hill: South Australia Dept. Mines Mining Rev., no. 108, p. 49-61, 1959.

Geologic exploration of a group of small radioactive anomalies one-half mile west of the Radium Hill main shaft is described. No mineable ore was disclosed but an electromagnetic survey of the area between this prospect and the mine lodes is recommended. Each radiometric profile is illustrated together with the geology as revealed by diamond drill cores. — V. S. N.

- 182-474. Mumme, I. A. Ground scintillation survey—Radium Hill area: South Australia Dept. Mines Mining Rev., no. 108, p. 62-65, 1959.

A ground scintillometer survey in an area just west and southwest of the Radium Hill mine revealed several anomalous radioactive areas, and uranium mineralization is shown to be associated with five of them. Geologic mapping is recommended to determine the economic possibilities, and a radon gas detection survey is recommended in the large areas of alluvium where uraniferous deposits may be concealed. — V. S. N.

## SEISMIC EXPLORATION

- 182-475. Olhovich, V[ladimir] A. Lateral velocity variations: Inst. Français Pétrole Rev., v. 15, no. 1, p. 112-120, 1960.

When there is a lateral velocity gradient (velocity  $V$  is a linear function of depth  $z$  and distance  $x$ ) the velocity function  $V=V_0+KZ$  discussed in the companion paper (see Geophys. Abs. 182-476) may be expressed mathematically as  $V(x, z) = V_0+K'z+Cx$ . It is shown that by rotating the coordinate axis about the origin by an angle  $\epsilon$  to bring the  $Z$  axis into the direction of greatest velocity variation, the lateral velocity variation may be treated as the linear case in which velocity is a function of depth only. Two charts have been constructed from which  $K$  and  $\epsilon$  may be read directly as functions of  $K'$  and  $C$ . — D. B. V.

- 182-476. Bois, P., and Oudelette, A. Seismic circular slide rule for the function  $V = V_0+KZ$ : Inst. Français Pétrole Rev., v. 15, no. 1, p. 93-111, 1960.

This is a description of a circular slide rule that has been devised for computing the function  $V=V_0+KZ$  in seismic surveying. On one side the dip  $\alpha$  and the normal moveout correction  $\delta T$  may be computed as a function of initial velocity  $V_0$  at the datum plane, velocity gradient  $K$ , spread length  $\Delta x$ , two-way time  $T$ , and two-way  $\Delta T$  read on the record. The projected dip  $\alpha'$  may also be computed, if true dip  $\alpha$  and the angle  $\delta$  between the plane of projection and the plane in the direction of the true dip are known.

On the other side the depth  $Z$ , offset  $X$  of a reflector, and radius  $R$  of a wave front may be computed, if  $V_0$ ,  $K$ ,  $\alpha$ , and  $T$  are known. Use of the slide rule is illustrated for typical examples. Two charts have been constructed for use in the case of lateral velocity variations; these are described in a separate paper (see Geophys. Abs. 182-475). — D. B. V.

- 182-477. Radzhabov, M. M., and Agranovskiy, L. Ye. Opredeleniye glubin i rel'yefa granitsy razdela po odinochnym poperechnym godografiam prelomlennykh voln [Determination of depths and relief of a discontinuity from individual transverse traveltimes curves of refracted waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 854-862, 1960.

A case of determination of the relief of a refracting boundary of a layer having velocity  $v_g$  of seismic wave propagation and a dip angle  $\phi < 15^\circ$  is considered. It is shown that the method of determination of the depth  $H$  to the refracting boundary from the individual transverse traveltimes curves of refracted waves produces an error in  $H$  of less than 5 percent if the condition  $\phi < 15^\circ$  is observed. (See also Geophys. Abs. 182-478.) — A. J. S.

- 182-478. Radzhabov, M. M. Vybor srednikh skorostey pri opredelenii effektivnykh glubin po odinochnym poperechnym godografiam prelomlennykh voln [Selection of mean velocities in determination of effective depths from the individual transverse traveltimes curves of refracted waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 863-867, 1960.

This is a continuation of a study of determination of the effective depth  $H_{eff}$  to a refracting boundary by the method of individual transverse traveltimes curves of refracted seismic waves. In this paper the problem of selection of mean velocities in determinations of  $H_{eff}$  according to the formula derived in the preceding paper (see Geophys. Abs. 182-477) is discussed. — A. J. S.

- 182-479. Gol'tsman, F. M. Chastotnaya teoriya interferentsionnykh sistem. I [Frequency theory of interference systems. I]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 7-23, 1960.

The theoretical basis and problems arising in the synthesis of interference systems for differentiation of seismic waves with different apparent velocities along the coordinate axes are discussed. Cases where the sensitivity of an interference system has a discrete distribution in space are analyzed. The general synthesis of an interference system is achieved by a selection of appropriate frequency characteristics in a given coordinate system and by a subsequent calculation of their inverse Fourier integral. It was found that the frequency characteristics of a discrete system are periodic. Filtration of apparent velocities, separation of the signals, and elimination of interferences are analyzed, and several cases of synthesis of interference systems along the coordinate axes are treated mathematically for given apparent wave velocities. (See also Geophys. Abs. 182-480.) — A. J. S.

- 182-480. Gol'tsman, F. M. Chastotnaya teoriya interferentsionnykh sistem. II [Frequency theory of interference systems. II]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 209-222, 1960.

Based on the theory presented in part 1 (see Geophys. Abs. 182-479), the spatial representation of frequency characteristics of interference systems and their properties in such a representation are discussed. Examples are given for one- and two-dimensional interference systems. — A. J. S.

- 182-481. Savarenskiy, Ye. F. Ob opredelenii gruppovoy i fazovoy skorostey iz nablyudeniy [On the determination of group and phase velocities from observations]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1550-1559, 1959.

The physical principals and methods of determination of group and phase velocities of surface seismic waves are discussed. The group velocity ( $C$ ) and the phase velocity ( $c$ ) for a layer lying on a half space are functions of the velocity of propagation of longitudinal and transverse waves, density, wave number, and thickness of the layer. These are expressed in rather complicated functions. For Love waves the expressions for  $C$  and  $c$  are somewhat simplified because the velocities of the longitudinal waves are excluded. A set of curves are plotted for various values of  $h$ ; by comparing these curves with observations, a value is obtained for  $h$ .

A formula is presented for the determination of group velocity, and an account is given of how this can be done in practice. A formula is derived for determination of the phase velocity of surface waves from observations. — J. W. C.

- 182-482. Shumway, George. Sound speed and absorption studies of marine sediments by a resonance method—Pt. 2: Geophysics, v. 25, no. 3, p. 659-682, 1960.

New measurements have been made on a large and varied suite of samples of marine sediments, including shelf and harbor sediments as well as deeper water sediment from the Pacific and Arctic Oceans, in order to investigate the relation between sound speed and the physical properties of unconsolidated sediments. It was found that in general, the smaller the median or mean diameter, the lower the sound speed; this relationship is more pronounced for mean than for median diameter, and it is not linear for it is mainly due to the

nonlinear sound speed-porosity relation. In addition to the porosity effect there is the effect of rigidity, which apparently increases as porosity decreases and as grain size increases.

Absorption is greatest for sediments of intermediate porosity and least for those of highest porosity. This is explained by consideration of the "acoustically effective" surface areas of particle aggregates. A theory of absorption applicable to a general sediment containing both suspended particles and particles in contact probably is not possible, but due to the additive nature of the absorption process some general predictions about the dependence of absorption on frequency in a general sediment can be made by adding the effects due to particles in both conditions. (See also Geophys. Abs. 165-99 and 174-89). — D. B. V.

- 182-483. Zverev, S. M. Dinamicheskiye osobennosti mnogokratno-otrazhennykh vodnykh voln v okeane i ispol'zovaniye ikh dlya opredeleniya skorostey uprugikh voln v osadkakh [Dynamic characteristics of multiple-reflected water waves in the ocean and their application to determination of velocities of elastic waves in sediments]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 24-36, 1960.

An analysis of traveltimes curves and amplitude graphs of multiply reflected seismic waves observed in the profiles of deep seismic soundings carried out in the Sea of Okhotsk and the Pacific Ocean indicates that the form of the amplitude curves depends upon the angle of incidence of the wave on the ocean floor and the consequent change in the coefficient of reflection. It was found that the intensive multiply reflected seismic waves observed in the deep parts of the sea and in the ocean correspond to the critical or greater angles which the incident wave makes with the floor. A comparison of the theoretical amplitude curves with those obtained in the sounding makes it possible to determine seismic wave velocities in several upper layers of the sediments. It is claimed that this method gives more information on seismic wave velocities in oceanic sediments than can be obtained by the Katz and Ewing method (see Geophys. Abs. 165-228). — A. J. S.

- 182-484. Faust, L. Y. Advances in seismic exploration: Am. Geophys. Union Trans., v. 41, no. 2, p. 157-160, 1960.

During the period 1957-60, 2 new methods of seismic exploration, 5 new techniques, and 4 aids to interpretation have been announced. The vigor of present seismic exploration is readily apparent in a summary of these developments. — D. B. V.

- 182-485. O'Brien, P. N. S. The use of amplitude and frequency in exploration seismology (with French abstract): World Petroleum Cong., 5th, New York, Proc., sec. 1, paper 34, p. 627-642, 1959.

Measurements on the amplitude and pulse shape of seismic events are not usually made. In refraction work it is easy to do this, and as magnetic recorders increase in dynamic range it may soon be possible with reflection records. This paper discusses the disturbing effects of variations in the source, the instruments, and the geophone plant. It is concluded that, whereas they have no serious effect on the seismic wave form, they cause a large amount of unwanted scatter in the amplitudes. Nevertheless, amplitudes give more information than do frequencies. Results are given for measurements on waves from refractors which are thick, thin, and anticlinal.

As the thickness becomes less than about one third of a wavelength, the residual attenuation increases rapidly. This provides a useful method for deter-

mining whether or not the refracted arrivals come from a thin stringer. It should be possible eventually to determine the thickness of a layer by making amplitude and frequency measurements on the refracted arrivals. When shooting over an anticline the refracted arrivals attenuate at an increased rate on the side of the crest closer to the shot-point and at a lesser rate on the opposite side.

Guided waves are mentioned and it is suggested that they may be used to obtain the time correction for the low velocity layers when doing long distance refraction work. — V. S. N.

- 182-486. Bortfeld R[einhard], and Hütgen, H. On the identification and construction of reflected refractions: *Geophys. Prosp.*, v. 8, no. 1, p. 12-24, 1960.

Reflected refractions may be considered to be the limiting case of steeply dipping ordinary reflection. The reflector of a reflected refraction may be constructed by the same methods as ordinary reflections. In traveltimes curves, and velocities computed from them, there is a continuous transition from ordinary reflections to reflected refractions. Reflected refractions may be attenuated in the same manner as steeply dipping reflections.

In practice it is impossible to distinguish between reflected refractions and steep reflections by seismic ray methods; however, they might be distinguished by means of energy (amplitude). It seems most feasible, however, to solve the problem by seismic model experiments. Steep events may be attenuated to a great extent by special shot and geophone setups. It is unnecessary to distinguish between reflected refractions and steep reflections. Steep events should all be regarded as ordinary reflections at the beginning of a survey and treated accordingly. — D. B. V.

- 182-487. Buffet, A., and Layat, C. Nouvel aspect de la sismique réfraction au Sahara: tirs non enterrés [New aspect of seismic refraction surveying in the Sahara—surface shooting (with English abstract)]: *Geophys. Prosp.*, v. 8, no. 1, p. 47-67, 1960.

Tests were conducted in September 1958 to evaluate some of the problems involved in surface shooting in sand dune areas of the Sahara because of difficulties in drilling shotholes. Shots using small charges (less than 25 kg) gave interesting results that are not, however, applicable to the heavy charges currently used (500-1,500 kg); with these, suspended charges gave better results than those laid directly on the ground. The relation between seismic energy and weight of charge shows a pronounced saturation effect as the size of the charge increases.

With heavier charges (200 kg) the results obtained are not as pronounced, but the following conclusions can be drawn: (1) Nitrate explosives give good refraction results; (2) the gain in energy with suspended shots is not sufficient to warrant their use; (3) detonation of individual charges by means of primacord laid parallel to the line is superior to simultaneous electric detonation from the energy point of view, and simplifies lay-out procedures; (4) the relation between weight of charges and seismic energy shows a less pronounced saturation effect than in the case of small charges; and (5) the distance between charges appears to be the most important variable, with optimum spacing at about 20 m; for a given overall charge it appears to be preferable to reduce the weight of individual charges and increase their spacing, but there are practical and economic limits to this rule.

At present prices of explosives, the cost of surface shooting is about the same as that of methods requiring shothole drilling; use of magnetic recording could reduce the size of charges needed and thus would reduce the cost. — D. B. V.

- 182-488. Khramoy, A. I. "Svodnyy" godograf otrazhennykh voln [A "composite" travelttime curve of refracted waves]: Razvedochnaya i Promyslovaya Geofizika, no. 17, p. 32-36, 1957.

Two contradictory requirements arising in seismic reflection surveying, namely, maximum curtailment of the travelttime curves for better correlation and maximum extension of the curves for more accurate determination of the effective velocities, call for construction of composite travelttime curves from overlapping curves. Khramoy assumes seismic reflections from a plane boundary and derives three systems of equations for the unknowns  $H$  (depth to reflecting boundary),  $\phi$  (dip),  $v$  (velocity), and  $T$  (travelttime). Solving the equations for the value of  $T$  at any point  $x$  on the extension of the overlapping travelttime curve, four formulas for the value of  $T$  for any desired  $x$  are obtained. — A. J. S.

- 182-489. Ivanova, T. G. Ob ispol'zovanii chastotnogo seismicheskogo zondirovaniya dlya izuchenii verkhney chasti razreza [On application of frequency seismic sounding to the study of the upper part of a section]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 223-228, 1960.

New experimental data on the variation of the apparent angles of incidence of seismic waves on the surface layer (soil) when the apparatus is being adjusted for recording of various frequencies are given. It was found that a thin layer of soil decreases the apparent incidence angle of the wave. A comparison of observed graphs of the apparent angle of incidence with the theoretical graphs constructed for two-layer mediums provides data for seismic P-wave velocity and for the thickness of the soil. The values obtained agree well with those derived from direct measurements of the soil layer; therefore, they confirm the applicability of the seismic frequency sounding method to determination of the upper part of the profile studied during the sounding. The high sensitivity of the proposed method to variations in the parameters of the medium is pointed out. — A. J. S.

- 182-490. Kawashima, Takeshi. On the deformation of reflected wave due to sampling filter [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 10, no. 7, p. 627-684, 1959.

Deformation of the reflected wave due to the sampling filter in pattern shooting, multiple geophone setting, mixing, and compositing in seismic prospecting is investigated. Ricker's wavelet is used as a reflected wave. Output wave forms of the equal weight sampling filter, such as a linear array of multiple geophones, and of the different weight sampling filter, such as pattern shooting, and the characteristic curves of amplitude and time delay are illustrated. Deformation of the wavelet is analyzed with respect to broadening and asymmetry of the wave form.

Various nomograms are prepared for conversion of the parameter  $\theta$  (phase angle) to the practical parameters such as apparent velocity frequency, geophone spacing, and so forth. Amplitude curves as functions of frequency and stepout time are also illustrated. — V. S. N.

- 182-491. Kametani, Takuya. Line ups on reflection records [in Japanese with English summary]: Butsuri-Tanko, v. 12, no. 1, p. 25-38, 1959.

Line ups which appear on field records of seismic reflection surveys and which have higher apparent velocities than first arrivals are generally thought to be reflections resulting from exceptional circumstances. The frequency of occurrence in recent records indicates, however, that these circumstances are not so exceptional. Some examples are discussed and classified into multiple reflections, bubble effects, wave guide phenomena, diffractions, and other unusual events. — V. S. N.

- 182-492. Adachi, Ryuzo. An experiment and its exploration concerning seismic refraction method [in Japanese with English summary]: Kumamoto Jour. Sci. ser. A, v. 4, no. 1, p. 99-102, 1959.

Mathematical results of an experiment with the seismic refraction method conducted at Misumi, Kumamoto Prefecture, Japan, are reported. Calculations are derived by using a formula presented in a previous paper (see Geophys. Abs. 173-346, -347). — V. S. N.

- 182-493. Rao, S. H., Gutdeutsch, R., and Klussmann, J. Aufbau einer modellseismischen Apparatur [Construction of a seismic model apparatus (with English abstract)]: Zeitschr. Geophysik, v. 25, no. 5, p. 253-264, 1959.

This paper describes the construction of an apparatus for model-seismic investigations. A spark gap generator produces high-voltage pulses which are fed to a piezoelectric transmitter crystal. The mechanical oscillations of the crystal produced by these pulses are propagated in the form of elastic waves in models made out of plastics or metals. Piezoelectric crystals are also used as receiving elements. The electrical signals produced by the pickups are amplified and displayed on a cathode-ray oscilloscope and are photographed for documentation. Some results obtained with simple two-dimensional models are also reported. — Authors' abstract

- 182-494. Sengbush, R. L. Errata for discussion of "Frequency analysis of seismic pulses": Geophysics, v. 25, no. 3, p. 687, 1960.

This calls attention to printing errors in Sengbush's comments (see Geophys. Abs. 180-365) on a paper by Howell and others. — D. B. V.

- 182-495. Currier, L. W. The seismic method in subsurface exploration of highway and foundation sites in Massachusetts: U. S. Geol. Survey Circ. 426, 8 p. 1960.

The principles of the refraction seismic method as applied to highway exploration work and the limitations and advantages of the method as compared with results from wash borings and core drilling are discussed. The seismic refraction method is concluded to be the most satisfactory procedure for preliminary subsurface exploration of highway sites; it is not infallible but is highly practical considering the time and money involved, especially when supported by collateral knowledge of regional and local geology. — V. S. N.

- 182-496. Broding, R. A., and Poole, J[oseph] L. Collection and processing of digitized acoustic log data: *Geophysics*, v. 25, no. 4, p. 939-947, 1960.

The mathematical processes involved in making acoustic logs useful for the geophysicist or production analyst have prompted the handling of log data by digital means. Digital punched tape logs from retraced analog recordings as well as digital recordings made by punching tapes directly from the recording galvanometer signal obtained during a logging survey are being used as input to electronic computers. These computers can be programmed to perform the normal computations now used in data reduction. This process yields higher precision data and allows computational procedures to be performed that previously were considered burdensome or tedious. The technique is attractive in preparation of geophysical logs, synthetic seismograms, calculating effective porosities and saturations. However, the requirement of converting recorded digital data to be compatible with the input of different digital computers and to all the various formats for individual programs is a problem that will require standardization in formats. It is evident that the advantages to be realized in data reduction processes will require the log of the future to be recorded in digital as well as analog form. — Authors' abstract

- 182-497. Hardy, H. W. How to use the continuous velocity logger in core and shot holes: *World Oil*, v. 151, no. 5, p. 160-168, 1960.

The continuous velocity logger as adapted to core and shot holes is described. The basic differences between deep- and shallow-hole instruments are relatively slight; they are smaller in length and diameter and lighter in weight.

The core-hole velocity log is an effective correlation tool. An example is given. In addition, such logs are valuable for velocity data on the near-surface low velocity layer.

The core-hole or shot-hole velocity logger is not now available on an economically feasible basis commercially. Continued improvements in instrumentation and utilization, however, indicate that its use may become routine in the near future. — J. W. C.

- 182-498. Millard, Frank S. Sonic log evaluates Morrow sand: *Petroleum Engineer*, v. 32, no. 9, p. B29-B34, 1960.

It is demonstrated that sonic logs run in conjunction with induction electric logs can be used to evaluate qualitatively the Morrow sands in western Oklahoma. Empirical curves which relate weighted core porosity and formation velocity or transit time have been developed for this relatively shale-free sand; the effect of fluid and residual gas in the invaded zone was investigated and is considered in the curves.

The comparison of formation resistivity and transit time using specially designed graph paper may provide a rapid method of formation evaluation. Some examples showing the application, advantages, and limitations of the procedure are presented. — V. S. N.

- 182-499. Tal'virskiy, D. B., and Yekhanan, Ye. V. Uprugiye svoystva [Elastic properties], in *Geologiya i neftenosnost' Zapadno-Sibirskoy nizmennosti*: Vses. Neft. Nauchno-Issled. Geol. - Razved. Inst. Trudy, no. 114, p. 83-88, 1958.

The velocity characteristics of the Mesozoic-Cenozoic section of the West Siberian Lowland are described. The data were derived largely from seismic

logging of deep wells. The velocity increases quite evenly with depth in most sections; typical values are 1,500-2,000 m per sec for Neogene and Paleogene sediments, 2,000-3,000 m per sec for Cretaceous, and 3,500-4,000 m per sec for Jurassic. Seismic surveying has revealed a large number of marker horizons; these are characterized by different types of reflected and refracted waves. — J. W. C.

Burton, R. P. New log interpretation techniques for the Gulf Coast. See *Geophys. Abs.* 182-204.

182-500. Raitt, Russell W. Marine seismic studies: Am. Geophys. Union Trans., v. 41, no. 2, p. 269-271, 1960.

The period 1957-60 was one of great activity in seismic studies of the ocean floor. The program carried out in the past decade in the United States, principally by the Lamont Geological Observatory, the Woods Hole Oceanographic Institution, and the Scripps Institution of Oceanography, was stimulated greatly by the International Geophysical Year. Another significant event was the formation of the AMSOC committee of the National Academy of Science for the drilling of a hole to the earth's mantle; the choice of site for this hole depends largely on marine seismic refraction observations.

The geographic scope of marine seismic operations in these three years was impressive; coverage of the sea floor was approximately doubled. A few preliminary results and tentative conclusions have been published, but detailed study is yet to be completed. — D. B. V.

182-501. Hobson, George D. A reconnaissance seismic refraction and reflection survey in southwestern Ontario: Canadian Mining Jour., v. 81, no. 4, p. 83-87, 1960; also in Canadian Oil and Gas Industries, v. 13, no. 7, p. 47-51, 1960.

A reconnaissance refraction and reflection seismic survey of that part of southern Ontario underlain by Paleozoic strata was undertaken by the Geological Survey of Canada in the summer of 1959. Southwestern Ontario had previously been considered unsuitable to the seismic method of prospecting for oil and gas. Past failures were probably the result of the presence of surface waves of exceptionally strong magnitude, and this handicap was not entirely overcome in this survey.

Results show that the refraction method may be used in southern Ontario in some places to map the bedrock surface and thus determine the extent of subsurface geological structures. The velocity discontinuity at the base of the Guelph-Lockport formation, however, completely eliminates refraction for mapping the basement in this geologic column.

Although investigation of reflection quality was not of prime importance in the eastern part of the area, it was found that by using careful field techniques to overcome interference from the strong surface waves and from the similarity of elastic properties, reflections could be obtained. The natural response frequency increased noticeably toward the west in the areas of higher-velocity bedrock. A continuous reflection profile across a dry reef between Adelaide Township and Warwick Township showed that the reflection method can be used to map reef structure in detail.

The seismic method is not recommended as a primary exploration tool in this area. The gravity method is considered better for the initial program. — V. S. N.

- 182-502. Roethlisberger, Hans. Seismic survey 1957, Thule area, Greenland: U. S. Army Snow, Ice, and Permafrost Research Establishment Tech. Rept. 64, 13 p., 1959.

A seismic reflection survey was made on the edge of the icecap in the vicinity of Camp Tuto, Thule, Greenland in August and September 1957. The thickness of the ice was determined to range from 200 to 800 feet. Only sporadic results were obtained with short shot point to geophone distances, but at distances up to 3.5 times the ice thickness very strong reflections were recorded. The presence of alternate layers of moraine and ice at the bottom of the icecap is indicated. The applicability of the refraction method was established by laboratory tests and by a test at the ice tunnel. More details concerning subsurface conditions could be revealed by the refraction method. — V.S.N.

International Geophysical Year Bulletin (No. 34). Seismic crustal studies during the IGY. Pt. 2: Continental program. See Geophys. Abs. 182-350.

Gane, P. G. Seismic work on crustal structure in South Africa. See Geophys. Abs. 182-353.

Hales, A. L. Seismic and gravity research on crustal structure in South Africa. See Geophys. Abs. 182-352.

- 182-503. Andres, J[akob], and Schad, A[lbert]. Seismic mapping of fault zones in the middle and northern part of the Upper Rhine Graben [with French abstract]: World Petroleum Cong., 5th, New York, Proc., sec. 1, paper 46, p. 829-848, 1959.

This paper is virtually the same as the paper published in Erdöl und Kohle, v. 12, no. 5, p. 323-334, 1959 (see Geophys. Abs. 177-358). — W.L.G.

Beránek, Břetislav. Local time anomalies and local gravity anomalies in the Inner Alpine Vienna basin. See Geophys. Abs. 182-320.

- 182-504. Neprochnov, Yu. P. Dannyye o glubinnom stroyenii banki Livanova [Data on the subsurface structure of the Livanov Bank]: Geologiya Nefti, no. 7, p. 41-43, 1958.

The Livanov Bank is located in the open waters of the Caspian Sea approximately 90 km west of the Krasnovod Gulf. It has developed as a result of a mud volcano, which is still active and forms an island from time to time.

The area of the bank was studied by a seismic profile. The apparatus consisted of 12 seismic receivers in a plastic tube 700 m long and 50 mm in diameter. During operations it was suspended 10 m below the water, and the towing vessel moved at about 5 km per hour. The explosions were set off not far from the side of the center of the string. The blasting charges were generally 5 kg at a depth of 1.5 m; they were set off at 4-minute intervals.

The seismic profile revealed an anticline in the area of the Livanov Bank. The effective depth of this method was 3 km on the flanks of this anticline but only 1 km on the crest. — J.W.C.

- 182-505. Pak, V. A. Ritmostratigraficheskoye racchleneniye molass Ferganypo seysmorazvedochnym dannym [Rhythmostratigraphic subdivision of the molasse of Fergana according to seismic exploration data]: Uzbek. Geol. Zhur., no. 6, p. 55-62, 1959.

The Cenozoic molasse of Fergana presents difficulties in correlation because of a paucity of fossils, facies changes, and the masking cover of Quaternary deposits. The results of the use of seismic exploration for subdivision of this unit is reported. This operation was quite successful; several units and unconformities were recognized and correlations were made. — J. W. C.

- 182-506. Pyatchin, N. F. Pervyye rezul'taty regional'nykh seysmicheskikh issledovaniy na yuge Irkutskogo amfiteatra [First results of regional seismic investigations in the south of the Irkutsk amphitheater]: Geologiya Nefti, no. 9, p. 64-67, 1958.

A seismic reflection profile 160 km long was made in the area of the Irkutsk amphitheater to elucidate the deeper subsurface structure of the Lower Cambrian sediments. As many as 10 seismic marker horizons are distinguished. Comparison of gravity data with the seismic data shows that the gravity anomalies are caused not by structures in the Paleozoic section but by variations in the relief of the Precambrian basement. A series of supporting refraction profiles coordinated with deep drilling is recommended. — J. W. C.

Gal'perin, Ye. I., and Kosminskaya, I. P. On seismic investigations of the deep crustal structure according to the International Geophysical Year. See Geophys. Abs. 182-356.

Weizman (Veytsman), P. S., Kosminskaja (Kosminskaya), I. P., and Riznichenko, J. V. (Riznichenko, Yu. V.). New deep seismic sounding data on the structure of the earth's crust and on mountain roots. See Geophys. Abs. 182-344.

- 182-507. Sorokhtin, O. G., Kondrat'yev, O. K., and Avsyuk, Yu. N. Metodika i osnovnyye rezul'taty seysmicheskikh i gravimetriceskikh issledovaniy stroyeniya Vostochnoy Antarktidy [Method and main results of seismic and gravity investigations of the structure of Eastern Antarctic]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 396-401, 1960.

The seismic and gravimetric methods used by the 2d and 3d Complex Antarctic Expeditions of the U.S.S.R. on the 2,100 km traverse Mirnyy, Pionerskaya, Komsomol'skaya, Sovetskaya, and the Inaccessibility Pole are described. The depths to bedrock were determined by the seismic method of reflected waves and its high frequency modification. The thickness of the snow-firn layer and the seismic wave velocity in the glacial ice and in the bedrock were also determined. Details of the structure in the intervals between seismic stations were obtained by the gravimetric method. Reliable data on ice thickness were obtained for the profile Mirnyy-Komsomol'skaya, where the seismic velocity of the reflected waves is  $3,750 \pm 70$  m per sec. Seismic velocity in the underlying rock is 5,500-5,800 m per sec. The gravity anomalies indicate that under the load of the ice the Antarctic Continent has subsided approximately 750 m, and that prior to isostatic compensation the average elevation of the continent was about 1,500 m. The profile crossed a mountain range that rises 3,000 m above sea level at a distance of 1,700 km from the station Mirnyy. The maximum ice thickness is 4,060 m, and its average thickness is 2,200 m. — A. J. S.

## STRENGTH AND PLASTICITY

- 182-508. Handin, John. Flow, fracture, and strength of rocks in the laboratory: Am. Geophys. Union Trans., v. 41, no. 2, p. 162-165, 1960.

Of the four natural environmental factors that significantly influence the mechanical properties of deeply buried crustal materials—confining pressure, pore pressure, temperature, and time—only the first had been adequately investigated prior to 1957. Our understanding of the effects of pore pressure and temperature has come almost entirely from studies made during 1957-60. These developments are reviewed briefly. Results of high-temperature experiments on rock deformation by different workers are summarized in a table.

The effectiveness of the laboratory work has suffered from the lack of theory; the experimental data even of creep tests cannot yet be extrapolated to geologic time. — D. B. V.

- 182-509. Wuerker, R. G. Influence of stress rate and other factors on strength and elastic properties of rocks, in Third symposium on rock mechanics: Colorado School of Mines Quart., v. 54, no. 3, p. 3-31, 1959.

A short review of the most common factors affecting the strength and elastic properties of rocks is presented. A stress rate of 100 psi per second for the standard compression test is prescribed by the U. S. Bureau of Mines for determining physical properties of rock. However, data from tests with greater speed of loading such as impact and sonic tests indicate that strength and modulus of elasticity might increase by a factor of two. This is illustrated with data from Watstein's (1953) static and dynamic tests on concrete. One sample has a compressive strength of 2,500 psi, another 6,500 psi. Rates of stressing ranged from 1 to  $10^8$  psi per second, rates of straining from  $10^{-16}$  to 10 inches per inch per second. Ability to absorb strain energy also increased with the rate of application of load.

The influence of other factors, such as combined stresses and confinement, is discussed by using an expansion of Mohr's theory for a range within which the straight line expression for Mohr's envelope is valid. Increase of compressive strength due to confining pressure is many times higher than the one due to increased stress rate. — V. S. N.

- 182-510. Rinehart, John S. The role of stress waves in comminution, in Third symposium on rock mechanics: Colorado School of Mines Quart., v. 54, no. 3, p. 61-76, 1959.

Rocks, being so much stronger in compression than in tension, can effectively transmit potentially damaging disturbances to regions remote from the sources of the disturbances. The problem of how small rocks break up under impact loads is primarily the geometrical problem of tracing these disturbances through the rock specimen, particularly with respect to the mutual interactions of incident and reflected stress waves. A number of simple cases are described to demonstrate the manner in which the comminution problem can be attacked from elementary physical principles of dynamical and mechanical behavior of elastic bodies under impulsive loads. Only fractures generated by the interference of fronts of longitudinal waves are considered. — V. S. N.

- 182-511. Hardy, H. R., Jr. Time-dependent deformation and failure of geologic materials, in Third symposium on rock mechanics: Colorado School of Mines Quart., v. 54, no. 3, p. 135-175, 1959.

The time-dependent behavior of geologic materials under conditions of low and high uniaxial stress is considered to be important in the study of comminution and underground failure. Under low values of applied stress it is postulated that time-dependent deformation may be described approximately by a viscoelastic model. In the case of higher values of applied stress, it is postulated that time-dependent deformation and failure may be described by the combination of a viscoelastic model and a microfracture mechanism. A comprehensive review of recent and past research in this field is given. The design and calibration of laboratory apparatus to study these properties is described, together with experimental results to date. — Author's abstract

- 182-512. Clausing, D. P. Comparison of Griffith's theory with Mohr's failure criteria, in Third symposium on rock mechanics: Colorado School of Mines Quart., v. 54, no. 3, p. 285-296, 1959.

An initial consideration of the fundamentals of rock failure is presented. The details of actual fracture processes are quite complicated as actual rock is not homogeneous, Hookean, and isotropic, and under certain conditions does not behave as a brittle material. Investigation of the slope of Mohr's envelope amounts to an investigation of the principal stress relation. Although Griffith's criteria can be plotted as a Mohr's envelope, Griffith predicts a curve of decreasing slope while Mohr predicts a linear principal-stress relationship. Experimental tests on rock and concrete conducted to higher stresses clearly demonstrate that the curve has a decreasing slope as predicted by Griffith. The slope at the higher lateral stresses tested is on the order of one-third the slope at zero lateral stress and, thus, the linear equations are only approximations at low pressure. It is concluded that the experimental data give strong qualitative support to Griffith's concept of failure. — V. S. N.

- 182-513. Jeffreys, Harold. Faults in a material that hardens when it yields: Royal Soc. [London] Proc., ser. A, v. 252, no. 1271, p. 431-435, 1959.

The problem of an elliptical rigid inclusion in an elastic solid, with homogeneous stress at large distance, is solved. The greatest stress differences are found to be at or near the ends of the flaw and to be determined mainly by the greatest principal stress. The result differs from that of G. I. Taylor (1934) for flaws filled with compressible but weak material, where the greatest stress differences, for similar but differently oriented flaws, would occur for flaws at 45° to the greatest principal stress.

The result would suggest that in dynamic metamorphism of rocks weak crystals would tend to form at 45° and strong ones would tend to form needles parallel to the greatest principal stress. Doubts are expressed about this interpretation, and an alternative is suggested, namely, that stress has little to do with the formation of minerals, but that they are sheared and rotated into parallel directions by flow in the surrounding rock after they are formed. — Author's abstract

Ito, Ichiro; Terada, Makoto; and Sakurai, Takehisa. Stress waves in rocks and their effects on rock breakage. See Geophys. Abs. 182-167.

- 182-514. Carey, S. Warren. The strength of the earth's crust: New York Acad. Sci. Trans., ser. 2, v. 22, no. 5, p. 303-312, 1960.

During the last 3 years geophysicists in three independent fields have concluded that the strength of the earth's crust is greater than had been commonly thought. Carey discusses the evidence and shows that none of the conclusions necessarily follow from the data presented.

Innes (see Geophys. Abs. 169-172), following Garland (see Geophys. Abs. 165-19, 177-45) argues that the large negative gravity anomalies in central Quebec are due to orogenic roots of Precambrian age and that the large implied isostatic loads have been borne by the crust through following geologic eras. Carey shows that Innes' data are more consistent with a substantial degree of isostatic recovery in the 10,000 years following Quaternary glaciation in one of the cold, stable regions of the earth's crust.

O'Keefe and colleagues (see Geophys. Abs. 176-159, 180-183, -184) interpret the north-south asymmetry of the geoid, observed from the orbits of artificial satellites, as indicating a very much greater strength for the crust over wide arcs than has been accepted by geophysicists generally. Carey points out that the order of magnitude and qualitative distribution of mantle density variation required to give the observed stability of the pole in opposition to the inertial effects of the continents is similar to that required to produce the asymmetry of the geoid. He predicts that the geoid eventually will prove to have broad nonsystematic irregularities perhaps as large as 30 m due to regional variations in the upper mantle. These will not imply crustal strength of greater order than that suggested by Heiskanen and Vening Meinesz, since they will be in isostatic equilibrium with respect to vertical loads.

Finally, Gough and van Niekerk (see Geophys. Abs. 168-244, 176-276), from a study of the thermoremanent magnetism of the Bushveld lopolith, observed that the paleomagnetic poles had a significantly smaller scatter when corrected for stratigraphic dip and interpret this to mean that the crust supported the load due to the intrusion for at least  $10^5$  yr, concluding that the South African crust  $2 \times 10^9$  yr ago had very considerable strength. They believe that the sagging of the lopolith to basin shape took place after the intrusion had cooled through its Curie point. Carey shows that sagging could have commenced well before this cooling and, moreover, since the Transvaal system, into which the gabbro is intruded, forms a typical sedimentary basin which characteristically suffers subsidence over times of  $10^7$ - $10^8$  yr, there is no reason for postintrusion-basin sagging in such an environment to be interpreted as implying that the crust has borne a load. — V. S. N.

- 182-515. Serata, Shosei, and Earnest F. Principles of structural stability of underground salt cavities: Jour. Geophys. Research, v. 65, no. 9, p. 2979-2987, 1960.

The principles of structural stability of underground salt cavities and the significance of the principles as they relate to other cavities are discussed. The theory of plasticity is applied to the evaluation of stress and strain conditions of the salt cavities. The concept of a yielded zone which develops around the cavities is introduced, and a theoretical development of the extent and stress distribution of the zone is illustrated through the use of ideal spherical and cylindrical cavities under uniform triaxial compression. Applicability of the concept to actual conditions, such as cavity irregularities, brittleness of formation, and nonhydrostatic loading, is discussed. — Authors' abstract

- 182-516. Clark, Don B. A strain gauge technique for the dynamic measurement of ice: *Arctic*, v. 13, no. 2, p. 123-131, 1960.

Techniques developed for preparing and applying strain gauges to the measurement and automatic recording of dynamic strain in both fresh-water and sea-water ice are described. Dynamic tests made on core samples to illustrate the successful application of strain gauges to ice samples are discussed. Results show that these techniques may be used to determine the physical properties of ice, such as the Poisson ratio and Young's Modulus, with considerable accuracy provided measurements are made under conditions of controlled temperature and with properly calibrated equipment. Further tests using these techniques under field conditions are planned. — V. S. N.

- 182-517. Butkovich, T. R. Mechanical properties of ice, in *Third symposium on rock mechanics*: Colorado School of Mines Quart., v. 54, no. 3, p. 349-360, 1959.

Ice is a substance which shows both plastic and elastic behavior when subjected to stresses of various kinds. Effects of the plastic-elastic behavior are discussed, and values of mechanical constants such as Young's modulus and viscosity coefficients, including results of laboratory and field studies, are presented for various types of ice. The mechanism underlying the deformation of ice under various conditions is indicated. The need for standardization of testing techniques is stressed. Ultimate strength, modulus of elasticity, and viscosity coefficients as functions of temperature, structure, orientation, and impurities are reviewed. — Author's abstract

- 182-518. Butkovich, T. R. On the mechanical properties of sea ice, Thule, Greenland, 1957: U. S. Army Snow, Ice, and Permafrost Research Establishment Research Rept. 54, 11 p., 1959.

This investigation of the mechanical properties of sea ice included tests of unconfined compressive strength, ring tensile strength, and flexural strength on simple beams for both horizontal and vertical test specimens; tests to determine the modulus of elasticity with the simple beams in flexure; and tests for creep in uniaxial compression. Results show a dependence of strength and creep on temperature and brine volume. Higher compressive, tensile, and flexural strengths, along with higher values of the elastic modulus were obtained at lower temperatures or brine volumes. The minimum creep rate decreases with decreasing temperature and brine volume. The data obtained are presented in tables in an appendix. — V.S.N.

- 182-519. Butkovich, T. R., and Landauer, J. K. The flow law for ice: U. S. Army Snow, Ice, and Permafrost Research Establishment Research Rept. 56, 7 p., 1959.

Results are reported of creep tests in a shear apparatus designed for both laboratory and field use on 2 samples of commercial ice, single crystals of artificial ice, and 6 types of ice from the Greenland Icecap at shear stresses of about 0.5-3 kg per cm<sup>2</sup>. Shear tests were supplemented by some uniaxial tests made at stresses from 6 to 28 kg per cm<sup>2</sup>. Creep data could be represented approximately by one or more linear sections on a log-deformation versus log-time plot. The linear sections of the double logarithmic curve imply a creep curve of the form  $\epsilon=ct^m$  where  $\epsilon$  is the strain. For all samples, except single crystals sheared in easy glide,  $m$  averaged 0.5 for shear deformations up to about 1 percent and approached unity with more deformation.

For single ice crystals oriented for easy glide (c-axis normal to direction of applied shear stress),  $m$  averaged 1.7 implying a strain softening. Except for single easy-glide crystals, the minimum creep rate was tangent to the deformation curve at the end of the experiment. Creep rates for single easy-glide crystals were several hundred times larger than for other crystals, the flow laws being similar. — V.S.N.

- 182-520. Kerr, Arnold D. Plastic deformation of floating ice plates subjected to static loads: U.S. Army Snow, Ice, and Permafrost Research Establishment Research Rept. 57, 10 p., 1959.

The problem of the effect of static loads on deformation of a floating ice-field is analyzed mathematically for decreasing and increasing rates of deflection. The analysis is based on the assumptions that for decreasing rates of deflection the floating ice plate will deform under lateral load without failure until the weight of the displaced water is equal to that of the load, and that for increasing rates of deflection the ice plate deforms until it collapses under and near the load. The total deflection at a certain time is the result of the elastic deflection surface and of the plastic deflection due to shear only—the shear forces obeying Newton's law of viscosity. Deflection equations for plastic deflection due to shear are derived for infinite plates subjected to a line load, to a concentrated force, and to a uniform circular load. Equations for elastic deflection to be added to the plastic deflection due to shear are suggested. The total system of an ice plate resting on a liquid base can be considered as a Kelvin body for the case of decreasing rates of deflection. — V.S.N.

- 182-521. Tabata, Tadashi. Studies on mechanical properties of sea ice, II and III. Measurements of elastic modulus by the lateral vibration method [in Japanese with English summary]: [Hokkaido Univ.] Low Temperature Sci., ser. A, no. 17, p. 147-166, 1958 (II); ibid, ser. A, no. 18, p. 115-129, 1959 (III).

In part 2, the elastic modulus of sea ice at various temperatures between  $-4^{\circ}\text{C}$  and  $-36^{\circ}\text{C}$  was obtained by using the lateral vibration method with a rectangular ice beam; a formula (to be used only when the thickness of the beam is very small compared with its length) is presented for calculating this value. The elastic modulus is controlled by changes in density or porosity and not by grain size or by chlorine content of the ice. It decreases as porosity increases.

Using the volume of pure ice within sea ice, the elastic modulus of sea ice within the temperature range  $-5^{\circ}\text{C}$  to  $-35^{\circ}\text{C}$  is calculated as follows:  $E=8.9 + 0.02t - 0.28(100-a) \times 10^{10}$  cgs, where  $t$  is absolute value of temperature,  $a$  is volume of pure ice and  $a=100-(n+n_0)$  percent. The volume of brine  $n_0$  percent and porosity  $n$  percent are effected by chlorine content, temperature, and density and are calculated by equations presented in the paper. The velocity of the elastic waves as a function of density and temperature is calculated and illustrated in a figure.

In part 3, the elastic moduli of 39 samples of sea ice measured at various temperatures between  $-3^{\circ}\text{C}$  and  $-52^{\circ}\text{C}$  are given. The elastic modulus of each sample increases slightly with decrease of temperature and shows a remarkable change in temperature dependency at  $-8.2^{\circ}\text{C}$  and  $-23^{\circ}\text{C}$  where  $\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}$  and  $\text{NaCl} \cdot 2\text{H}_2\text{O}$  are crystallized respectively from the brine. The elastic modulus decreases rapidly with temperature rise above  $-20^{\circ}\text{C}$  and linearly with decrease in density of the samples. Although the elastic modulus of sea ice is dependent mainly upon temperature and density of ice, measurements on these samples show that the elastic modulus decreases with increase

in the volume of brine. The volume of brine is thus represented as a power function of temperature. — V. S. N.

## SUBMARINE GEOLOGY

- 182-522. Menard, H[enry] W. Sea floor relief: Am. Geophys. Union Trans., v. 41, no. 2, p. 274-275, 1960.

In the years 1957-60 the Aleutian, Middle America, Peru-Chile, Marianas, Puerto Rico, and South Sandwich Trenches have been surveyed or explored by precision sounding. The first five trenches have flat floors in some places, and the floor in the Aleutian Trench is continuously flat for more than 1,000 miles.

The North Atlantic has been found to consist of many topographic provinces parallel to and symmetrically disposed around the Mid-Atlantic Ridge. The crest of the ridge is marked by a median trough which is seismically active. The median rift continues into the Indian Ocean but appears to be absent in the Pacific except south of New Zealand; instead, the continuous East Pacific Rise is cut by fracture zones at approximately right angles to the general trend.

New seamounts are discovered on every expedition, but the number of guyots (drowned ancient islands) has not increased significantly in the 14 years since they were discovered; the latter appear to be characteristic only of the central western Pacific Ocean, although small groups exist in all the oceans.

Studies of abyssal plains confirm the turbidity current theory of their origin. Abyssal hills have been found to have a greater geographic extent than any other topographic form on earth, but their origin is still unknown. — D. B. V.

- 182-523. Emery, K. O. Basin plains and aprons off southern California: Jour. Geology, v. 68, no. 4, p. 464-479, 1960.

Precision echo soundings made across the submarine basins off southern California show that parts of their floors are remarkably smooth and horizontal. Fringing these flat areas are larger areas which have gentle slopes and extend to the basin sides. Where submarine canyons reach from near the shore to the basins, the upper parts of the gently sloping plains take the form of submarine fans. Physiographic and sedimentary evidence indicate that turbidity currents flow from the canyon mouths and deposit most of their load of sediment on the submarine fans and on the aprons beyond them. As the basins become filled with sediments from turbidity currents, from suspension in the whole water column, and from marginal mass movements, the sediments spill from basin to basin in a manner analogous to the prograding of alluvial deposits in the block-faulted desert region of the Western United States. — V. S. N.

- 182-524. Hill, M[aurice] N[eville]. A median valley of the Mid-Atlantic Ridge: Deep-Sea Research, v. 6, no. 3, p. 193-205, 1960.

A median valley of the Mid-Atlantic Ridge at least 75 miles in length running in a north-south direction is described. Its bottom lies at a depth between 1,800 and 2,200 fathoms, and the flanks rise steeply to between 900 and 1,200 fathoms. The width between the flanks is approximately 12 miles.

No direct evidence of the rock types in the area is available, but the seismic evidence suggests the existence of basaltic lavas on the flanks. Evidence for present-day volcanic activity in the area comes from a measurement of the heat flow through the floor of the valley; this was about six times higher than is usual in deep sea or continental areas.

The valley was not associated with any large magnetic anomaly; it is however possible that its axis corresponds with the line of earthquake epicenters through the area. — Author's abstract

- 182-525. Lacombe, H. Quelques traits remarquables du relief sous-marin en Mer Méditerranée et en Mer Noire [Some remarkable characteristics of submarine relief in the Mediterranean Sea and in the Black Sea (with English abstract)]: Deep-Sea Research, v. 6, no. 3, p. 211-216, 1960.

Soundings obtained in July and August 1955 show the existence of depths of 5,000 m south of continental Greece in the Ionian Sea and of ripple marks 40 m in height in regular depths of 1,900 m off the Bosporus in the southern Black Sea. — V. S. N.

- 182-526. Hayter, P. J. D. The Ganges and Indus submarine canyons: Deep-Sea Research, v. 6, no. 3, p. 184-186, 1960.

Two submarine canyons near the mouths of the Ganges and Indus Rivers, known as the Swatch of No Ground and the Swatch, respectively, have been located by hydrographic surveys. Only 25 miles of the head of the Swatch of No Ground, which appears to lead into the Passur River, has been surveyed, but it probably extends another 45 miles southward before debouching onto the floor of the Bay of Bengal. A flat channel with leveed sides, located in the center of the Bay of Bengal 900 miles south of the mouths of the Ganges, may have been formed by turbidity currents from the Swatch of No Ground (Dietz, 1953).

The Swatch debouches onto the floor of the Arabian Sea without any marked fall. At this point it is bell-shaped and about 10 miles wide. — V. S. N.

Raitt, Russell W. Marine seismic studies. See Geophys. Abs. 182-500.

Mason, R. G. Geophysical investigations of the seafloor. See Geophys. Abs. 182-349.

Malurkar, S. L. Microseisms and exploration of submarine anomalies. See Geophys. Abs. 182-443.

#### VOLCANOLOGY

- 182-527. Friedman, Irving. Volcanological observations: Am. Geophys. Union Trans., v. 41, no. 2, p. 281, 1960.

A geochemical laboratory has been established at the Hawaiian Volcano Observatory, and during the recent (1959-60) eruption of Kilauea a round-the-clock program of gas sampling, daily analysis of the changing lavas, and geophysical and geological observations was in force. Seismograph and tiltmeter observations gave reliable warnings of impending outbursts.

Other recent volcanological work in the United States has included an attempt to correlate the chemical composition of volcanic and other thermal waters with their geologic history. Deuterium and oxygen-18 are used as natural tracers for an independent approach to determine the origin and history of thermal waters. — D. B. V.

- 182-528. Rittmann, A[lfred]. Vulkane und ihre Tätigkeit [Volcanoes and their activity]: Stuttgart, Ferdinand Enke Verlag, 336 p., 1960.

This is a revised and enlarged second edition of Rittmann's classic work on volcanoes, the first edition of which was published in 1936. The main sections of the book deal with volcanic activity; the products of volcanoes; the form and structure of volcanoes; volcanism and tectonics; the physicochemical properties of magma; the magma chamber; the eruptive mechanism; orogenesis, epeirogenesis, and volcanism; and the nature of volcanism. — D. B. V.

- 182-529. Thorarinsson, Sigurdur. Die Vulkane Islands [The volcanoes of Iceland]: Naturw. Rundschau, v. 13, no. 3, p. 81-87, 1960.

There are 150-200 postglacial volcanoes in Iceland. At least 30 of these have been active since Iceland was settled 1,100 years ago, and in the last two centuries an eruption has occurred on the average of every 5 years. The amount of lava issued has been the largest in the world, estimated as 16 km<sup>3</sup> or about a third of the world total since A. D. 1500. Almost all types of volcanoes known elsewhere are represented, and there are some that are unique to Iceland. Examples of the different types, including pseudocrater groups, are discussed briefly and illustrated by photographs and sketches. — D. B. V.

- 182-530. Ma, Ting Ying H., and Pan, Chia-Lin. Volcanic belts discussed with respect to the shifting of crustal masses due to the Cenozoic sudden total displacements of solid earth shell: Internat. Geol. Cong., 20th, Mexico City, 1956, Vulcanologia del Cenozoico, sec. 1, v. 1, p. 9-17, 1957.

Based on the relative shifting of crustal masses due to the total displacements of the solid earth shell, the appearance of the Cenozoic volcanic belts can be attributed to reduced pressure where the earth crust is (1) folded in front of a moving crustal mass or assemblage of crustal masses of continental scale, (2) crumpled between crustal masses running into each other or one into the other, and (3) loosened behind a moving crustal mass.

The drifting of continents into the Pacific resulted in the Cenozoic volcanic belts encircling that ocean. The collision of continents resulted in the East and West Indies, the Himalaya-Assam, and the Alpine volcanic belts. The moving away of continents resulted in the volcanic belts in the Indian Ocean area and along the mid-North Atlantic ridges.

Rotation of a continent also causes volcanic belts. The rotation of Africa clockwise resulted in the volcanic belt along the mid-South Atlantic ridges. The rotation of Australia counterclockwise resulted in the Melanesian volcanic belts and the Tonga-Kermadec volcanic belt. — Authors' abstract

- 182-531. Richards, A[drian] F. Volcanism in eastern Pacific Ocean basin: 1945-1955: Internat. Geol. Cong., 20th, Mexico City, 1956, Vulcanologia del Cenozoico, sec. 1, v. 1, p. 19-31, 1957.

During the last decade active volcanism, exclusive of fumarolic activity, in the eastern Pacific basin appears to have been confined to the Islas Revillagigedo of Mexico and the Islas Galapagos of Ecuador.

In the Revillagigedo a new volcano named Barcena was born on Isla San Benedicto August 1, 1952. A cinder cone 390 m high formed by August 12, trachyte was extruded into the crater in November, and a delta of lava developed between December and February 1953. Large crater solfataras became inactive in 1954.

In the Galapagos, volcanic activity was limited to Isla Isabela (Albemarle Island). Flank and (or) crater eruptions occurred on Volcan Wolf, Volcan Alcedo, Sierra Negra, and Cerro Azul between 1945 and 1955. Early in 1954

the shore of Bahia Urvina on the west flank of Volcan Alcedo was uplifted, apparently by the ascent of magma which was erupted in November. — Author's abstract

- 182-532. Sirin, A. N., and Timerbayeva, K. M. Izversheniye Koryakskogo vulkana v nachale 1957 g. [Eruption of Koryakskiy volcano in the beginning of 1957]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta., no. 28, p. 3-20, 1959.

Koryakskiy volcano in Kamchatka, dormant since 1896, began to erupt late in 1956. Data on the beginning of the eruption are scanty. According to local inhabitants white fumarolic clouds appeared in September and October, and in the beginning of November a gray gas column rose above the summit. The amount of smoke and gas steadily increased until in the second half of December the cloud was several hundred meters high. At the end of December the violence of gas emission increased, and cracks appeared on the flanks of the volcano; their formation was accompanied by short-period volcanic tremors registered at the Petropavlovsk seismic station on December 24 and 25. Ash fell to the west of Koryakskiy on January 17 or 18, 1957; the cloud by that time was 1,600-1,700 m high.

Day-by-day observations made from January 20 to March 15 are tabulated. The activity was purely explosive. Two maximums of activity occurred, one at the end of January and a smaller one early in February.

The timing of the explosions, ash falls and gas avalanches that followed closely after bursts of dark gray to black material, and sound and light effects accompanying the eruption are discussed, and the mineralogic and chemical composition of the ejecta are described.

This activity of Koryakskiy was part of a general increase in activity of the volcanoes of the east coast of Kamchatka. Activity of Zhupanovskiy and Dzenzurskiy was resumed and that of Karymskiy increased moderately. The state of the last two as observed from the air on January 28, 1957, is mentioned briefly. — D. B. V.

- 182-533. Gushenko, I. I. Sostoyaniye Koryakskogo vulkana v aprele-maye 1957 g. [The state of Koryakskiy volcano in April-May 1957]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta., no. 28, p. 21-22, 1959.

Koryakskiy volcano was observed for 30 out of the 44 days from April 11 to May 24, 1957. During that period there were rather intensive emissions of gases from a new subterminal fissure on the northwest flank at an elevation of 2,700-2,800 m. Spurts of dense snow-white gas usually rose about 400-500 m above it. Activity was somewhat intensified on April 14 when a little ash was emitted; a dark-gray gas plume 10 km long rose 1.5-1.8 km above the fissure. The next day activity diminished sharply. — D. B. V.

- 182-534. Namba, Munetosi. Some studies on Volcano Aso and Kuju (Pt. 15). On the explosion of Volcano Aso in 1958: Kumamoto Jour. Sci., ser. A, v. 4, no. 1, p. 58-69, 1959.

When Aso Volcano, Kyushu, Japan is in an active phase, it often erupts following a severe nearby earthquake. On June 19, 1958, severe earthquakes occurred in the Ariake Bay area about 40 km from Mt. Aso and on June 24 a severe explosion occurred in the first crater of Mt. Aso. A total of about  $8 \times 10^5$  tons of ashes were ejected with a total energy of explosion of about  $3.1 \times 10^{19}$  ergs. Tilting at Mt. Aso during the year preceding the eruption was predominately in the north-south component; the eruption in June followed an extraordinary rise in the north component. — V. S. N.

- 182-535. Matsumoto, Hatao, and Tanaka, Seizo. The 1958 activity of the Aso Volcano: Kumamoto Jour. Sci., ser. A, v. 4, no. 2, p. 151-157, 1959.

The eruption of Aso Volcano on June 24, 1958, occurred without prior seismic or other warning. The activity was in vent 1 of the 4 vents in the active cone, Naka-dake, which rises from the center of this gigantic caldera. This was the first major eruption of the volcano in 25 years. The amplitude of the explosion was recorded as 84 mu; 50,000 tons of old ejecta from the vent and volcanic ash were thrown distances up to 13 km; and the ejected ash deposited on the west side of the crater reached about 70 cm in thickness. Following this eruption, the crater was quiet until September 29; activity was then renewed with eruptions occurring at intervals of 2-15 seconds and continuing until November 7. These eruptions of ash and lava were Strombolian in type and had an amplitude of 2-4 mu.

Analysis of the halogen content of the gas and ejecta from the various eruptions showed that the quantities of fluorine and chlorine were very large; the halogen content increased as the activity progressed in the volcano, and it is possible that the ratio of fluorine to chlorine may be used as a guide for forecasting volcanic activity. — V. S. N.

- 182-536. Sekiya, H. An analysis of volcanic activity of Mt. Asama (2d paper)—On volcanic activity in 1958 (in Japanese with English abstract): Quart. Jour. Seismology [Tokyo], v. 24, no. 4, p. 91-101, 1960.

Mt. Asama, rather quiet since June 1955, resumed activity in February 1958. By mid-March, swarms of type A microearthquakes were occurring from time to time; by late July, the duration of the preliminary tremor of these microtremors was 1.3-1.5 sec, the number of microvolcanic tremors of type B near the crater increased, and rumblings were heard near the crater. A slight eruption on October 10 marked the beginning of a period of markedly frequent earthquakes of larger amplitude, a series of tremors with periods of 0.8-1.5 sec, and frequent eruptions of Mt. Asama. On November 10, a great explosion with an estimated kinetic energy of about  $7 \times 10^{19}$  ergs occurred. Since November 1958, explosions of moderate intensity have continued to occur intermittently at mean intervals of 9 to 14 days. (See also Geophys. Abs. 178-433.) — V. S. N.

- 182-537. Taylor, G. A. The 1951 eruption of Mount Lamington, Papua: Australia Bur. Mineral Resources, Geology and Geophysics Bull., no. 38, 117 p., 1958.

Reactivation of Mount Lamington, lat  $8^{\circ}56' S.$ , long  $148^{\circ}10' E.$ , on the north coast of Papua, began with 6 days of preliminary phenomena consisting of landslides in the crater area, earthquake swarms, and emissions of gas and ash; it culminated in a catastrophic explosion of Peléan type on January 21, 1951. The nuée ardente produced completely devastated a surrounding area of 68 sq mi and killed 3,000 people. In March the large dome that had been rising in the crater since January was explosively destroyed. Activity then became predominantly effusive, and a second period of dome building ensued lasting for  $1\frac{1}{2}$  years; this dome was typical of the Peléan type and grew to 1,850 feet in height.

The distribution of the ash suggests that powerful vulcanian explosions or sustained mobility in a nuée ardente may upset the conventional thickening of deposits close to the crater. Observation of draining of ash flows from the upper part of their course throws doubt on the validity of Lacroix' principal argument for the occurrence of horizontally directed explosions of Peléan type volcanoes.

The broad picture of events in adjacent island regions suggests that the Mount Lamington eruption was triggered by a crustal stress pulse. The stress pulse was manifest in an increase in frequency of tectonic earthquakes and reactivation of volcanic centers in New Guinea, the Solomon Islands, and the New Hebrides. Tilt measurements, started in April, suggested swelling of the mountain before the main extrusive movements. During critical conditions of its activity the volcano responded to tidal effects of the sun and moon; intense activity near positions of maximum lunar declination suggested that the direction of the tractive force was as important as the magnitude of the tidal force. (See also Geophys. Abs. 168-325.) — V. S. N.

- 182-538. Minakami, Takeshi. The study of eruptions and earthquakes originating from volcanoes. Pt. 1, Some statistical relations between explosive eruptions and earthquakes of Volcano Asama: Volcanol. Soc. Japan Bull., ser. 2, v. 4, no. 2, p. 104-114, 1959.

This is the first report from a series of studies, based on seismometric investigations, of the relationship between eruptions and earthquakes at various volcanoes in Japan. In general the seismic activities preceding an eruption depend not only on the magnitude of the eruption and the structure of the volcano but also on the viscosity of the lava at the time of eruption. The more viscous the lava, the greater the resistance in elevating it from the magma chamber to the earth surface, and, consequently, the greater the stress produced in and under the volcano.

A statistical study of the relationship between the frequency of earthquakes and the explosive eruptions of Volcano Asama is reported as observed by seismographs of comparatively low magnification ( $T=1.0$  sec,  $V=350$ ) at the Asama Volcano Observatory, 4.2 km east of the center of the summit crater. An experimental formula based on this statistical relationship is presented for use in predicting eruptions of Asama. Most explosive eruptions of Asama are preceded by an increase in unfelt earthquakes. — V. S. N.

- 182-539. Minakami, Takeshi; Hiraga, Shiro; Uchibori, Sadao; and Miyazaki, Tsutomu. The study of eruptions and earthquakes originating from volcanoes. Pt. 2, Some contribution to prediction of explosive eruption of Volcano Asama: Volcanol. Soc. Japan Bull., ser. 2, v. 4, no. 2, p. 115-130, 1959.

The relationship between the frequency of earthquakes and the large number of explosive eruptions at Asama Volcano from 1954 to 1957 was studied statistically, and experimental formulas derived from this relationship for the prediction of eruptions are given. The earthquakes originating at Asama are mainly those recorded by transducers set at two stations, 0.9 km and 2.5 km from the crater. Seismographs were adjusted to a magnification of 4,000 of the displacement amplitude, which ranged from 0.3 to 0.7 sec of the vibration period.

In August 1958 a remarkable increase in earthquake activity occurred at Asama. The experimental formulas were applied, and in September warnings were issued of a possible explosion of Asama. The first eruption in the 1958 activity took place one month after the warning; thus, it is felt that seismometrical observations using various magnifications are useful for prediction of volcanic eruptions at Asama and also for volcanoes with ejecta consisting of andesitic or dacitic lava. It is also noted that Asama and Sakura volcanoes are similar in the nature of earthquake motion and mode of seismic activity, in chemical and physical properties of erupted lava, and in the position and nature of eruption. — V. S. N.

- 182-540. Minakami, Takeshi; Sakuma, Shuzo; Mogi, Kiyoo; and Hiraga, Shiro. The study of eruptions and earthquakes originating from volcanoes. Pt. 3, Relation between depth of volcanic earthquakes and subsequent volcanic phenomena: Vulkanol. Soc. Japan Bull., ser. 2, v. 4, no. 3, p. 133-151, 1960.

Seismograph observations at Asama for the last 25 years show that the earthquakes occurring at the volcano were mainly of the B-type, that is, extremely shallow earthquakes with epicenters concentrated near the summit crater. Earthquakes with hypocenters deeper than 1 km were rare during the period. It was observed that B-type earthquakes, classified according to hypocentral depth, could be related more or less closely with the respective volcanic phenomena. The B-types which preceded the violent eruption of November 10, 1958, were of the shock type and were extremely shallow as compared with those occurring in the calm state, and those which occurred in a swarm soon after the strong eruptions in December 1958 were not only deeper than those preceding the eruptions but also deeper than those which occurred in the calm state. Probably a close connection can be established between the frequency of the B-type earthquakes and the eruption of the volcano.

At the beginning of the 1943-45 activity of Usu Volcano, A-type earthquakes were predominant in frequency and intensity. However, B-type earthquakes started before the beginning of eruptions and increased by degrees while the A-type decreased in frequency. Thus the position of the hypocenter moved toward the earth's surface as activity of the volcano increased.

It is concluded that prediction of time, place, and nature of volcanic eruptions should be made by a study not only of the total frequency of volcanic earthquakes but also of the depth of the hypocenters and of the movement of the hypocentral positions. — V. S. N.

- 182-541. Mériel, Yves. L'energie geothermique [Geothermal energy]: La Nature, no. 3292, p. 356-362, 1959.

The utilization of geothermal energy for power in Iceland, Italy, and New Zealand is reviewed, and several excellent photographs depict installations in Italy and New Zealand. — J. W. C.

- 182-542. Nekhoroshev, A. S. Gidrotermal'naya deyatel'nost' rayona khrebt-a Kambal'nogo na yuzhnay Kamchatke [Hydrothermal activity in the Kambal'nyy Range area in southern Kamchatka]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta., no. 28, p. 23-32, 1959.

The hydrothermal activity in the Kambal'nyy Range is manifested only as emissions of dense, high-temperature gas and steam clouds. The absence of thermal springs is attributed to unfavorable hydrographic conditions. The three hydrothermal fields of the northern Kambal'nyy group and the three fields of the southern group are described, and chemical analyses of the gases from both groups are given. — D. B. V.

- 182-543. Markhinin, Ye. K. Vykhody para na o-be Kunashir (Goryachiy Plyazh) [Emissions of steam on Kunashiri Island (Hot Beach)]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta., no. 28, p. 33-42, 1959.

An area of hot springs and intensive steam emissions known as "Hot Beach" occurs on the Pacific Ocean shore of Kunashiri Island in the Kuriles near the foot of Mendeleyev Volcano. The temperature of the hot springs is 99°C, and that of the steam is 100°C (both at the surface and in borings 1.5-2 m deep). The geology of the area is outlined, the results of a temperature survey of the beach are plotted on a map, chemical analyses of the waters and gases are given, and the probable source of the heat is discussed.

The possibilities of further geothermal development of the area are considered promising, not only for balneological purposes but also for domestic heating, as the beach is only 7 km from the city of Yuzhno-Kuril'sk. — D. B. V.

- 182-544. Nakamura, Hisayoshi, and others. Relation of the geological structure to the occurrence of natural steam in the Onikobe Basin, Miyagi Prefecture [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 10, no. 7, p. 575-600, 1959.

Subsurface geological surveys, analyses of fumarolic gases and thermal waters, two test drill holes, and electrical and geochemical logs were made in the Onikobe Basin, Miyagi Prefecture, Japan, over a period of 3 years to study the relation of the geological structure to the occurrence of natural steam. The basin consists of Tertiary green tuff and granite overlain by lake deposits and younger dacite flows. Hot springs issue from the lake deposits; their distribution, however, is controlled by the geologic structure of the northeast and northwest trending basement rocks. The hot springs enclose a fumarolic area which is located in explosion craters formed by the volcanic action of the younger dacite.

Results from the geochemical and electric logs and from the temperature gradient recorded in the drill holes indicate that an agglomerate formation in the lake deposits acts as a cap rock for the natural steam which accumulates in a reservoir formed by the fractures in the basement rocks. In this respect the Onikobe Basin is similar to the Tuscany district in Italy where the natural steam has been utilized to produce electric power for industrial use. (See also Geophys. Abs. 178-258.) — V. S. N.

- 182-545. Ando, Takeshi. Ground water and hot springs in the Sambei volcanic area, Shimane Prefecture [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 10, no. 9, p. 785-799, 1959.

Underground water in the Sambei volcanic area is emitted at the boundary between loose volcanic materials and the granite forming the foundation rock of the volcano. The total discharge corresponds to 70-80 percent of the total rainfall in the area. The chemical character of hot springs in the area is remarkably different from that of hot springs in other Quaternary volcanic areas; the springs are characterized by high  $\text{Cl}^{-1}$  and  $\text{HCO}_3^{-1}$  and by strong radioactivity. — V. S. N.

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