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UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

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Geophysical Abstracts 176 January-March 1959

By DOROTHY B. VITALIANO, S. T. VESSELOWSKY, *and others*

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GEOPHYSICAL ABSTRACTS 176, JANUARY–MARCH 1959

By DOROTHY B. VITALIANO, S. T. VESSELOWSKY, and others

INTRODUCTION

EXTENT OF COVERAGE

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

Abstracts are prepared only of material that is believed to be generally available. Ordinarily abstracts are not published of material with limited circulation (such as dissertations, open-file reports, or memoranda) of or 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.

LISTS 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.

The following references cited in Geophysical Abstracts 176 are not included in this master list:

British Solomon Islands Geol. Survey Mem.—Geological Survey of the British Solomon Islands Memoir. London.

Inst. Antartico Argentino pub.—Instituto Antartico Argentino publicacion [Argentine Antarctic Institute publication]. Cordoba, Argentina.

Ministerstvo vysshego obrazovaniya SSSR, Izvestiya vysshikh uchebnykh zavedeniy, Geologiya i razvedka [Ministry of higher education of the U.S.S.R., Bulletin of schools for higher education, Geology and prospecting]. Moscow.

Missouri Geol. Survey and Water Resources, Rept. Inv.—State of Missouri Department of Business and Administration, Division of

Geological Survey and Water Resources, Report of Investigation. Rolla, Missouri.

Okayama Univ. Balneological Lab. Repts.—Reports of the Balneological Laboratory of Okayama University. Misasa Hot Springs, Japan.

Utah Acad. Sci., Arts, and Letters Proc.—Proceedings of the Utah Academy of Arts, Sciences, and Letters. Logan, Utah.

FORM OF CITATION

The abbreviations of journal titles used are those adopted by the U.S. Geological Survey and used 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 on Geographic Names. This system of transliteration for Russian is given in Geophysical Abstracts 148 (January–March 1952, Bulletin 991–A) and in the new "List of Journals" announced above. Titles of papers in Japanese and Chinese are given in translation only.

ABSTRACTORS

Abstracts in this issue have been prepared by Henry Faul, R. G. Henderson, Anna Jespersen, G. E. Manger, Virginia S. Neuschel, L. Peselnick, and A. J. Shneiderov, as well as by the principal authors. Authors' abstracts are used in many instances. The initials of an abstractor following the notation "Author's abstract" indicates a translation from the original language.

AGE DETERMINATIONS

176–1. Mayne, K. I., Lambert, R. St. J., and York, D. The geological time-scale: Nature, v. 183, no. 4656, p. 212–214, 1959.

A new absolute time scale is drawn up on the basis of 17 age determinations on samples chosen because of their well-defined stratigraphic position. A systematic divergence from Holmes' time scale appears. An extension of the Holmes' scale appears necessary.—*D. B. V.*

176–2. Voitkevich, G. V. Yedinaya geokhronologiya dokembriya [Unified geochronology of the Precambrian]: Priroda, no. 5, p. 77–79, 1958.

Age determinations on minerals from various parts of the world and on meteorites have established the following subdivisions of Precambrian time: 4,550±70 million yr as the age of the earth (from lead in meteorites); oldest lead mineralization, 3,350 million yr ago and "Chambayanskiy" orogeny, 2,650 million yr ago, both in lower Archean time; "Svekofennskiy" orogeny, 1,800 million yr ago in upper Archean; Grenville orogeny, 1,030 million yr ago in lower Proterozoic; "Indo-oceanic" orogeny, 550 million yr ago in upper Proterozoic.—*D. B. V.*

176–3. Perrin, René, and Roubault, Marcel. Remarques sur les déterminations d'âge des minéraux et des roches à l'aide de minéraux radiogéniques [Remarks on the age determinations of minerals and rocks by means of radiogenic minerals] : Acad. Sci. Paris Comptes Rendus, v. 248, no. 7, p. 881–883, 1959.

The validity of age determinations based on radiogenic minerals depends on two conditions, namely, that no radiogenic element was present at the time of formation of the minerals, and that no introduction or loss of radiogenic elements took place subsequently, particularly by alteration. In the case of zircons, for instance, it is pointed out that some radiogenic lead and uranium, separated by alteration and leaching during the metamorphism or granitization, could become incorporated into crystallizing zircon to add their effect to that of disintegration subsequent to crystallization. Since the radiogenic lead is more easily leached than uranium, this ought to result in enrichment in lead and age determinations greater than the age of the earth. As this is not actually the case, zircon must incorporate uranium selectively into its lattice, and the lead must enter other minerals; possibly this might help to explain the formation of anomalous leads.

Another possibility to be taken into account in dating zircons is the fact that a crystal formed in an earlier metamorphism or granitization might become incorporated in a younger granite. Careful study of the geologic relationships is necessary to avoid error in this case.—*D. B. V.*

176–4. Dicke, R. H. Dirac's cosmology and the dating of meteorites: Nature, v. 183, no. 4655, p. 170–171, 1959.

An argument based on Mach's principle has been used to support Dirac's cosmogonic hypothesis which involves a varying gravitational constant (see Geophys. Abs. 176–179, and 180), and hence by implication also the β-decay constant. If the hypothesis is correct, the rate of β-decay should vary with time as t^{-n}, with $\frac{1}{4}<n<\frac{1}{2}$. Therefore a discrepancy should appear in ages determined by β-decay compared with those determined by α-decay.

The correspondence between α- and β-decay ages is calculated, using Sandage's new estimate of the age of the universe as 13×10^9 yr, in order to see if available data on meteorite ages can be used to test the hypothesis. It is found that for meteorite ages as great as $\approx4.5\times10^9$ yr there is a more noticeable discrepancy than for rock ages of less than 2.8×10^9 yr. Unfortunately there is reasonable doubt as to the accuracy of ages based on lead ratios and on the argon method. It is concluded that there is no present evidence sufficiently reliable to rule out the possibility of a variation with time in the β-decay rate.—*D. B. V.*

176–5. Olson, Edwin A., and Broecker, W. S. Sample contamination and reliability of radiocarbon dates: New York Acad. Sci. Trans., v. 20, no. 7, p. 593–603, 1958.

A few out of the several thousand radiocarbon measurements reported as accurate estimates of absolute age of events during the last 40,000 yr, are clearly anomalous. The source of error most probably lies in the basic assumption of the radiocarbon method that the carbon-14 concentration in the carbon of the sample has not been altered since formation by any process other than radioactive decay. There are several ways by which a sample's isotopic composition can be altered, the most important of which is by contamination with foreign carbon of different carbon-14 concentration. The method of recognition of con-

tamination and chemical pretreatment to remove the contaminant is discussed and it is concluded that appreciable contamination of buried samples is the exception and that radiocarbon ages younger than 20,000 yr are more likely to be correct than in error even with no pretreatment; that samples with ages beyond 25,000 yr are subject to question until evidence is presented to show no contamination or removal of contamination; that ages in error because of contamination will probably be less than the true ages; and that efforts to extend the dating range of radiocarbon counters must be accompanied by development of techniques for detection and removal of contamination.—*V. S. N.*

176–6. Flint, Richard Foster, and Gale, W. A. Stratigraphy and radiocarbon dates at Searles Lake, California: Am. Jour. Sci., v. 256, no. 10, p. 689–714, 1958.

Upper units of the strata beneath Searles dry lake, in a desert basin in southeastern California, record two deep lakes each followed by precipitation of evaporites and at least near-desiccation. Each lake is thought to imply a pluvial climate; the time of near-desiccation represents the warmer, drier, nonpluvial climate of today. Carbon-14 dates of samples from these strata show that the later of the two pluvial climates lasted from before 23,000 to ≈10,000 yr B. P.; it was therefore contemporary with the classical Wisconsin glaciation of the central United States. The earlier pluvial had been well established by ≈46,000 yr B. P. and had begun to wane before ≈32,000 yr B. P. The later history of the lake in the Searles basin is in agreement with the published data on the later history of Lakes Bonneville and Lahontan. Still earlier lake fluctuation can be discerned in underlying strata, but these are not controlled by dates.—*Authors' abstract*

176–7. Tauber, H[enrik], and de Vries, H[l]. Radiocarbon measurements of Würm-interstadial samples from Jutland: Eiszeitalter und Gegenwart, v. 9, p. 69–71, 1958.

The radiocarbon content of Würm-interstadial samples from Brörup, Jutland, has been measured in the dating laboratories in Copenhagen and Groningen. The samples were contaminated with comparatively large amounts of infiltrated younger material, but after an extraction of humic acids none of the samples showed a significant activity. This means that the interstadial at Brörup and the preceding cold period are older than 50,000 B.C. If Anderson (1957) is right in correlating the Brörup interstadial with the "Göttweig Interstadial" this implies that Old Würm and at least the lower part of the Göttweig interstadial also should be older than 50,000 B.C.—*Authors' summary*

176–8. Brinkmann, R., Münnich, K. O., and Vogel, J. C. C^{14}- Alterbestimmung von Grundwasser [C^{14} age determination of groundwater]: Naturw., v. 46, no. 1, p. 10–12, 1959.

The age of samples of ground water from different springs near Cologne, Germany, and from a mine in the Harz, determined from the carbon-14 content, ranges from 0 to 10,500 yr. Considerable uncertainty exists, due to the fact that the percentage of carbon-14 can be lowered, and therefore the apparent age increased, due to original contamination with other waters, to subsequent exchange with carbon-14–free limestone, to exchange or admixture with magmatic CO_2, or to CO_2 exchange due to oxidation of lignite or other organic sub-

stances. Determination of stable isotope carbon-13 eliminates the first and third of these possibilities as sources of error. (See also Geophys. Abs. 168–204.)—*D. B. V.*

176–9. Harrington, H. J., and McKellar, I. C. A radiocarbon date for penguin colonization of Cape Hallett, Antarctica: New Zealand Jour. Geology and Geophysics, v. 1, no. 3, p. 571–576, 1958.

During maxima of ice advances in the Last Glaciation, 10,000 to 30,000 years ago, the Ross Sea was filled by ice, so penguin colonization of shoreline breeding sites must have occurred since that time. The age of a frozen Adelie penguin body from the base of an accumulation of penguin bodies and guano at the Cape Hallett rookery has been determined by the radiocarbon method as 1,210±70 years. The rookery was probably colonized between about 400 and 700 A.D., at approximately the same time as a Northern Hemisphere warm period that stimulated a Viking expansion. There is no sign that it was temporarily abandoned at the time of a Northern Hemisphere cold period between 1650 and 1750 A.D.—*Authors' summary*

176–10. Amirkhanov, Kh. I., Brandt, S. B., and Bartnitskiy, Ye. N. K opredeleniyu absolyutnogo vozrasta kaliyevykh polevykh shpatov argonovym metodom [On the determination of the absolute age of potash feldspars by the argon method]: Akad. Nauk SSSR Izv. ser. geol., no. 11, p. 110–112, 1958.

Loss of radiogenic argon in potash feldspars takes place from unstable zones within the mineral; if argon and potassium could be removed from these unstable zones, a potassium-argon determination on the remaining stable parts should give the true age of the sample. The argon is easily removed by heating to low temperatures. This paper is a brief report on work testing a method of removing potassium, using samples of Precambrian potash feldspar from Karelia and of a phlogopite mica.

Samples ground to 0.03–0.05 mm and finer were treated with thallium nitrate solution under both normal and high temperatures and pressures. The results show that the replacement of potassium by thallium depends on pressure alone. Ages were calculated for the feldspar as follows: before treatment, $1{,}375\times10^6$ yr; after treatment (0.03–0.05 mm fraction), $1{,}650\times10^6$ yr; after treatment (<0.03 mm fraction), $1{,}800\times10^6$ yr. The method should be suitable for many other minerals and rocks.—*D. B. V.*

176–11. Evernden, J[ack] F[oord], Curtis, G[arniss] H., and Kistler, R. Potassium-argon dating of Pleistocene volcanics: Quaternaria, v. 4, p. 13–17, 1957.

Preliminary work indicates that the potassium-argon dating method may provide absolute dates throughout the Pleistocene, that is, in the range of 50,000 to 1,00,000 yr. The major problem to be solved is that of contamination caused by the absorption of atmospheric argon on the surfaces of the crystal grains used for dating purposes. Experiments for the removal of this atmospheric argon in the case of potassium feldspars and micas are discussed and the results of dating of sanidine from the Laacher See phonolite and from the Bishop tuff are given. Results indicate that some evidences of mountain glaciation are to be correlated with events of at least 900,000 yr ago and that the last phase of Elster glaciation is on the order of 350,000 to 400,000 yr ago.—*V. S. N.*

176–12. Burwash, R. A. Age of the Alberta Precambrian basement: Alberta Soc. Petroleum Geologists, v. 6, no. 9, p. 214–217, 1958.

Recent potassium-argon dating of biotites from basement cores of wells in Alberta has given ages ranging from 1,600 to 2,000 million yr, with most samples ranging from 1,800 to 2,000 million yr. The few dates which do not fit the latter range are believed to be low due to argon loss from the biotite since crystallization. In 1957 Burwash (see Geophys. Abs. 168–135) proposed a post-Tazin mountain belt along the western margin of Alberta to be designated as the Peace River orogenic belt. On the basis of the recent dating, the Peace River orogenic belt is discarded and a large part of the Precambrian basement of Alberta is assigned to the Churchill geologic province extending from Hudson Bay to the Rocky Mountain trench.—*V. S. N.*

176–13. Herz, Norman, and Dutra, C. V. Preliminary spectrochemical and age determination results on some granitic rocks of the Quadrilátero Ferrífero, Minas Geraes, Brazil: Soc. Brasileira Geologia, v. 7, no. 2, p. 81–95, 1958.

Trace elements have been used to classify the granitic rocks of the Quadrilátero Ferrífero in Minas Geraes, Brazil, into five distinct groups. In the first three, correlations can be made of rocks separated by great distances and by other intervening formations; in the last two, trace elements suggest a single mode of origin for rocks of different age or appearance or both.

A tentative argon age determination dates one of the samples in Group I (Prado Lopez quarry, Belo Horizonte) as $1{,}260\times10^6$ yr. Two samples in Group II, both from Itabira, gave tentative ages of 475–560 and 490×10^6 yr, respectively. Group III, similar to Group II in trace elements but showing certain significant differences, gave ages of $475\text{–}500\times10^6$ yr (Peti Dam) and 555×10^6 (Ibirité). Two rocks in Group IV gave ages of $720\text{–}760\times10^6$ yr (Cachoeira do Campo), $1{,}330\times10^6$ yr (Itabirito), and $2{,}440\text{–}2{,}520\times10^6$ yr (Engenheiro Correa); it is tentatively concluded that the later granites in this region represent a remobilization with no essential change of chemical composition. No age determinations are yet available on Group V.—*D. B. V.*

176–14. Krylov, A. Ya., Silin, Yu. I., and Lobtsyus, A. V. Vozrast granitoidov severnoy zony Tyan'-Shanya [Age of the granitoids of the northern zone of the Tien-Shan]: Akad. Nauk SSSR Doklady, v. 124, no. 3, p. 658–660, 1959.

Potassium-argon ages determined on granitoid rocks of the northern Tien-Shan mountains are compiled. Average age of the Proterozoic granitoids is about 500×10^6 yr, of Caledonian about 340×10^6 yr, and of Hercynian 260×10^6. Calculations were based on Gerling's value of the decay constant of K^{40} ($\lambda_k=7.02\times10^{-11}$ yr^{-1}); if the new value $\lambda_k=5.57\times10^{-11}$ yr^{-1} is used, the calculated ages would be 8 or 9 percent higher.—*D. B. V.*

176–15. Smolin, P. P. Slyudonosnyye pegmatity i absolyutnyy vozrast posleyurskikh intruziy Aldana [Mica-bearing pegmatites and absolute age of post-Jurassic intrusions of Aldan]: Akad. Nauk SSSR Izv. ser. geol., no. 1, p. 45–49, 1959.

Pegmatites, not heretofore known among the young intrusives of the Aldan region of the Yakutsk A.S.S.R., are described briefly. Potassium-argon determinations on 2 biotites, 1 orthoclase, and 1 anorthoclase give ages of 107, 120, 135,

and 135 million yr, respectively; together with geological observations, these indicate that the greater part of this magmatic complex is upper Jurassic in age.—*D. B. V.*

176–16. Aswathanarayana, U. Age of the samarskite of Kishengarh, Rajasthan, India: Geol. Soc. America Bull., v. 70, no. 1, p. 111–114, 1959.

Ages have been determined for samarskite and feldspar from a post-Delhi pegmatite from the Bajrang mine near Kishengarh in Rajasthan (Rajputana), India. The concentrations of uranium and lead in samarskite and of lead in the feldspar were determined by using isotope dilution techniques, and their isotopic compositions determined from mass-spectrometric data. The uranium-lead ages computed for the samarskite have an unusually small spread ($207/206=579\times10^6$ yr; $206/238=587\times10^6$ yr; $207/235=578\times10^6$ yr), hence an age of $580\pm20\times10^6$ yr can be given with confidence.

The lead ages of the feldspar ($206/204=1{,}200\times10^6$ yr; $208/204=200\times10^6$ yr; 207/204, $206/204=1{,}400\times10^6$ yr) are grossly discrepant. This is attributed to the fact that the lead in the feldspar is abnormal; its isotopic composition, having a marked deficiency in lead-206 and marked excess of lead-208, does not correspond with that of lead ore of the same age.

The age data permit the following explanation: both samarskite and feldspar crystallized 580 million yr ago, but the latter drew into its lattice lead evolved in a region which, for long periods in the past, contained abnormally high concentration of thorium and low concentration of uranium relative to lead; it remained "frozen" with this abnormal lead, as there was practically no subsequent contribution of lead from the negligible amounts of uranium and (or) thorium contained in the feldspar.—*D. B. V.*

176–17. Carroll, Dorothy. Zircon from a bentonite bed in Martinsburg shale (Ordovician) at Fisher's Hill, Virginia: Geol. Soc. America Bull., v. 70, no. 2, p. 223–224, 1959.

The apparent age of zircon in the heavy residue from a bentonite collected in the Martinsburg shale about two miles south of Strasburg, Virginia, has been determined by the lead-alpha method as 353×10^6 yr, which is in close agreement with the range obtained for igneous rocks of Ordovician age ($360–440\times10^6$ yr) on Holmes' time scale.—*D. B. V.*

176–18. Larsen, Esper S., Jr., Gottfried, David, Jaffe, Howard W., and Waring, Claude L. Lead-alpha ages of the Mesozoic batholiths of western North America: U.S. Geol. Survey Bull. 1070–B, p. 35–62, 1958.

The ages of some of the rocks from the four great groups of batholiths of western North America—Baja and Southern California, Sierra Nevada, Idaho, and Coast Range—have been determined by the ratio of lead content to alpha activity of the accessory minerals zircon, monazite, thorite, and xenotime. A suite of 10 intrusive rocks from Baja California, Guerrero, and Oaxaca, in Mexico has a mean age of 101 ± 5 million years; the batholith of Baja California has been determined as being of early Late Cretaceous age on the basis of stratigraphic and paleontologic evidence. Twenty-five age determinations on rocks from the batholith of southern California, ranging from tonalite to granite, give a mean age of 110 ± 13 million years; geologic evidence indicates that this batholith is early Late Cretaceous in age. Age determinations on 15 rocks from the Sierra Nevada batholith give a mean age of 102 ± 11 million years; on

geologic evidence the Sierra Nevada batholith is considered to be Late Jurassic. Age determinations on 16 rocks from the Idaho batholith average 108±12 million years; this batholith has been geologically dated as Cretaceous in age. Age determinations on 16 rocks of the Coast Range batholith including the batholiths of Washington, British Columbia, and Alaska, average 105±13 million years; these batholiths are believed to be equivalent in age to the Sierra Nevada batholith.

The ages of the four groups of rocks are the same—about 106±12 million years; they are all believed to be early Late Cretaceous. The time required for emplacement of the entire batholithic system is believed to be only a few million years. The batholiths make a discontinuous echelon group of intrusive bodies about 4,000 miles long and possibly much longer.—*Authors' abstract*

176–19. Deutsch, S[arah], and Longinelli, A. Âge des halos pléochroïques de quelques granites tertiares de la Toscane [Age of the pleochroic haloes of some Tertiary granites from Tuscany]: Experientia, v. 15, no. 1, p. 8–9, 1959.

The relative ages of two granites from the islands of Montecristo and Giglio in the Tuscan archipelago, Italy, and of the Gavorrano granite from the mainland of Tuscany have been determined by quantitative study of the pleochroic haloes in their biotite. The results show they are associated with different phases of Apennine folding, at intervals of the order of tens of millions of years. The Montecristo granite is comparable in age to the definitely Tertiary Elba granite, about $30\pm5\times10^6$ yr; the Giglio is younger, and the Gavorrano youngest.—*D. B. V.*

176–20. Oakley, Kenneth P., and Rixon, Arthur E. The radioactivity of materials from the Scharbauer site, near Midland, Texas: Am. Antiquity, v. 24, no. 2, p. 185–187, 1958.

This paper presents an example of the use of β-radioactivity, due to uranium and its daughter products, in relative dating of fossil bones. The method is better suited to separating Late Tertiary or older Pleistocene material from recent, rather than Late Pleistocene from recent, because the radioactivity increases more steeply as the adsorbed uranium approaches secular equilibrium with its daughter elements. Absolute dating by this method is generally considered to be out of the question.—*D. B. V.*

EARTH CURRENTS

176–21. Carstoiu, John. Induced electromagnetic fields in the earth: Natl. Acad. Sci. Proc., v. 45, no. 2, p. 204–208, 1959.

The effect in the earth of daily and irregular geomagnetic variations are analyzed mathematically. It is shown that a dielectric body in the primary field E_H gives rise to an induced secondary field such as is generated by a distribution of sources produced by the surfaces of discontinuity of the dielectric. If an underground dielectric rock contains a conducting fluid, a pondermotive force perpendicular to the geomagnetic field will act on the fluid, which will start to move; its motion will be governed by the equations of magnetohydrodynamics.

A formula is derived for intensity of the electromagnetic energy in the fluid, and four fundamental solutions of the induction equation are given, by means of which particular problems can be solved under suitable boundary conditions.—*D. B. V.*

176–22. Fleischer, Ulrich. Charakteristische erdmagnetische Baystörungen in Mitteleurope und ihr innerer Anteil [Characteristic magnetic bay disturbances in central Europe and their internal part]: Zeitschr. Geophysik, v. 20, no. 3, p. 120–136, 1954.

The endpoint of the horizontal vector of bay disturbances describes a loop. The loops which are characteristic for every time of day were derived for Wingst observatory. The maximal vectors agree with the magnetic field of Silsbee and Vestine's ionospheric current-system for bays. The *psc*-disturbances, however, follow other laws.

The vertical component at every station is different and is therefore ascribed to an interior (induced) current-system. The knowledge of the regional distribution of that current-system promises to give information about abnormal electric conductivities in the earth's crust. Such an anomaly exists in northwestern Germany, where the author had recorded with a transportable "Askania Geomagnetic Variograph." The inner part of ΔH and ΔZ derived from these records may be interpretated as the magnetic field of a linear current in the depth of 70 to 100 km flowing beneath Bremen either from West to East or in the opposite direction. The intensity of this current depends on the rate of change as well as on the direction of the exterior field. The greatest interior current occurs, if the exterior field has the direction SSW–NNE. This fact may be explained by induction of the exterior field within a conductive body (plate) extending from WNW to ESE and to depth. With this conception the observed "linear current" is taken to flow along the upper edge of this plate.—*Author's English summary*

176–23. Lippmann, H. J. Erdmagnetische Induktion in Leitfähigkeitseinlagerungen im Untergrund [Geomagnetic induction in conducting bodies in the ground]: Zeitschr. Geophysik, v. 24, no. 3, p. 113–124, 1958.

The induced inner part of a geomagnetic bay disturbance is calculated for two models, an infinitely long conducting cylinder and a sphere. The induced magnetic field is that of a 2- or 3-dimensional dipole, depending on which body is considered.

Applied to observations by Rikitake and his colleagues in central Japan (see Geophys. Abs. 162–39 through 43, 163–27), these results indicate that the conducting body must be spherical, with a magnetic moment of 10^{18} emu (a first approximation, like Rikitake's 8.6×10^{18} emu) and radius of 130 km. For north Germany fewer data are available (see Geophys. Abs. 163–26 and 176–22) but it appears that the conducting body may be elongated in an east-west direction.—*D. B. V.*

176–24. Barsukov, O. M. Variatsii preimushchestvennogo napravleniya i sredney amplitudy korotko-periodicheskikh kolebaniy telluricheskikh tokov [Changes in preferred direction and average amplitude of short-period variations of telluric currents]: Akad. Nauk SSSR Izv. ser. geofiz., no. 8, p. 1040–1043, 1958.

In the beginning of the IGY an attempt was made to work out a program of common observations of variations of telluric currents; five Russian stations scattered from the Carpathians to Kamchatka and from Crimea to the Arctic Circle participated in this program for 3 months. The results obtained are not very encouraging. Variations in direction and average amplitude have a clearly

pronounced diurnal period; but these variations as observed at different stations have very little similarity whether referred to local or to world time. Only an extended harmonic analysis of the observed variations will yield some information on the causes of these phenomena.—*S. T. V.*

176–25. Ádám, Antal. Über ein modifiziertes tellurische Schurfgerät und dessen Verwendung zu tellurischen Untersuchungen grossen Ausmasses [On a modified telluric prospecting apparatus and its application to large-scale telluric investigations]: Freiberger Forschungshefte, C45 Geophysik, p. 52–61, 1958.

A detailed description of the telluric current apparatus designed and built in Hungary, consisting of a galvanometer, compensator, and optical-mechanical recorder. Sensitivity is 0.01 to 0.06 mv per mm, outer dimensions 644×274×242 mm, weight about 40 kg, width of recording film 160 mm, film speed 20 mm per min; 6-v, 25-w current is required. One of these instruments was sent to Peking and comparison measurements were made for 6 days there and at Sopron; results have been published elsewhere (see Geophys. Abs. 171–50, 51).—*D. B. V.*

EARTHQUAKES AND EARTHQUAKE WAVES

176–26. Richter, Charles F. Elementary seismology: San Francisco, W. H. Freeman and Co., 768 p., 1958.

This book is designed particularly for students in geology who are not planning to specialize in seismology or geophysics, but also includes descriptive and reference material for instructors and research workers. The text is divided into three parts: Part 1, "Nature and observation of earthquakes", includes chapters on the nature of the motion, some great earthquakes, types of shocks, effects of earthquakes, types of earthquakes, seismograph theory and practice, elastic and seismic waves, intensity, magnitude, etc.; Part 2, "Geography and geology of earthquakes", includes chapters on seismic geography, California, New Zealand, Japan and Formosa, and other regions, and compressions and dilatations; and Part 3 consists of 17 appendices including chronology of earthquakes, detailed proofs, scales, tables, calculations, bibliography, etc.—*V. S. N.*

176–27. Oliver, Jack [E.]. Seismology and the IGY, *in* Geophysics and the IGY: Am. Geophys. Union Geophys. Mon. no. 2, p. 190–197, 1958.

A review of some selected topics of earthquake seismology serves to indicate the large amount of significant information on the earth that this branch of science has produced in its relatively brief history.—*D. B. V.*

176–28. Lotze, Franz. Aktuo-geologische Charakteristik des Jahres 1957 [Actuo-geological characteristics of the year 1957]: Neues Jahrb. Geologie und Paläontologie Monatsh., no. 12, p. 527–544, 1958.

Statistics are compiled on natural disasters in 1957. Endogene processes (earthquakes and volcanic eruptions) killed 3,000 people, three times as many as in 1956, and caused damage estimated at 5,000 million German marks. Seismic activity was particularly strong. In central Europe 983 definite and 14 questionable earthquakes were recorded, an average of 2.69 per day. As in previous years, their distribution was rather systematic; seismic activity was relatively mild in January and February, increased suddenly to an unusually

high maximum in March, declined gradually to a minimum in August, showed slight rises in September and December. Epicenters were determined for 391, or 39.8 percent, of the definite shocks; of these 79 were in Europe including the Mediterranean area, 12 in the Atlantic and Arctic, 16 on the continent of Asia, 16 in the Indian Ocean (to Antarctica) and Indonesia, 244 on the northern and western Pacific border (New Zealand to Alaska including the Hawaiian Islands), 24 on the southwestern Pacific border including the west coast of America. Focal depths were determined for 31 as follows: 10 at 450–650 km, 4 at 200–350 km, 14 at 100–190 km, and 3 at 50–90 km. According to Pasadena, magnitudes of 74 shocks were more than 6, of 27 shocks more than 7, and of 3 shocks about 8. The three strongest earthquakes were those of April 14 in Samoa, November 29 in southern Bolivia, and December 4 in Outer Mongolia; the last was the strongest in the period 1955–57.

In contrast, volcanic activity was weaker in 1957 than in the previous year. The most interesting volcanological event was the formation of the new volcano in the Azores (see Geophys. Abs. 173–361, 175–409 and 410). The Volcan de Fuego in Guatemala erupted in February; the "Volcan de Fuego de Colima" in Mexico emitted gas in May after 48 yr of quiescence; and in February lava flowed from Llaima in Chile. In Europe Etna continued active. Activity was reported from Indonesia (Merapi on Java in June, and near Sumbawa Island), Japan (Sakurajima, beginning in January; and Mihara, beginning October 13, with one killed and 54 injured), New Guinea (Manam, in December), and Lomonosov Ridge in the Arctic Ocean.—*D. B. V.*

176–29. Berg, Joseph W., Jr., and Resler, R. C. Investigation of local earthquakes February 13, 1958, near Wallsburg, Utah: Utah Acad. Sci., Arts, and Letters Proc., v. 35, p. 113–117, 1958.

An isoseismic map based on field investigations made on February 14 and 16, 1958, indicates that the earthquake of February 13, 1958, ranged in intensity between 1 and 5 and was felt over 1,000 sq mi in an area of known faulting. The epicenter was determined from seismograms to lie 8 or 10 miles south of Wallsburg, Utah; it seemed not to be related to any particular known fault.—*A. J.*

176–30. Tocher, Don, and Miller, Don J. Field observations on effects of Alaska earthquake of 10 July 1958: Science, v. 129, no. 3346, p. 394–395, 1959.

A major earthquake was felt late on the evening of July 9, 1958, (local time) in southeastern Alaska and adjoining parts of Canada. According to the U.S. Coast and Geodetic Survey, the epicenter was at lat 58.6° N., long 137.1° W., origin time $06^h15^m51^s$ Greenwich Civil Time, July 10, 1958. Pasadena reports magnitude $M=8$ (Richter) and $m=7\frac{1}{2}$ (Gutenberg unified).

The earthquake was caused by movement on the Fairweather fault in the Fairweather Range of the Saint Elias Mountains, about 100 miles west of Juneau; displacement amounted to at least 21½ ft horizontally and 3½ ft vertically. Earth slumps, lurches, rock and soil avalanches, rockslides, earth flows, and minor cracks and fissures were observed over a large area. In Lituya Bay the shock was followed almost immediately by an enormous wave that destroyed 4 sq mi of forest along the shores. A large rockslide along the Fairweather fault at the head of the bay was the probable cause of this wave, either alone or in conjunction with the fault displacement.—*D. B. V.*

176–31. Figueroa Abarca, Jesús. El macrosismo del 28 de julio de 1957 [The macro-earthquake of July 28, 1957]: Mexico Univ. Inst. Geofísica Anales, v. 3, p. 55–87, 1957.

The Mexican earthquake of July 27, 1957, resulted from movement on a fault in the Pacific paralleling the coast of Guerrero. The epicenter has been located at lat 16°21′ N., long 99°13′ W.; focal time was $08^h40^m00^s$, focal depth 25 km, magnitude 7.5, and energy $10^{29.4}$ ergs. An isoseismal map shows that maximum energy was radiated in a northsouth direction. Mexico City, 358 km to the north of the epicenter, suffered severe damage (intensity 7); numerous photographs are given of damage there. A time-distance graph gives *P*, *S*, and *L* velocities as recorded at various Mexican stations.—*D. B. V.*

176–32. Merino y Coronado, J. El temblor del 28 de julio de 1957 [The earthquake of July 28, 1957]: Mexico Univ. Inst. Geofísica Anales, v. 3, p. 88–125, 1957.

Damage in Mexico City due to the earthquake of July 28, 1957, was influenced by ground conditions rather than by the actual intensity of the shock; the area of destruction was confined to the lower part of the city where the foundation is soft with a high percentage of water. Accelerations given by the Tacubaya seismic station should be multiplied by 4 or 5 for that part of Mexico City. The period was of the order of 1.6 sec. Details of damage to ground and buildings are described.—*D. B. V.*

176–33. Martelly, Julian. Determinación de las aceleraciones en el terremoto de Pelileo, (Ecuador, 1949)—Aceleración y grados de intensidad según la escala de Mercalli-Wood-Neumann—Un metodo de calculo de la profundidad del hipocentro. Aplicaciones al terremoto do Pelileo (Ecuador, 1949) [Determination of accelerations in the Pelileo earthquake (Ecuador, 1949)—Acceleration and grades of intensity according to the Mercalli-Wood-Neumann scale—A method of calculating focal depth. Applications to the Pelileo earthquake (Ecuador, 1949)]: Quito, Editorial Casa de la Cultura Ecuatoriana, 41 p., 1956.

Under these three titles (on the cover) are presented two papers by Martelly ("Relation between acceleration and grades of intensity of the Mercalli-Wood-Neumann scale" and "A method of calculating focal depth; application to the Pelileo earthquake, Ecuador, 1949"), translated from the French by Alberto D. Semanate. The first paper attempts to relate earthquake intensity with acceleration, based on accelerations determined from macroseismic effects of the Pelileo earthquake of August 5, 1949. The relation $\log a = m \log \frac{I+J}{K}$ (where a is acceleration, m, J, and K are constants, and I is intensity) is found to be best adapted to the Mercalli-Wood-Neumann scale. As larger and larger values of J are taken, the variation of the second member in the interval used ($I=1$ to $I=12$) gradually becomes linear, and the formula $\log a$=linear function of I, used by many authors, is included as the limiting case. Maximum accelerations attributed to each grade on the MWN scale are tabulated; they range from <0.3 gals for intensity 1 to >1,600 gals for intensity 12.

The second paper describes a graphic method of determining focal depth that uses the geographic distribution of intensity, and is based on the fact that the decrease of intensity as a function of epicentral distance is more rapid the shallower the focus. It is assumed that the focus is a point, that the epicenter is known, and that the relation $I=f(D)=f(\sqrt{h^2+\Delta^2})$ exists, in which I=intensity,

D=focal distance, h=focal depth, and Δ=epicentral distance. The method is applied to two independent sets of observations of the Pelileo earthquake, and the most probable value of the focal depth is found to be 8 km with a possible error of 30 percent (prudently extended to 50 percent in view of the approximate character of the relation involved). Energy release in that earthquake was more than 10^{24} ergs, felt area 700 km.—*D. B. V.*

176–34. Dzhibladze, E. A. Zemletryaseniya Bol'shogo Kavkaza [Earthquakes of the Greater Caucasus]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 16, p. 103–114, 1957.

This paper discusses the instrumentally determined epicenters of the earthquakes of the Greater Caucasus for the period 1912–53 and macroseismic data on some great earthquakes of earlier years. The earthquakes were classified according to energy, and according to the accuracy of their focal determination. The energy liberated by all the earthquakes during the period from 1912 to 1953 was found to be approximately 1.24×10^{21} ergs. A map of seismicity indicates a displacement of seismic activity within the central and eastern parts of the main Caucasus ridge (see Geophys. Abs. 165–29). Seismic analysis of the Greater Caucasus geology suggests nonuniform vertical motions in the earth's crust in the area along the deep faults of Kazbek-Shemakha and Alazan-Kaknetiya.—*A. J. S.*

176–35. Tvaltvadze, G[uri] K., and Kartsivadze, G. E. Novyye dannyye o raspolozhenii epitsentrov i gipotsentrov zemletryaseniy Kavkaza [New data on distribution of epicenters and foci of earthquakes in the Caucasus]: Akad. Nauk Gruzin. SSR, Inst. Geofiziki Trudy, v. 16, p. 165–175, 1957.

Epicentral distances of seismic stations and the epicentral coordinates are determined mainly from the difference in arrival time of P and S waves from the traveltime tables in which the effect of the sedimentary layer of the earth's crust on wave propagation is usually disregarded. Tvaltvadze and Kartsivadze have developed traveltime equations which reflect the influence of sedimentary multilayered strata, which in the Caucasus may be of an order of thickness commensurable with that of the granitic layer. The following equations were developed: for direct waves

$$t_{nn}=\frac{h-\sum_{1}^{n-1}H_i}{V_k \sin e_k}+\sum_{1}^{k-1}\frac{H_i}{V_i \sin e_i},$$

and for head waves (first arrival)

$$t_{nk}=\frac{\Delta}{V_n}+\frac{\sum_{1}^{n}H_i-(h-H_n)}{V_k}\sin e_{nk}+\sum_{1}^{n-1}\frac{H}{V_i}\sin e_{in}+\sum_{n+1}^{k-1}\frac{2H_i}{V_i}\sin e_{in},$$

where index n=1,2,3. . .k is the number of the focal layer, k=1,2,3. . .n is number of layers through which the direct and head waves propagate, and h is the depth of focus. Analysis of 200 earthquakes gave comparatively accurate data on epicenters and foci.—*A. J. S.*

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176-36. Lebedeva, T. M., and Papalashvili, V. G. Zemletryaseniye 12 fevralya 1953 goda v Goriyskom rayone [The earthquake of February 12, 1953 in the Gori region]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 13, p. 149–157, 1954.

An earthquake which occurred in the southern part of the Georgian S.S.R. at 7:46 a.m. on February 12, 1953, was recorded instrumentally by the Borzhomi, Abastumani, Tsikhisdzhavari, Tbilisi, and Gori stations as having an intensity of 3 to 6.5 points on a 12 point scale. Radius of the felt area was 30 to 40 km, epicentral coordinates were determined to be lat 41°51′ N., long 43°54′ E., and the depth of focus was determined graphically to be 13 km.—*A. J. S.*

176-37. Dzhabna, Sh. A., Kats, A. Z., Safaryan, A. N., Tskhakaya, A. D., and Churayan, A. L. Krasnopolyanskoye zemletryaseniye 21–27 dekabrya 1955 g. i yego posledstviya [The earthquake of December 21–27, 1955 in Krasnaya Polyana and its consequences]: Akad. Nauk SSSR, Sovet po Seysmologii Byull., no. 5, p. 3–33, 1958.

On December 21, 1955, at 24^h54^m and again on December 27 at 11^h43^m (Moscow time) strong shocks occurred in Krasnaya Polyana, Sochi and points along the Black Sea shore of the Caucasus. The strongest previous earthquakes in this area occurred in 1870 and 1909; the 1955 earthquake was the strongest of the three. It was recorded by all seismic stations in the Caucasus and in the Crimea. On the basis of the instrumental records it can be concluded that the epicenter of both 1955 shocks was in the vicinity of Krasnaya Polyana, where the intensity was 7. The depth of the focus is estimated to be very shallow. The greater part of the article describes the damage to buildings, giving numerous photographs illustrating the effect on buildings in Krasnaya Polyana, Sochi, and other places.—*S. T. V.*

176-38. Kats, A. Z. Nekotoryye rezul'taty seysmometricheskikh issledovaniy v zone Krasnopolyanskikh zemletryaseniy v svyazi s seysmicheskim mikrorayonirovaniyem [Some results of seismometric investigations in the zone of the Krasnaya Polyana earthquakes in their relation to sesmic microzoning]: Akad. Nauk SSSR, Sovet po Seysmologii Byull., no. 5, p. 35–54, 1958.

Aftershocks of the two strong shocks which occurred in the vicinity of Krasnaya Polyana in December 1955 were recorded by five temporary seismic stations established at Krasnaya Polyana, Sochi, Adler, and Kalinovoye Ozero. Two were established in Sochi, 400 m apart but on different foundations; station no. 1 was built on marly and sandy clay, dipping 12° to 22° southward, whereas station no. 2 was erected on a terrace of porous loam some 22 m thick. All stations were equipped with identical seismographs and time recording instruments.

The propagation of seismic waves through media of different elastic properties was analyzed theoretically, and extensive experimental material was collected by the stations on the effect of seismic waves of different frequency on stations built on different foundations. The instrumental data show that the amplitudes of seismic waves are different on massive rocks, argillaceous soils, and gravel deposits, and that the ratios of the amplitude of vibrations on clays and gravels to those observed on hard ground depend on the frequency. Near resonance conditions, for periods from 0.15 to 0.2 sec, this ratio ranges from 1.5 to 2.75; for longer periods it approaches unity. It was also established that the complete seismic characteristics of a ground can be determined only when the deforma-

tions caused by the propagation of seismic waves is taken into account. The article contains valuable data on the effect of seismic waves on buildings under various conditions.—*S. T. V.*

176–39. Rustanovich, D. N. Predvaritel'nyye rezul'taty instrumental'nogo izucheniya seysmichnosti zony Krasnopolyanskikh zemletryaseniy [Preliminary results of the instrumental study of the seismicity of the zone of the earthquakes of Krasnaya Polyana]: Akad. Nauk SSSR, Sovet po Seysmologii Byull., no. 5, p. 55–61, 1958.

This is a preliminary report on the results obtained by an expedition sent to the Krasnaya Polyana region after the earthquakes of December 1955 to study the seismicity of the area. The focal time of the shock of December 21 was $22^h54^m52^s$ (Moscow time), intensity 6. From December 27 to January 3, 1956, several aftershocks were felt, with intensities up to 7. Weaker shocks (less than 4 in the Krasnaya Polyana region) occurred on March 7 at 3^h11^m, June 26 at 13^h06^m, and August 8 at 3^h51^m. The five temporary seismic stations set up by the expedition (see Geophys. Abs. 176–38) recorded 40 shocks in the period September–December 1956. Epicenters were determined for 23 of these, using the method of isochrone lines and Wadati's method; accuracy is high owing to the good quality of instruments used. It is concluded that the Krasnaya Polyana-Sochi region is characterized by multiple foci scattered over the area, and that the frequent weak shocks are merely aftershocks of the stronger earthquakes. For more definite conclusions concerning the seismic regime of the area and its relation to local geologic conditions, it is necessary to continue the observations for a long time.—*S. T. V.*

176–40. Gzovskiy, M. V., Krestnikov, V. N., Nersesov, I. L., and Reysner, G. I. Sopostavleniye tektoniki s seysmichnost'yu Garmskogo rayona Tadzhikskoy SSR. I [Comparison of the tectonics and seismicity of the Garm region of the Tadzhik SSR, part 1]: Akad. Nauk SSSR Izv. ser. geofiz., no. 8, p. 959–976, 1958.

This article presents the results of a study of the structural geology of the Garm region, seismically one of the most active zones of the U.S.S.R. Geologically it is very complex, being at the junction of the Pamir and Tien Shan Mountains. The southern part of Central Asia shows the same general regularities which characterize geosynclines everywhere, such as frequent inversions of tectonic movements, undulatory migration of depressions and elevations, disharmonic folding, and parallelism between the displacements of the deep basement and those of sedimentary deposits.

The second part of the article will discuss the relations between the tectonic and seismological characteristics of this area.—*S. T. V.*

176–41. Rantsman, Ye. Ya. Geomorfologiya i seysmichnost' doliny r. Surkhov [Geomorphology and seismicity of the Surkhov river valley]: Akad. Nauk SSSR Doklady, v. 124, no. 1, p. 171–174, 1959.

Geomorphologic studies in the valley of the Surkhov river in the Tadzhik S.S.R. (the most seismically active part of the U.S.S.R.) show that the mainly shallow earthquakes (5–10 km focal depth, a few 15–40 km) in this vicinity are due to differential Holocene movements. The intensity of these movements is less significant than their constancy. Details of direction of uplift and subsidence of various blocks, as well as of the intensity and constancy of the movement, can be worked out from the geomorphologic data.—*D. B. V.*

176–42. Kondorskaya, N. V., and Postolenko, G. A. Seysmicheskaya aktivnost' Kurilo-Kamchatskoy oblasti za 1954–1956 gg. [Seismic activity of the Kurile-Kamchatka region during the years 1954–1956]: Akad. Nauk SSSR Izv. ser. geofiz., no. 9, p. 1114–1120, 1958.

The Kurile-Kamchatka region is the most seismically active zone of the Soviet Union, belonging to the circumpacific seismic belt. The area covered by this study is limited by the geographic lines $\varphi=43°$ to 48° N.; $\lambda=144°$ to 165° E. Previous seismological analysis of this area for the years 1952–54 was made by Monakhov and Tarakanov (see Geophys. Abs. 163–102). In their study numerous Russian seismic stations in the Far East were eliminated due to discrepancies in the data of these stations. Kondorskaya has recently proved that the Jeffreys-Bullen travel time tables do not give fully satisfactory results when applied to these stations, whereas better results are obtained when regional travel times are used (see Geophys. Abs. 173–85).

Wadati's method was used to determine the foci of 219 earthquakes ranging in magnitude from $7¾>M>3½$. The most seismically dangerous region during the period in question was the area to the east of Urup Island, near the intersection of known longitudinal and transverse ruptures of the earth's crust. The article contains several maps showing distribution of epicenters.—*S. T. V.*

176–43. Gregg, D. R. Reports of a submarine eruption off New Zealand in 1877: New Zealand Jour. Geology and Geophysics, v. 1, no. 3, p. 459–460, 1958.

Reports of a submarine eruption off the east coast of New Zealand near East Cape on December 1, 1877, are quoted. It is unlikely that the disturbance was caused by a volcanic eruption, as it was felt by two ships some 25 miles apart. More probably it was a tsunami resulting from submarine landslides or faulting connected with an earthquake felt at Gisborne the same day.—*D. B. V.*

176–44. Grover, John C. The Solomon Islands—geological exploration and research 1953–56: Part 2, Structure of the region: British Solomon Islands Geol. Survey Mem., no. 2, p. 23–39, 1958.

This report on the structure of the Solomon Islands is divided into three chapters dealing respectively with earthquakes in the years 1952–56, residual volcanism in the years 1952–56, and a regional picture of the Central Solomons. Records of major earthquakes before 1952 indicate that the Solomon Islands lie in a region of seismic activity possibly exceeded only by that of the Japanese Archipelago. From present evidence it appears that earthquakes are more frequent in the Western Solomons and in the San Cristoval-Santa Cruz area than in the Central Solomons. In the period 1952–56, the earthquakes of greatest magnitude occurred in 1955: one at the eastern end of Santa Cruz, intensity 6¾–7; one on western Bougainville, intensity 7¼; and one near Malaita, intensity 7. A detailed account is given of the shock near Malaita. A list and brief description are given of hot springs, solfataras, fumaroles, and volcanoes in the islands. Savo volcano, lat 9°10′ S., long 159°50′ E., with a record of peléan-type eruptions, is a potential danger to inhabitants.

Although the Solomon Islands are classified as a part of the circumpacific island belt, they are not a typical island arc in that their seismic zone in the crust dips towards the Pacific instead of toward the continent as in other arc areas, the island chains are linear rather than convex toward the Pacific, the ocean-deep occurs on the continental side rather than on the Pacific side of the

islands, there has been active volcanism in recent times only on the inner southerly line of islands, and ultrabasic rocks are found associated with subparallel major fault zones on Guadalcanal, Florida, Santa Ysabel, and San Cristoval. No associated metamorphism has been found on San Cristoval, Florida, or Malaita.—*V. S. N.*

176–45. Goldberg, John E., Bogdanoff, John L., and Moh, Za Lee. Forced vibration and natural frequencies of tall building frames: Seismol. Soc. America Bull., v. 49, no. 1, p. 33–47, 1959.

A procedure is presented for determining the response of a tall building frame to a harmonic motion of the ground. The procedure takes account of the elastic effects of the horizontal beams and requires the use only of a desk computer. Normal modes and natural frequencies can be determined to any desired degree of accuracy by trial and error. Response to any arbitrary motion of the ground can be determined in terms of the responses of the normal modes or, alternatively, by superposing the responses of the complete frame to each harmonic of the motion.—*Authors' abstract*

176–46. Adem, Julián. Estudio dinámico de los effectos sísmicos en las estructuras reticulares [Dynamic study of the seismic effects in reticular structures]: Mexico Univ. Inst. Geofísica Anales, v. 3, p. 1–53, 1957.

A mathematical treatment of the problem of earthquake vibration of a building. Using reasonable simplifying assumptions, a building frame is considered as a vibratory system with a finite number of degrees of freedom, one for each floor. The general solution is given for a system of equations for the motion due to lateral ground displacement of a building frame of n floors, and applied to the case of a five-story building.

It is concluded that for a long period, for instance 3 sec, the frame behaves practically as rigid, with an acceleration at each floor almost equal to the seismic acceleration; but if the seismic wave period is smaller (such as 1 sec) and approaches the fundamental natural period of vibration of the frame, the maximum acceleration at the different levels is higher than the ground acceleration and varies almost linearly with height of the building frame.—*D. B. V.*

176–47. Kanai, Kiyoshi; Tanaka, Teiji; and Suzuki, Tomisaburo. Rocking and elastic vibrations of actual building. 1. (Experiments by vibration generator): 2. (Observation of earthquake motion): Tokyo Univ. Earthquake Research Inst. Bull., v. 36, pt. 2, p. 183–199 (part 1) and p. 201–226 (part 2), 1958.

Two three-storied reinforced concrete apartment houses at the Hitachi Mine site, one built on rock and the other on crushed stone with concrete piles, were subjected to artificial vibrations. The results, presented in graphs, confirm earlier findings concerning the influence of the nature of the ground. Horizontal seismographs were installed on the top and ground floors of the same houses to record natural earthquakes. It was found that although the amplitudes on the ground floor of the house built on bedrock were smaller than in the other, the amplitude ratios of top floor to ground floor were larger. Both buildings made a rocking oscillation, relative horizontal movement against the ground at the basement together with elastic deformation of the members. The less the rigidity of the subsoil surrounding the foundation, the larger the damping of the building vibration in an earthquake. It is concluded that the best condition for earthquake-

proof construction is to have hard ground extending for a considerable distance around a building, with soft soil in a limited area immediately surrounding the foundation.—*D. B. V.*

176–48. Kanai, Kiyoshi; Kishinouye, Fuyuhiko; Nasu, Nobuji; and Kawasumi, Hirosi. Vibration of a reinforced concrete building moved with vibration generators: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, pt. 2, p. 165–182, 1958.

This is a report on vibration studies made on a six-story building in Tokyo that was constructed shortly before the 1923 earthquake and razed in 1953. The observed amplitude-period relationships are given in numerous graphs.—*D. B. V.*

176–49. Riznichenko, Yu. V. O izuchenii seysmicheskogo rezhima [On study of the seismic regime]: Akad. Nauk SSSR Izv. ser. geofiz., no. 9, p. 1057–1074, 1958.

This is an address delivered at the conference of the Russian Seismological Council held in May 1957 in Moscow. It is suggested that seismicity of a region be defined in such a way as to allow a number of different problems arising in the evaluation of its seismic characteristics to be approached from a common point of view. It has been noted that frequency of occurrence of earthquakes is in inverse proportion of their intensity. In statistical study of the seismicity of a region we are dealing with five variables, the focal coordinates x, y, z, time t, and energy E. Gutenberg and Richter have noted a relationship between the frequency of earthquakes and their intensity. In this study only violent earthquakes were included. Riznichenko points to the fact, of enormous importance in seismology, that in studying the frequency of earthquakes as a function of their intensity, the Tadzhik expedition discovered a similar statistical relationship in very weak earthquakes; these occur much more often and can be observed only instrumentally, thus reducing the necessary period of observation and increasing the reliability of the results. Statistical study of earthquakes is a very young branch of seismology. Many questions remain to be clarified.—*S. T. V.*

176–50. De Noyer, John. Determination of the energy in body and surface waves (Part 2): Seismol. Soc. America Bull., v. 49, no. 1, p. 1–10, 1959.

The methods of estimating energy in various phases of seismic waves, presented in the first part (see Geophys. Abs. 175–47), are applied to records of 12 earthquakes, for the most part obtained from horizontal seismographs. The values obtained for energy of *P*, *SV*, *SH*, *L*, and *R* waves agree reasonably well with estimates of strain energy released at the source. The ratio of the energy in body waves to that in surface waves is not a fixed quantity for shallow-focus earthquakes. Earthquakes known to have been accompanied by large surface fault breaks tend to produce surface waves with a relatively high proportion of energy. In most cases the shear wave energy is greater than the longitudinal wave energy.—*D. B. V.*

176–51. Droste, Zofia, and Gibowicz, Sławomir. Determination of the magnitude of distant earthquakes at the Silesian geophysical station in Racibórz: Acta Geophys. Polonica, v. 6, no. 3, p. 222–235, 1958.

Two basic formulas for determination of magnitude of distant earthquakes ($\Delta > 20°$) registered at the Racibórz seismograph station in Selesia, Poland, were

derived from data of 148 earthquakes, using surface waves with periods of about 20 sec. The two formulas, based respectively on magnitudes determined at Pasadena and at Praha, give values differing by as much as 0.06 units. The formula obtained from the Pasadena magnitudes ($M=\log A_{20}+1.641 \log \Delta+1.815$) was adopted.—*D. B. V.*

176–52. Teisseyre, Roman [K.]. Note on relationship between focus dimensions and earthquake magnitude: Acta Geophys. Polonica, v. 6, no. 3, p. 260–261, 1958.

A method is outlined for determining the dimensions of the focus of an earthquake from the magnitude. Berckhemer's relationships between focal dimensions S and magnitude M are used in the formula for earthquake energy according to the theory of dislocations; however, two parameters are distinguished for focal dimensions, the "focus length" l_o (the length of dislocation) and "focus width" L (here equal to depth of first impulse, H). The formula is

$$E=\frac{\mu}{4\pi}\frac{1}{1-\sigma}b^2 l_o\left[\log\frac{L}{r_o}-\frac{1}{4}\frac{1}{1-\sigma}\right],$$

where b=amplitude of dislocation vector, r_o=radius of dislocation line. For the Nevada earthquake of 1915, whose parameters were

$$l_o=30 \text{ km}, \; b=5 \text{ m}, \; M=7.7 (E=2.1\times 10^{28})$$

Berckhemer's relationship gives $S=5{,}000$ km^2

and the formula gives $E\approx 10^{23}\log\frac{L}{r_o}$;

therefore

$$\frac{L}{r_o}=2.1,$$

and the values $L=166$ km, $r_o=0.83$ km can be calculated.

Considerable error is no doubt involved. The radius r_o should not be interpreted macroscopically as the actual radius of the dislocation boundary but rather as the radius of the disturbance area.—*D. B. V.*

176–53. Lensen, G. J. Note on the compressional angle between intersecting transcurrent clockwise and anti-clockwise faults: New Zealand Jour. Geology and Geophysics, v. 1, no. 3, p. 533–540, 1958.

On theoretical grounds supported by geologic and seismological evidence, the following rule is proposed: the compressional angle between transcurrent clockwise and transcurrent anticlockwise faults is acute in tensional regions and obtuse in compressional regions. Fault plane solutions of 99 earthquakes are quoted from Scheidegger (see Geophys. Abs. 165–164), with compressional angles incorporated. The fault type is indicated by the symbols *d* (dextral, or clockwise); *s* (sinistral, or anticlockwise); *p* (pressure); and *t* (tensional).

In all 24 earthquakes in compressional regions, indicated by fault types *sp*, *dp*, or *p*, the compressional angle γ is obtuse. In two extreme cases γ is 180°, the fault is solely *p*, and *s* and *d* have disappeared. The two possible faults are colinear and differ only in direction of dip. In all 17 earthquakes in tensional regions, indicated by types *st*, *dt*, or *t*, the compressional angle is acute. In four extreme cases γ is 0°, the fault type is solely *t* and the transcurrent com-

ponents have disappeared. Again the two possible faults are colinear and differ only in dip.

In 45 cases the angle γ is exactly 90° and in all of these the faulting is solely transcurrent. In 12 cases γ is again 90°, faulting is predominantly transcurrent, and because the ratio of horizontal to vertical component approaches infinity, γ is 90°.—*D. B. V.*

176–54. Lensen, G. J. Measurement of compression and tension: some applications: New Zealand Jour. Geology and Geophysics, v. 1, no. 3, p. 565–570, 1958.

Stress can be equated to vertical and horizontal fault displacements. Plotted on a map of New Zealand, the pattern of isallo-stress lines corresponds with that of Bouguer gravity anomalies. The regions of tension correspond with those of large negative gravity anomaly, while the compressional regions correspond with those of small negative and of positive gravity anomalies.—*Author's summary*

176–55. Galanopoulos, A. G. Die makroseismische Ausbreitung im Faltenstreichen und ihre Bedeutung für die Festlegung der Scherungsfläche [Macroseismic propagation along the strike of folds and its significance for the determination of the shear plane]: Neues Jahrb. Geologie u. Paläontologie, Monatsh., no. 6, p. 241–243, 1958.

Since the amplitudes of the longitudinal waves and those of the transverse waves are zero in all directions situated in the fault plane, the minimum radius of the felt area should occur in the direction of the fault plane. Such being the case, the minimum radius of the macroseismic area should be used auxiliarly in the case it is not possible with the help of the initial motion of transverse waves or in other way to determine which of the two nodal planes for longitudinal waves in the focus was the actual fault plane. The macroseismic evidence presumably fails in case of dip-slip motion and is a striking one in the transcurrent type earthquakes. The direction of maximum radiation of transverse waves is approximately at right angles to the plane of the fault. In most cases destructiveness produced by shear waves is greater than that produced by other types of waves. Since the strike of the fault plane of the great majority of the shocks is directed more or less perpendicular to the seismic and structural zones, it is selfevident why the earthquakes are mostly felt over greater distances parallel to the structural lines than perpendicular thereto.—*Author's abstract*

176–56. Kasahara, Keichi. Physical conditions of earthquake faults as deduced from geodetic data: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, pt. 4, p. 455–464, 1958.

Horizontal displacement of triangulation points around an earthquake fault provides valuable information about physical conditions of faulting. Kasahara applies his theory of a strike-slip fault to several earthquakes (San Francisco 1906, Tango 1927, North Izu 1930, Imperial Valley 1940, Fairview Peak 1954) all of which were accompanied by strike-slip faulting, in order to determine their probable depth, magnitude of stress change in the fault plane, and strain energy associated with the crustal deformation.

From the results, which are tabulated, it is concluded that these faults range from 6 to 15 km deep, nearly equal to the focal depths of their respective shocks;

that stress changes amounting to 5×10^7 to 3×10^8 cgs took place in the fracture planes, values that agree well with other calculations of the strength of the crust; that the energy of crustal deformation and of the seismic waves are of the same order in each of the respective cases; and that the diminution curves of deformation indicate some distortion due to elastic drift in the crust (the longer the interval between surveys before and after the earthquake, the greater the distortion). The results thus seem to confirm the view that the faulting was the immediate cause of each of these earthquakes.—*D. B. V.*

Hiersemann, L[othar]. The rheological properties of the earth's crust from the standpoint of recent knowledge of the focal process in large earthquakes. See Geophys. Abs. 176–346.

176–57. Bonchkovskiy, V. F. Deformatsii zemnoy poverkhnosti, predvaryayushchiye i soprovozhdayushchiye katastroficheskiye zemletryaseniya [Deformations of the earth's surface, heralding and accompanying catastrophic earthquakes]: Akad. Nauk SSSR Izv. ser. geofiz., no. 9, p. 1111–1113, 1958.

A study is presented of crustal deformations related to earthquakes. It has long been known that such a relationship exists in epicentral areas, but two recent observations suggest that such a relationship may exist in regions far from the epicenters. The first observation refers to a violent earthquake which occurred off the island of Taiwan; 18 hr before the earthquake, strong tilting of the ground was observed several thousand kilometers away in a mine near Winsford, England. After the earthquake the inclinometers came to a new equilibrium position. In 1956 two mutually perpendicular inclinometers were installed at the geophysical station at Yalta in the Crimea. A catastrophic earthquake on March 9, 1957, with its epicenter in the Aleutian Islands displaced the inclinometers at Yalta, again beginning 18 hr before the seismic waves reached Yalta. The importance of further observation of these phenomena at as many seismic stations as possible is pointed out. These phenomena may have great practical value for earthquake prediction, as well as a theoretical value pointing to the possibility that earthquakes at any points on the earth must be considered to be a common phenomenon involving the entire globe.—*S. T. V.*

176–58. Ruprechtová, Libuše. Dependence of amplitudes of seismic body waves on the distance: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 4, p. 397–399, 1958.

The variation of amplitude of seismic body waves as a function of epicentral distance was investigated for the interval 2° to 30°, using the records of five shallow earthquakes from 35 European stations. The curves drawn through representative points are similar for both *PH* and *SH* waves. Up to $\Delta=10°$, amplitudes decrease rapidly with distance, more rapidly for *PH* than for *SH*; the minimum for *PH* occurs in the vicinity of $\Delta=11°$, for *SH* at about 13°. Then amplitudes increase with distance; *PH* reaches a maximum at 19°, and *SH* at about 22°. It is concluded that the structure of the upper mantle affects longitudinal and transverse waves differently.—*D. B. V.*

176–59. Nuttli, Otto W. The particle motion of the S wave: Seismol. Soc. America Bull., v. 49, no. 1, p. 49–56, 1959.

A micrometer microscope has been used to obtain particle motion diagrams for the *S* phase rerecorded at Florissant for distances from 50° to 80°. The diagrams indicate that the particle motion is linear. Furthermore, the diagrams show that the *SV* and *SH* components arrive simultaneously. They also show that it is sometimes very difficult to obtain the sense of the first *S* motion from a simple visual inspection of the seismograms.—*Author's abstract*

176–60. Thomson, William T. Spectral aspect of earthquakes: Seismol. Soc. America Bull., v. 49, no. 1, p. 91–98, 1959.

Considering ground acceleration associated with earthquakes to be composed of a series of velocity impulses of random amplitude, time spacing, and wave shapes, a statistical approach is used to establish its power spectral density. It is concluded that ground motion spectrum can be defined independently of the response; that the velocity spectrum of the ground motion is independent of frequency when the pulse duration is short in comparison to the vibration period; that the ground motion spectrum is independent of the time sequence of the pulses when the mean value is zero, and different pulse shapes and pulse duration can be combined without altering this conclusion; and that pulse shape has very little influence for large values of τ/Δ (τ=vibration period, Δ=pulse duration). Housner's theory of equipartition of energy is thus supported.—*D. B. V.*

176–61. Kanai, Kiyoshi. The amplitude and the period of earthquake motions. II: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, no. 3, p. 275–293, 1958.

Continuing the study of amplitude and period of earthquake motion (see Geophys. Abs. 162–134), their relationship is examined using the results of spectral analysis of seismograms obtained 300 m underground in the Hitachi mine, Ibaraki Prefecture, Japan. The empirical formula $A_{m\cdot s}=53\,T_m^{2.56}$ is derived, in which $A_{m\cdot s}$ is the maximum value of the displacement spectrum in microns at a focal distance of 100 km, and T_m is the corresponding period in seconds. Analysis of data based on magnitudes of seven different earthquakes shows that except for very long and very short periods, the amplitude-period relationship can be assumed to be $2\pi A/T$ ($\equiv$velocity)=constant; this means that seismic waves of a considerably wide range of period satisfy the nature of energy equipartition.—*D. B. V.*

176–62. Kanai, Kiyoshi. A study of strong earthquake motions: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, pt. 3, p. 295–310, 1958.

The relationship of magnitude of an earthquake to its period is studied, using the expressions derived in the preceding paper (see Geophys. Abs. 176–61), in order to determine whether the results can provide information about waves in destructive earthquakes. Strong motion seismograms of seven earthquakes obtained at four stations in California and an incomplete seismogram of the Kwanto earthquake recorded at Tokyo were analyzed.

It is concluded that the empirical formula $A_{m\cdot s}=53\,T_m^{2.56}$ seems to be applicable to destructive earthquakes. At the same time equipartition of energy is recognized with regard to the waves at bedrock, and there is considerable modification of wave amplitudes according to vibration characteristics of the ground.—*D. B. V.*

Ewing, Maurice, and Press, Frank. Determination of crustal structure from

phase velocity of Rayleigh waves. Part 3: The United States. See Geophys. Abs. 176–230.

176–63. Willmore, P. L. The application of the Maxwell Impedance Bridge to the calibration of electromagnetic seismographs: Seismol. Soc. America Bull., v. 49, no. 1, p. 99–114, 1959.

It is shown that an electromagnetic seismograph may be calibrated by observing the deflections of the galvanometer when an electrical signal is injected through a suitable coupling circuit. A specially designed version of the Maxwell Impedance Bridge is used for this purpose, the seismometer being connected in one arm and the galvanometer across the output. The bridge is balanced when the seismometer is clamped. The seismometer is then unclamped, and the galvanometer starts to swing with an amplitude equal to that which would be produced by a ground acceleration proportional to the bridge current. The constant of proportionality is found by injecting a "substitution e.m.f." across the ratio arm of the bridge. By carrying out the substitution experiments in their most complete form it is possible to determine the mass, the suspension stiffness, and the damping constant of the seismometer, either including or excluding the effects of the galvanometer reaction. Typical calibration curves for Benioff, Wilmore, and Sprengnether seismometers are included.—*Author's abstract*

176–64. Kanai, Kiyoshi, and Tanaka, Teiji. Self-levelling vibrograph: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, pt. 3, p. 359–368, 1958.

A self-levelling vibrograph pendulum which can be used in boreholes and other narrow spaces or at the bottom of a body of water is described, with photographs, schematic diagrams, and reproductions of seismograms. The vibrograph pendulum is enclosed in an inner casing which itself forms a simple pendulum fixed to the outer casing in a bed of paraffin. After the instrument is installed, an electric heater melts the paraffin, freeing the inner casing which then can swing to a level position. A buzzer signals when the level position is reached, the heater is cut off, the paraffin sets, and the inner casing is fixed perfectly to the outer. The entire operation takes about 15 min.—*D. B. V.*

176–65. Kawasumi, Hirosi; Shima, Etsuzo; Sibano, Muturo; and Yanagisawa, Masumi. A seismographic starter using a phototransistor: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, pt. 4, p. 447–453, 1958.

A sensitive seismograph starter which uses a phototransistor is described. The transistor is illuminated continuously by the light from a lamp, reflected by the mirror of a galvanometer, which is connected to a pickup. By the first relay, the sustained collector current of the transistor keeps breaking the circuits that operate the recorder. Onset of an earthquake motion with an amplitude larger than a prescribed limit deflects the light from the transistor to nullify the current, and the recorder can begin to function. Among other advantages this starter may be used where a-c power is not available; it is sensitive enough, without delicate electronic amplifiers, for use in low seismicity areas; and it does not require a trained operator. The wiring scheme is given.—*D. B. V.*

176–66. Tanaka, Teiji. A starter for observation of earthquakes [in Japanese with English summary]: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, pt. 4, p. 465–470, 1958.

A seismograph starter pendulum is described, with photographs and diagrams. Although the mechanism is simple, sensitivity is high, recording time is change-

able, and automatic starting and stopping of recording may be repeated several times.—*D. B. V.*

176–67. Tabulevich, V. N., Struk, Ye. V., and Brandt, S. B. Avtomaticheskiy priyem signalov vremeni seysmostantsiyey "Makhachkala" [Automatic signal device of the "Makhachkala" seismic station]: Akad. Nauk SSSR Izv. ser. geofiz., no. 9, p. 1137–1138, 1958.

This article describes briefly a device which automatically records the time signals from Moscow Observatory directly on a seismogram. This is an improvement in the precision of time records. The installation consists of an addition of an amplifier and an interrupter to the radio receiver. Tested in operation, the device was found to be fully reliable. All its elements are assembled on a small board. It is normally operated by alternating current through a voltage stabilizer, but it can be also operated on a storage battery. It responds to a frequency of 1,000±40 cycles per sec. It is not affected by music, speakers, or any disturbances coming through radio.—*S. T. V.*

ELASTICITY

176–68. Chakraborty, S. K. On disturbances produced by a time-periodic twist on the surface of a spheroidal cavity: Geofisica Pura e Appl., v. 40, p. 15–18, 1958.

The problem of disturbances in an elastic medium produced by a time-periodic twist about the axis of a prolate spheroidal cavity is solved, using spheroidal functions. The corresponding case of an oblate spheroidal cavity may be treated similarly.—*D. B. V.*

176–69. Duwalo, George, and Jacobs, J. A. Effects of a liquid core on the propagation of seismic waves: Canadian Jour. Physics, v. 37, no. 2, p. 109–128, 1959.

Effects of a spherical cavity in an infinite, homogeneous, isotropic elastic solid, containing nonviscous compressible liquid, on the propagation of elastic waves are investigated mathematically. The waves emitted by a simple harmonic point source in the solid are of the types known as *SH* and *P* in seismology. The discussion is restricted to the case $ka \gg 1$ ($ka = 2\pi$ cavity radius/wave length). Series solutions are transformed into contour integrals by Watson's method. Evaluation of these by the method of residues results in expressions describing the *P* and *S* components of the diffracted waves.—*Authors' abstract*

176–70. Fredricks, R. W. Solution of a pair of integral equations from elastostatics: Natl. Acad. Sci. Proc., v. 44, no. 4, p. 309–312, 1958.

The integral equations under consideration arise in the following two-dimensional elastostatic mixed boundary value problem: there is zero shear stress over the plane boundary of the elastic half-space; the normal component of stress is zero on the surface exterior to a finite strip; the normal component of displacement is prescribed within this strip. The displacement is decomposed into even and odd parts each of which is expanded in infinite series involving Bessel functions. The solutions to the integral equations are then written down with the aid of Weber's discontinuous integrals. The absolute convergence of the series representing the solutions is rigorously established.—*R. G. H.*

176–71. Postma, G. W. Changes of shape of seismic impulses in homogeneous viscoelastic media: Geophys. Prosp., v. 6, no. 4, p. 438–455, 1958.

Essentials of the theory of viscoelasticity are reviewed briefly, and Ricker's explanation of changes of shape of seismic impulses (see Geophys. Abs. 149–13586) is presented with some modifications which allow for a finite duration of the initial impulse and for the approximate character of his basic assumptions. It is concluded that Ricker's method of determining the nature of the inelasticity of earth materials by study of changes of shape and amplitude is not as successful as his results seem to indicate, although some objections can be removed by assuming a finite duration of the initial pulse.

The general observation over an extremely wide frequency range is that the logarithmic decrement does not depend significantly on frequency. If this is to be explained by nonlinear effects, the nonlinearity should also become apparent by failure of the principle of superposition.—*D. B. V.*

176–72. Menzel, H[einz], and Rosenbach, O[tto]. The influence of a layer complying with a linear velocity law on the shape of seismic pulses: Geophys. Prosp., v. 6, no. 4, p. 408–432, 1958.

A layer with parallel plane boundaries is assumed to have a constant density and exhibit a velocity of propagation of seismic waves which increases linearly with the distance from one boundary plane. The influence of this layer on the shape of seismic pulses is investigated in two different cases, in which: 1) the layer is embedded between two media each of which has a constant density and velocity of propagation; and 2) the layer is adjacent to one medium of constant density and velocity; i. e. one boundary plane of the layer is the free surface of a two-layered elastic half space.

Through one medium with constant velocity a plane compressional wave impinges at normal incidence on the layer complying with the linear velocity law. The incident seismic pulse is therefore split up into reflected and transmitted parts, the elastic motions of which are studied in the neighbourhood of the layer. The mathematical solution can be deduced for a general pulse by using the Laplace-Transformation. The general solution reveals that the layer following the linear velocity law influences the shape of the reflected and transmitted pulses. This influence is discussed in detail by demonstrating some numerical examples.—*Authors' abstract*

176–73. Anstey, N. A. Why all this interest in the shape of the pulse? Geophys. Prosp., v. 6, no. 4, p. 394–403, 1958.

Theoretical work on seismic pulse propagation must, of necessity, use advanced mathematical methods. To the general reader these researches may seem far removed from the necessities of commercial geophysics; this paper attempts to show in non-mathematical terms that the basic potential of the seismic method permits the obtaining of considerably more information than is currently expected, and that, of all the advances which are required to realise that potential, a knowledge of the laws governing the transmission of the seismic pulse is most desired.—*Author's abstract*

176–74. Knopoff, Leon. Scattering of compression waves by spherical obstacles: Geophysics, v. 24, no. 1, p. 30–39, 1959.

The scattering of plane P waves by a spherical obstacle is formulated. A calculation is given for the special case of scattering by a perfectly rigid sphere

in which the medium outside has a Poisson's ratio of ¼. The range of sizes of obstacles used in the calculation includes radii very small compared with wave length and radii comparable to the wave length. For incident *P* waves, scattered *P* and *S* are computed with shifts in time phase occurring in both with respect to the incident beam. For small obstacles, the scattered *S* wave is generally broadside to the scattered *P*-wave beam.—*Author's abstract*

176–75. Skuridin, G. A. Priblizhennoye resheniye zadachi diffraktsii ploskoy uprugoy prodol'noy volny otnositel'no gorizontal'nogo sbrosa [An approximate solution of the problem of diffraction of a plane elastic longitudinal wave on a horizontal fault]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 14, p. 79–90, 1955.

This paper presents a mathematical treatment of the theory of diffraction of elastic waves on a horizontal fault, and derives the formulas to help in recognizing and interpreting these waves and distinguish them from refracted and reflected waves. The presence of a diffraction zone due to a fault should be taken into consideration in planning seismic exploration in the field.—*A. J. S.*

176–76. Davydova, N. I. O zavisimosti dinamicheskikh kharacteristikh prodol'nykh golovnykh voln, svyazannykh s tonkimi sloyami, ot skorostnoy differentsiatsii sred [On the dependence of the dynamic characteristics of longitudinal head waves, produced in thin layers, on the velocity contrast between the layers]: Akad. Nauk SSSR Izv. ser. geofiz., no. 10, p. 1181–1191, 1958.

This is a continuation of Gamburtzev's study of the generation and propagation of waves produced in an elastic medium by a moving source (see Geophys. Abs. 132–9794). Theoretical seismograms are computed for the vertical and horizontal components of the displacements propagating in a thin layer surrounded by a medium of different velocity. It is found that the amplitude of vertical displacement $W(t)$ at the point of observation not only vary with time in absolute value but also change sign, whereas the amplitudes of horizontal displacement $U(t)$ vary only in absolute value, maintaining the sign; the variation of the vertical component is oscillatory for all values of δ (δ=ratio of velocity of surrounding medium to velocity in the thin layer), but the variation of the horizontal component $U(t)$ is aperiodic when $\delta<0.56$, oscillatory when $\delta>0.56$; the amplitudes at the moment of origin (moment of pentration of the waves into the thin layer) are greatest for the vertical component $W_o=W_{max}$ (that is, amplitude does not increase in the layer) when $\delta<0.9$, and for the vertical component $U_o=U_{max}$ when $\delta>0.56$.

Examination of the dependence of relative amplitude (W_{max}, U_{max}, A_{max}) on the velocity contrast shows that the amplitude A of the complete vector of movement along the ray at the moment t_o is maximum when $\delta=0.707$; W_{max} occurs when $\delta=0.574$ and U_{max} when $\delta=0.816$.—*S. T. V.*

176–77. Rosenbaum, J. H. A note on the propagation of a sound pulse in a two-layer liquid medium: Jour. Geophys. Research, v. 64, no. 1, p. 95–102, 1959.

The contribution from the branch line integral in Pekeris' formulation of the propagation of explosive sound in a two-layer liquid medium is investigated. It is shown that there is no net contribution to the solution in terms of pressure amplitude measured in the upper layer, which decays less rapidly than r^{-2}. The horizontal range, designated by r, is large compared with the depth of the layer.

This result is applicable to early arrival pressure signals and is in agreement with recently published model experiments.—*Author's abstract*

176–78. Sato, Yasuo. Numerical integration of the equation of motion for surface waves in a medium with arbitrary variation of material constants: Seismol. Soc. America Bull., v. 49, no. 1, p. 57–77, 1959.

Calculations of the dispersion of surface waves when the physical properties of the media in which they propagate change arbitrarily with depth, can be performed with the aid of high-speed computers. Dispersion of both Love and Rayleigh waves has been obtained for such cases by numerical specification of surface displacement followed by numerical solution of the equations of motion.

For Love waves, an extra condition is stated, besides the ordinary boundary condition that stress vanishes at the free surface, that requires that the displacement amplitude be unity at the surface. The equation of motion is then solved numerically for tentative values of frequency and wave number, and this solution produces the distribution of displacement amplitude in the half space. For all combinations of frequency and wave number which are not solutions, the values of computed displacement do not converge and tend to become positively or negatively infinite for increasing depth below the free surface. To obtain a solution one of the parameters—for instance wave number—is fixed and frequency is varied in small steps until the computed displacement converges to a zero at great depth. This combination fulfills all the standard boundary conditions and is the required solution.

Rayleigh wave dispersion can be solved similarly. In this case the parameter a, the ratio of the amplitude of horizontal and vertical components of displacement at the free surface, is needed. Wave number is fixed, and a two-dimensional search in the a–c plane (c=phase velocity) is used to locate the point that produces a convergent solution.

After the method was tested by applying it to cases which had been solved analytically, the following problems were solved: Love waves in a medium with constant density and linearly increasing rigidity; sound waves in a medium whose density and velocity are given by experimental curves; and Rayleigh waves in a medium having constant density and equal rates of increase for λ and μ. Using an IBM "650" computer, it takes a few minutes to get a point for the first and second case, and from 30 min to 2 hr for the third.—*D. B. V.*

176–79. Dorman, James. Numerical solutions for Love wave dispersion on a half-space with double surface layer: Geophysics, v. 24, no. 1, p. 12–29, 1959.

The IBM 650 computer of the Watson Scientific Computing Laboratory, Columbia University, was programmed to obtain numerical solutions for the period equation for Love waves on a half-space with a double surface layer. Solutions including higher modes for seven models of the continental crust-mantle system are presented. This group of related cases shows that certain properties of the solutions are diagnostic of crustal structure. These relationships are illustrated graphically.—*Author's abstract*

176–80. Buckens, F. The velocity of Rayleigh waves along a prestressed semi-infinite medium assuming a two-dimensional anisotropy: Annali Geofisica, v. 11, no. 2, p. 99–112, 1958.

The velocity equation for surface waves of the Rayleigh type is derived for the case of an idealized medium with two-dimensional symmetry and transverse

anisotropy, taking into account the possibility of uniform initial stress (horizontal tension or compression), in which case five independent elastic constants must be considered. This type of anisotropy may appear in the average in certain parts of the earth's surface (symmetrical folds, grabens), and the purpose of this paper is to determine its specific effect on the velocity of the Rayleigh wave as compared to the isotropic case.

It is shown that although initial stress usually has little direct effect on the wave velocity, it may modify the elastic characteristics of the material enough in the long run to have a significant influence. Specific application to geophysical problems is difficult at present because of the lack of experimental data on the elastic constants in anisotropic geological formations, not to mention their modification under large initial stresses.—*D. B. V.*

176–81. Yanovskaya, T. B. O dispersii releyevskikh voln v sfericheskom sloye [On the dispersion of Rayleigh waves in a spherical layer]: Akad. Nauk SSSR Izv. ser. geofiz., no. 7, p. 801–817, 1958.

Ewing and Press (see Geophys. Abs. 158–137, 159–128) have reported Rayleigh waves with wave lengths of more than 2,000 km. As the ratio of wave length to radius of the earth is therefore not negligible, theoretical calculations of wave propagation in the earth must take into account the sphericity of the earth. This paper is a mathematical analysis of Rayleigh wave dispersion based on the assumption that the waves are propagating in a spherical layer overlying a homogeneous elastic sphere. The elastic constants for the upper layer and for the sphere are given. It is assumed that waves are produced by a fixed constant source having a frequency p. The problem consists of the evaluation of the displacement vectors U_1 and U_2 in the layer and in the sphere; these vectors must satisfy the corresponding wave equations. The boundary conditions are the equality of stresses and displacements on the boundary surface and on the surface separating the layer from the sphere. The solutions of the wave equations expressed in spherical coordinates can be found more conveniently when they are developed in spherical harmonics. Furthermore the stress-vector F_r on the spherical surface can be expressed in terms of the divergence and the curl of the vector U. The solutions are obtained after introduction of Legendre functions and rather cumbersome transformation of the determinant resulting from these. Yanovskaya finally expresses the velocity v of the waves in the spherical layer in terms of the velocity v_0 in the plane layer; v_0 was determined by Keylis-Borok (see Geophys. Abs. 148–13329) for more simple conditions of the problem.—*S. T. V.*

176–82. Ivakin, B. N. O modelirovanii pogloshcheniya seysmicheskikh voln [The modeling of the absorption of seismic waves]: Akad. Nauk SSSR Izv. ser. geofiz., no. 7, p. 818–832, 1958.

General methods for the construction of continuous mechanical and elastic models of imperfectly elastic media are discussed. Such models are determined for imperfectly elastic media characterized either by afterworking effect, or by viscosity (inner friction), or by residual deformations. Equations of the motion for such models are established as well as formulas for the resistance to wave motion propagating through such media. The application of such models in experimental mechanics for the solution of different problems not amenable to analytical methods are discussed. In the treatment of the problems the only assumption made is that the media in which the waves are propagating are not perfectly elastic but are ideally inert, that is, the entire consumption of energy

is caused by the imperfect elasticity of the medium, its density remaining independent of the absorption of energy.

Operational methods are used in the treatment of the problems. Many references to studies of both Russian and Western scientists are given.—*S. T. V.*

176–83. Shima, Michiyasu. On the thermoelasticity in the semi-infinite elastic solid: Kyōto Univ. Disaster Prevention Research Inst. Bull., no. 25, 17 p., 1958.

A heated spheroidal region in a semi-infinite elastic body is considered. The material in the heated region has a thermal expansion coefficient larger than the surrounding cooler material. This condition results in the generation of stress around the thermal origin and in displacements of the free surface. Calculation of the displacement at the free surface and the stresses about the thermal origin are obtained. From the data of crustal movement at Aso volcano, the diameter of the magma chamber is estimated to be about 1 km.—*L. P.*

176–84. Helbig, Klaus. Elastische Wellen in anisotropen Medien. Tiel II [Elastic waves in anisotropic media. Part 2]: Gerlands Beitr. Geophysik, v. 67, no. 4, p. 256–288, 1958.

This is the conclusion of Helbig's study of propagation of elastic waves in anisotropic media (see Geophys. Abs. 175–79). The third chapter discusses the shape of the characteristic surfaces in layered structure, a case which is of interest in seismic problems. Chapter four describes model experiments by means of schlieren photographs of wave fronts in layered media, and discusses the results in the light of the theory developed in the first three chapters.—*D. B. V.*

176–85. Vosahlo, Hans. Fortschritte beim Impuls-Schlieren-Verfahren, einem Hilfsmittel geophysikalischer Forschung und Praxis [Progress in the impulse-schlieren method, an aid in geophysical research and practice]: Freiberger Forschungshefte, C45 Geophysik, p. 62–67, 1958.

The impulse-schlieren method is based on the fact that elastic deformations in transparent media due to ultrasonic processes produce interference phenomena that can be made visible with schlieren apparatus, in a manner analogous to the apparent stopping of motion by a stroboscope. The ultrasonic velocity can be determined from the measured angle of the trace of the wave formed in front of the impulse at the boundary between two media (like the bow wave of a ship or head wave of a projectile). Improvements in the apparatus to give a sharper image, and therefore more accurate measurement, have reduced the mean error to one or two percent. The apparatus can also be used for model experiments on earthquake wave propagation; an experiment showing wave propagation through a spherical core (carbon tetrachloride surrounded by water) is illustrated.—*D. B. V.*

176–86. Evans, J. F. Seismic model experiments with shear waves: Geophysics, v. 24, no. 1, p. 40–48, 1959.

The experimental study of shear waves in the earth has been limited by the difficulty of producing them in sufficient strength. However, sensitive piezoelectric shear plates can now be made which enable experimentation with shear waves using small-scale seismic models. Seismic model experiments serve to demonstrate the simplicity of *SH*-shear wave reflections in a single homogeneous

layer, the production of *SH* waves by an implusive horizontal thrust, and the development of relatively high amplitude Love waves in a low-velocity surface layer. The results of these model experiments with shear waves are in general agreement with and confirm theory. They also agree with the results of field experiments in the scattered cases for which comparison is available.—*Author's abstract*

176–87. Fatt, I. Pore volume compressibilities of sandstone reservoir rocks: Jour. Petroleum Technology, v. 10, no. 3, p. 64–66, 1958.

Pore volume compressibility is defined as the change in pore volume per unit pore volume per psi change in the pressure of the fluid in the pore spaces while the external pressure is kept constant. Core samples show that there may be a fourfold difference in compressibility from one sandstone to another. Compressibility for each sample is also a function of pressure. With one core sample near 20 percent porosity and the others in the range from 10 to 15 percent porosity, no correlation was evident between porosity and compressibility. In the range from 2,000 to 10,000 psi net overburden pressure (the difference between external pressure and fluid pressure in the pores), pore volume compressibility can be expressed as $C=A-B \log P$, where A and B are constants for each sample.—*G. E. M.*

176–88. Kalinina, R. V. Sootnosheniye mezhdu skorost'yu rasprostraneniya uprugikh voln i otnositel'noy uprugoy kharakteristikoy gornykh porod [The relationship between the velocity of propagation of elastic waves and the relative elastic characteristic of rocks]: Prikladnaya Geofizika, no. 19, p. 216–229, 1958.

The relative elastic characteristic (E) of a rock is expressed by

$$E=\sqrt{\frac{h}{H}},$$

where h is height of recoil of a small ball falling on the rock from the height H. Study of this property of different rocks shows that a sufficiently close relationship exists between the elastic wave velocity and the relative elastic characteristic for clays, argillaceous sandstones, and carbonate rocks, whereas in homogeneous and crystalline rocks, as well as in the coarse-grained sandstones and similar strongly cemented rocks, the elastic characteristic does not correspond to the elastic velocity. The method of the elastic characteristic can be effectively used in the laboratory and in the field for investigation of argillaceous carbonates and argillaceous sandstones.—*S. T. V.*

176–89. Karus, E. [Ye.] V. Absorption of stationary elastic vibrations in rocks: Annali Geofisica, v. 17, no. 2, p. 125–129, 1958.

An English version of Karus' paper published in the Akad. Nauk SSSR Izvestiya ser. geofiz., no. 4, p. 438–448, 1958 (see Geophys. Abs. 174–77).—*D. B. V.*

176–90. Grossling, B. F. Seismic waves from the underground atomic explosion in Nevada: Seismol. Soc. America Bull., v. 49, no. 1, p. 11–32, 1959.

Seismic waves from the underground atomic explosion of September 19, 1957, were recorded for 45 min. on multichannel magnetic tape at a point 25 miles north of Holbrook, Arizona, about 370 miles from their source. Twelve vertical-component seismometers were laid out in the form of an L 5,280 ft by 1,600 ft to

permit determinations of apparent velocity and of direction of arrival. The frequency range recorded, about 6 to 40 cycles per sec, was higher than usual in earthquake seismology. During tape playback, supplementary filtering, gain adjustments, and changes in time scale served to improve the quality and legibility of the records.

The playback seismograms reveal strikingly well not only the P_n and P* waves transmitted and refracted by the crust, but also many others as well. Some of these, as clearly indicated by their directions of arrival, did not originate from the explosion. We have attempted only an elementary interpretation, our main purpose being to make the data available to anyone who might be interested in them. The relatively short wave lengths of the recorded events may make them of unusual significance. In addition to arrival times, we made a few measurements of absolute amplitude and of frequency spectra.—*Author's abstract*

176–91. Kârník, Vít. The blast near Eschenlohe, Bavaria, recorded at Průhonice: Československá Akad. Věd. Studia Geophys. et Geod., v. 2, no. 4, p. 400–401, 1958.

Two quarry blasts (of 6 and 12 tons of explosives, respectively) on February 15, 1958, near Eschenlohe, Bavaria, were recorded at Průhonice, Czechoslovakia, about 360 km away. Onsets of *Pn* and *Pg* are clear and unambiguous. The *Pn* arrival is in good agreement with the traveltime curves for central European near earthquakes, but the *Pg* arrival is early, showing a greater velocity (5.9 kmps), as usually occurs in the case of explosions. The existence of two phases of *Pg* is confirmed (see also Geophys. Abs. 173–141).

Interpretation of transverse waves is more difficult because onsets are less clear. *Sb* and *Sg*, the latter with a velocity of 3.4 kmps, were recognized.—*D. B. V.*

176–92. Research Group for Explosion Seismology (Japan). Crustal structure in northern Kwanto District by explosion-seismic observations. Part 1. Description of explosions and observations: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, pt. 3, p. 329–348, 1958.

Two explosions of 3.70 and 1.55 tons of dynamite made in connection with construction of a dam near Lake Nazori in Gumma Prefecture, Japan, and one planned for purposes of crustal study at Hokota were observed at a total of 33 stations more or less on a line between the two shot points. The exact location of each station, altitude, azimuth, distance from shot point, type of electromagnetic seismometer, and observers, also arrival times of *P*-waves at each station, are tabulated, and 31 seismograms are reproduced.

P-wave velocity in the surface layer was found to be 2.7 kmps near Nozori and 1.79 Kmps near Hokota; deeper layers showed *P* velocities of 5.5 kmps and 7.7 kmps. (See also Geophys. Abs. 176–237).—*D. B. V.*

176–93. Burke-Gaffney, T. N., and Bullen, K. E. On the seismological aspects of the 1954 hydrogen bomb explosions: Australian Jour. Physics, v. 2, no. 3, p. 318–321, 1958.

A reexamination of tentative conclusions drawn from analysis of seismic records of the four 1954 hydrogen bomb explosions (see Geophys. Abs. 169–73, 170–203, 173–238), made in the light of source data recently released by the United States Atomic Energy Commission, leads to the conclusions that earlier computed origin times for the four explosions were correct within 0.0, 0.4, 0.7,

and 0.1 sec respectively, and that the Jeffreys-Bullen *P*-tables need a correction of -2.2 ± 1.0 sec for surface epicenters in the mid-Pacific and recordings at continental stations. The analysis also confirms the fact that the difference between *P* travel times from Bikini to Australia and from Bikini to the United States is not much more than ½ sec, does not alter previous inferences on velocities of air waves from explosions; and confirms the arrival of diffracted *PKP* waves in front of the 142° caustic, at times significantly earlier than *PKIKP* waves.—*V. S. N.*

ELECTRICAL EXPLORATION

176–94. Baranov, Vladimir [I.], and Kunetz, Geza. Distribution du potential dans un milieu stratifié [Distribution of potential in a stratified medium]: Acad. Sci. Paris Comptes Rendus, v. 247, no. 23, p. 2170–2171, 1958.

If the function $F(p,z)$, in the customarily used equation for the potential of an electrical field created by a direct current in a ground having conductivity $\sigma(z)$, is considered to be the image (Laplace-Carson's) of a function $f(t,z)$, it becomes evident that f is an integral of the equation

$$\frac{\partial}{\partial z}\left(\sigma\frac{\partial f}{\partial z}\right)=\sigma\frac{\partial^2 f}{\partial t^2},$$

which is the same as the equation for propagation of a shock in a fictitious formation of density σ and velocity $v=1$. Consequently the calculation of the function f is identical with that of a synthetic seismogram (see Geophys. Abs. 176–316). An equation is derived for apparent resistivity

$$\xi(r)=\int_0^\infty f(t,0)\frac{3r^3t\,dt}{(t^2+r^2)^{5/2}},$$

where $f(t,0)$ represent emissivities of the electrical image (in the sense of Kelvin), which by analogy with seismic results obey laws identical with those of reflection and geometric optics.—*D. B. V.*

176–95. Nedyalkov, I. P. Analiticheskiy metod interpretirovaniya elektricheskikh anomaliy gomogennykh rudnykh tel [An analytical method of interpreting electric anomalies of homogeneous ore bodies]: Bolgar. Akad. Nauk Doklady, v. 11, no. 1, p. 9–12, 1958.

A direct method for determining the shape of an ore body when measurements of its geoelectric anomaly are known is proposed by solving the inverse problem of geoelectrics. It is assumed that the anomaly is produced by direct current flowing through a homogeneous medium of conductivity Λ_e, which includes a homogeneous ore body of conductivity Λ_i, and surface S. The shape of the body surface is described by the radius vector $\boldsymbol{R}\ (\alpha,\beta)$. A solution is sought for the following nonlinear integro-differential equation

$$W(\boldsymbol{R})=\iint_{(s)}\frac{Q(\alpha,\beta)dS}{\boldsymbol{R}-\boldsymbol{R}(\alpha,\beta)};\ 2\pi\frac{\Lambda+1}{\Lambda-1}Q(\alpha_o,\beta_o)+\left(\frac{\partial U}{\partial N}\right)_{\alpha_o\beta_o}+\iint_{(s)}\frac{\cos\gamma-Q(\alpha,\beta)dS}{[\boldsymbol{R}(\alpha,\beta)-\boldsymbol{R}(\alpha_o,\beta_o)]^2}=0$$

where $Q\ (\alpha,\beta)$ is the density of a simple layer; U is the known normal potential; W is the anomalous potential; and Λ is the ratio of the electric conductivity within and without the body. The system is replaced approximately by a system

of nonlinear algebraic equations which is solved by Newton's method. A procedure for a unique interpretation of geoelectric anomalies is given. The method is considered to be suitable for layered and irregular rock structure, and for anomalies caused by alternating currents.—*A. J. S.*

176–96. Chanturishvili, L. S. O kolichestvennom uchete vliyaniya rel'yefa postoyannym tokom [The quantitative evaluation of the terrain effect for some cases of electric prospecting]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 14, p. 199–209, 1955.

A new method of calculating apparent resistivity ρ_k is discussed and the following formula developed: $\rho_{ki}=\rho_k\ (l+\frac{\Delta Ui-\Delta U}{\Delta U}\ 100\ \%)$; $i=l,\ldots.n$, where $\Delta U=\frac{\Delta U}{n}$ is the mean gradient for an interval l having n gradient distances. The case of a trihedral prism of infinite resistivity, representing a valley, is treated as an example, using appropriate master charts.—*A. J. S.*

176–97. Tarkhov, A. G. Ob odnom sposobe opredeleniya moshchnosti nanosov [On a method of determination of the thickness of alluvial deposits]: Razvedka i okhrana nedr, no. 9, p. 34–35, 1957.

Tarkhov criticizes the method of determining the thickness of alluvial deposits suggested in 1952 by Sokovtsev and attempts to prove that the latter's formula gives inaccurate results. He calculates the thickness as according to Sokovtsev's procedure, based on the known relationships between the resistance of different members of the four-electrode arrangement. Then he calculates these values from the potential drop function of ΔU; if the body of alluvium is considered to be annular in form, with the lines of current perpendicular to the ring, the formula $\Delta U=I\rho\frac{1}{2\pi rh}$ can be applied (h=thickness, r=radius, I=current, ρ=alluvium resistivity). The value obtained by the latter method is 50 percent higher than Sokovtsev's value. Sokovtsev's assumption that the resistivity of bedrock is infinite is also questioned; at many places, particularly in the Urals, resistivity of bedrock may be of the same order as that of the alluvium. Also, in most cases the alluvium cannot be considered to be one homogeneous layer but consists of several layers with different resistivities.—*S. T. V.*

176–98. Schufle, J[oseph] A. Cation exchange and induced electrical polarization: Geophysics, v. 24, no. 1, p. 164–166, 1959.

The mechanism proposed by Vacquier (see Geophys. Abs. 170–101) for induced electrical polarization (*I.P.*) has been tested by measuring *I.P.* experimentally in the presence of different cations. The results show a decrease in *I.P.* with increase in valence of the cation for the highest concentration used (0.005 normal), as predicted from the cation exchange mechanism. As concentration decreases, the *I.P.* values for sodium, calcium, and lanthanum nitrates appear to approach a common value of about 560 mv-sec per v; the value for thorium nitrate however remains low even at lowest concentrations. These experiments give some support to the cation exchange mechanism for the *I.P.*, but the inconsistencies in the results suggest that other factors may be involved.—*D. B. V.*

176–99. Bulashevich, Yu. P. Printsip podobiya pri modelirovanii polyarizatsii rudnykh tel, vyzyvayemoy tokom [The principle of similarity in model studies of polarization of ore bodies produced by a current]: Akad. Nauk SSSR Ural. Filial Gorno-Geol. Inst. Trudy, no. 30, geophys. sbornik no. 2, p. 53–59, 1957.

The physical basis of the phenomenon of induced polarization as applied to prospecting for sulfide ore bodies is discussed. Stress is put on the fact that in the process of induced polarization two factors enter, the polarization of the ore body and the polarization of the surrounding formations. Both these processes are parallel; a fact which complicates the problem is that the polarization of adjoining zones of the formation may reach great intensity and seem to be independent of the polarization of the ore body itself. Laboratory experiments are set up in conditions basically different from those met in the field. This has resulted in great discrepancy between experimental and field data. A criterion for similarity between field and laboratory conditions is derived and given in vectorial form at the end of the article. The necessity of further study of the process of induced polarization both in the field and in the laboratory is also indicated.—*S. T. V.*

176–100. Shaub, Yu. B. Pole sfericheskogo rudnogo tela vkraplennogo tipa, polarizovannogo odnorodnym peremennym tokom [The field of a spherical ore body of disseminated type, polarized by a uniform alternating current]: Akad. Nauk Kazakh. SSR Vestnik, no. 5(158), p. 45–54, 1958.

The case of a spherical ore body composed of uniform and disconnected grains of equally conducting material, placed in a uniform electrical alternating field is considered from the point of view of interpreting the results of amplitude and phase measurements in electrical prospecting. The current frequency is assumed to be low enough that the field can be considered quasi-stationary. For the usual shape of inclusions (elongated needle shapes or laminar forms excluded) the overall resistance and the dielectric constant of the ore body remain unaffected up to 10 to 20 percent of inclusions. The solutions of the direct and inverse problems of the case are given, and the coefficient and phase of polarization are determined in terms of physical properties and size of the disseminated particles.—*A. J. S.*

176–101. Ward, S. H., Cartier, W. O., Harvey, H. A., McLaughlin, G. H., and Robinson, W. A. Prospecting by use of natural alternating magnetic fields of audio and sub-audio frequencies: Canadian Mining and Metall. Bull., v. 51, no. 556, p. 487–494, 1958; Trans., v. 61, p. 261–268, 1958.

An account of a new method of investigating the electrical properties of the earth's crust is presented. The method, called *AFMAG*, employs as a source, natural alternating magnetic fields of audio and sub-audio frequencies. Measurements of the distortion of these fields caused by geological features are made with the aid of search coil detectors at several discrete frequencies. Many results of field surveys made with the method are presented and they illustrate its advantages and limitations when applied to the search for massive sulphide mineralization. The advantages far outweigh the limitations; and in fact indicate that a major breakthrough in geophysical exploration technique and instrumentation has been made.—*Authors' abstract*

176–102. Slichter, Louis B., and Knopoff, Leon. Field of an alternating magnetic dipole on the surface of a layered earth: Geophysics, v. 24, no. 1, p. 77–88, 1959.

The magnetic field near a vertical alternating magnetic dipole on the surface of a layered earth is computed for points on the surface, for assumed values of the dimensionless conductivity in the layer (S_1) of 0, ¼, 1, and 4, and in the homogeneous substratum (S_2) of 0, ¼, 1, and 4. The induced field is computed at distances from the source of ½, 1, 2, 4, 8, and 16 times the layer thickness. Results are presented in graphs which show the effect of a change of conductivity at the base of the layer by departure of the curves for specified values of S_1 and S_2 from the comparison curve $S_1=S_2$.—*D. B. V.*

176–103. Bhattacharyya, Bimal Krishna. Electromagnetic fields of a transient magnetic dipole on the earth's surface: Geophysics, v. 24, no. 1, p. 89–108, 1959.

Transient electric and magnetic fields close to the surface of the earth, as developed by a step-function current flowing in a circular loop of wire, have been determined. The effect of the insulating air region is fully taken into account. It is observed that the air region has an appreciable influence on the fields over the surface of the earth. The effect of displacement current within the earth has also been considered. Expressions of electric and magnetic fields have been utilized to determine (a) the mutual impedance function between the primary loop and a small length of wire and (b) the voltage induced in a secondary loop. Both these functions are found to have appreciable magnitudes only during the time interval between the arrival of the wave travelling through air and that of the wave via the conducting medium. From a study of this duration and the initial amplitude of either of the two functions, it is possible to obtain values of conductivity and permittivity of the earth. Curves have been plotted to depict the nature of variation of these functions with time for different values of the electric constants of the earth.—*Author's abstract.*

176–104. Teisseyre, Roman [K.]. The general problem of a conducting wedge: Acta Geophys. Polonica, v. 6, no. 3, p. 205–221, 1958.

A solution is given for the problem of diffraction of an electromagnetic dipole field by a conducting wedge. The method is analogous to that of Senior for a half-plane, but simpler. The chief difference is that the point of departure is Sommerfield's solutions for spherical waves, not the solution for plane waves as in Senior's method. The approximation for short waves is presented as well as the general solution for the dipole field.—*D. B. V.*

176–105. Wait, James R. On the electromagnetic response of an imperfectly conducting thin dyke: Geophysics, v. 24, no. 1, p. 167–191, 1959.

The slab solution of the theoretical electromagnetic response of an imperfectly conducting dike is simplified by assuming a thin conducting sheet whose thickness d and conductivity σ are respectively small and large in such a way that σd is finite. Approximate solutions are derived for the case where source (P') and observer (P) are in the first quadrant, not near the edge, and for the case where P' is in the first quadrant and P in the fourth, not near the edge. These solutions are valid only if one or both of the perturbation terms are small. There is no justification for assuming the solution to be valid if the source and ob-

server are in the second and third quadrants, since the induced currents are seriously modified by the truncation. The "merged type of solution" in fact is valid only if P and P' are in the first and fourth quadrants and far from the edge. (See also Geophys. Abs. 172–74 and 75 and 166–136.)—*D. B. V.*

176–106. Kimura, Koichi. Theoretical study on the electromagnetic induction method (VI) [in Japanese with English abstract]: Butsuri-Tankō, v. 11, no. 2, p. 79–84, 1958.

This report describes a method of electromagnetic prospecting which uses a set of crossed coils. With this method the secondary field can be calculated by using the formula of the secondary field produced by an ore body in the field of a magnetic dipole. The secondary field is zero above the ore body with a maximum and minimum on both sides. The electromagnetic character of the ore body is similar to that of an ore body in a uniform field.—*V. S. N.*

176–107. Dayev, D. S. Modelirovanie nekotorykh zadach vysokochastotnoy electrorazvedki [Modeling of some problems of high frequency electrical exploration]: Ministerstvo Vysshego Obrazovaniya SSSR, Izvestiya vysshkikh-uchebnykh zavedeniy, Geologiya i razvedka, no. 4, p. 121–132, 1958.

Since the radio-transmissivity method of high frequency electrical exploration presents difficulties for mathematical analysis of the data, Dayev resorts to models in continuous media subject to the following criteria: $\epsilon_1 f_1^2 l_1^2 = \epsilon_2 f_2^2 l_2^2$ and $\rho_2 f_1 l_1^2 = \rho_1 f_2 l_2^2$, where f=field frequency, l=linear dimensions, e=dielectric constant, and ρ=resistivity of the medium; indices 1 and 2 refer to the parameters of the natural conditions and of the model respectively. In the experiments described the model was made to correspond to ρ=3,000 ohms, ϵ=8, and f=5 megacycles as in natural conditions. Diffraction of electromagnetic waves on vertical metal plates was studied for waves perpendicularly incident to the plate and for waves with different angles of incidence. Similar experiments were conducted with square conducting plates and linear conductors. The results of the study are presented in graphs which provide data on the location and size of conducting deposits.—*A. J. S.*

176–108. Yoshizumi, Eizaburo, and Taniguchi, Keiichiro. On the measurement of small phase difference [in Japanese with English abstract]: Butsuri-Tankō, v. 11, no. 2, p. 85–89, 1958.

This paper describes the electrical prospecting equipment designed to make highly accurate measurements of the small phase difference between the primary and secondary field induced by the structure of the earth. Test results show that the equipment will measure phase differences of less than a degree.—*V. S. N.*

176–109. Meidav, Tsvi, Hayes, William C., and Heim, George E. Resistivity surveys of Missouri limonite deposits: Missouri Geol. Survey and Water Res. Rept. Inv., no. 24, 27 p., 1958.

A resistivity survey was made of secondary brown iron deposits in six mines and prospects in Howell and Shannon Counties in south-central Missouri, in an effort to establish an inexpensive method for determining the thickness and lateral extent of the ore-bearing residuum in sinks prior to mining operations.

The apparatus used for determining the resistivity contrast between mineralized zone and host rock is described.

It is concluded that the electrical resistivity method is applicable to the exploration of limonite deposits of Missouri.—*A. J.*

176–110. Bragg, J. G. Saturation geophysical exploration: Canadian Mining and Metall. Bull., v. 52, no. 561, p. 49–55, 1959.

This paper describes an example of saturation geophysical exploration by the staff of the Hudson Bay Exploration and Development Company, using a horizontal loop-frame electromagnetic apparatus to locate copper and zinc sulphide deposits in a lake- and drift-covered portion of the Canadian Shield in northern Manitoba and Saskatchewan. Details of the geophysical survey are discussed including location of the area, establishment of the camp, operation of the instruments, and the plotting and interpretation of results.—*V. S. N.*

176–111. Cantos [Figuerola], J[osé], Borrego [González], J[oaquin], and Gea, Rufino. Investigación electrica y magnética en el pantano de Valduengo, de Jerez de los Caballeros (Badajoz) [Electrical and magnetic investigation on the Valduengo dam, at Jerez de los Caballeros (Badajoz)]: Rev. Geofísica, v. 16, no. 63–64, p. 391–411, 1957.

Electrical and magnetic as well as geological surveys were made of the area to be inundated upon construction of an irrigation dam on the Ardila River near Jerez de los Caballeros in Badajoz province, Spain, in order to determine whether any of the iron deposits of the area might be lost.

The only anomalies in the inundated area represent about 150 m of veins 4 to 5 m thick and about 15 m deep; as their tonnage and quality could not be determined exactly from the geophysical data, borings were made in the anomalies, which indicated that about 11,250 m^3 of mineralized zone, or some 56,250 tons of supposed ore, would be covered.—*D. B. V.*

176–112. Chanturishvili, L. S., and Varazashvili, G. S. Primeneniye elektrorazvedki pri izuchenii prichiny zabolachivaniya [Use of electrical prospecting in the studies of the causes of swamping]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 13, p. 119–127, 1954.

A discussion of electric prospecting used to find the cause of swamping of an irrigation area where hydrogeological methods proved unsatisfactory is presented in the paper. Lithological profiles of the area were determined by the electrical resistivity method, and the layers causing the swamping were identified.—*A. J. S.*

176–113. Chkhenkeli, Sh. M., and Tsitsishvili, D. A. Primeneniye elektrorazvedki dlya resheniya nekotorykh zadach inzhenernoy geologii [Application of electric prospecting to the solution of some problems in engineering geology]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 13, p. 105–117, 1954.

This paper describes the use of direct current electrical prospecting in the study of karst phenomena in the Tkibul' region and to the determination of the geoelectrical features of the Gomaret plateau, in the Georgian S.S.R.—*A. J. S.*

176–114. Noma, Yasuji. On the electrical prospecting in the Gongen mineral spring, Horie, Matsuyama City [in Japanese with English abstract]: Butsuri-Tankō, v. 11, no. 2, p. 90–95, 1958.

This report describes a spontaneous polarization and geological survey of the complexly jointed granite area of the Gongen mineral spring north of Matsuyama City, Ehime Prefecture, Shikoku, Japan. It was determined that the mineral spring is related to the joint systems striking N. 10° W. and N. 70°–75° W.—*V. S. N.*

176–115. Ono, Yoshihiko; Murozumi, Masayoshi; and Homma, Ichirō. On the application of resistivity method for horizontally stratified layer problems (some notes on geo-electrical measurements at Tanashi and Tako) [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 9, no. 6, p. 1–10, 1958.

Test resistivity measurements (two-electrode method) were made in bore holes at Tanashi, Tokyo Prefecture, and at Tako, Chiba Prefecture, Japan to improve the interpretation of electrical data obtained from surface electrical profiling (Wenner method). Comparison of the results of profiling with those of electrical logging demonstrated that the two-layer standard curve method may be applied to the three- or multi-layer problem; that for subsoil structure of different successive layers, equivalence effect and pseudo-anisotropic effect should be taken into account; that for a deeper layer the resolving power of vertical profiling depends on the ratio of the layer's depth to its thickness, and more accurate results may be obtained in this case by using electrical logs.—*V. S. N.*

176–116. Research Group for Spontaneous-Polarization Method (Japan). Study of the spontaneous-polarization method at the Hosokura Copper mine, Miyagi Prefecture [in Japanese with English abstract]: Butsuri-Tankō, v. 10, no. 4, p. 191–205, 1957.

The results of an experimental survey at the Hosokura copper mine, Miyagi Prefecture, Honshu, Japan, using the spontaneous-polarization method are described. The vertical distribution of the *SP* potential of the surface layer was measured in 5 boreholes 10 m deep. The distribution of the anomalous *SP* potential across the copper vein was measured along the walls and in the horizontal holes in the adits. Some experiments were also conducted along the walls of the adits to determine the contact potential between electrodes and minerals and (or) rocks.—*V. S. N.*

ELECTRICAL LOGGING

176–117. Southwick, S. H., Kerver, J. K., and Winsauer, W. O. Electric-log interpretation: Oil and Gas Jour., v. 56, no. 46, p. 193–195, 197–200, 203, 206, 209, 1958.

This paper presents a qualitative method of electric log interpretation which gives good representation of potential and resistivity data on both clean and shaly rocks containing formation waters of high or low salinities. The method requires an accurate measurement of the potential, the resistivity of the mud filtrate, the resistivity of the invaded and uninvaded zones, and an estimate of formation temperature. Two nomographs are provided for use in making interpretations: a nomograph for determination of R_{wa}/R_w for formation waters and

mud filtrates at temperatures of 125°F., 175°F., and 250°F.; and a five-step nomograph to determine R_o and the resistivity index.—*V. S. N.*

176–118. Plewa, S. Metodyka geofizycznej interpretacji i pomiarów kopalnianych za węglem kamiennym z uwzględnieniem profilowania neutron-gamma [Methods of geophysical interpretation and mine surveys including neutron-gamma logging in prospecting for coal]: Nafta (Poland), no. 10, p. 286–288, 1957.

Plewa advocates the system of joint prospecting by several methods in order to arrive at a unique interpretation of graphs plotted for self-potential, electrical resistivity, neutron-gamma, and natural gamma radiations. The self-potential curves supply no data for differentiating between coal horizons; electrical resistivity curves are ambiguous in case of coal and sandstone, as their resistivities are almost equal; natural gamma radiation gives only a rough definition of coal horizons. A field investigation is presented in the paper in the form of four logs made by the above methods in the same borehole in coal. It was found that the neutron-gamma method compensates for the ambiguities of other methods, thus providing a satisfactory geophysical interpretation of the profile.—*A. J. S.*

176–119. Winn, R. H. A report on the displacement log: Jour. Petroleum Technology, v. 10, no. 2, p. 57–59, 1958.

When a porous formation containing mobile hydrocarbons and irreducible interstitial water is invaded by mud filtrate, the latter displaces the interstitial water radially away from the drill hole to form a bank of interstitial water between the flushed zone and the undisturbed formation. With the resistivity of the mud filtrate (R_{mf}) greater than that of the interstitial water (R_w), as is usually true, and with mobile hydrocarbons present, a resistivity profile with increasing radial distance from the drill hole shows: high, low, and high resistivity. The zone of low resistivity is known as the low zone. If mobile hydrocarbons are absent (or if a water zone is present) the bank of interstitial water is indistinguishable from the undisturbed formation.

Lateral curves recorded simultaneously with electrode spacings of 16, 24, 32, 40, 48, 56, 64, and 72 in. yield a displacement log. Rubber bumpers reduce the shunting effect of the drill hole and mud and provide that the sonde effectively occupies 90 percent of the diameter of the borehole. A plot at a given depth of the resistivity obtained with the various spacings is used to detect the low zone.

Field tests indicate dips or inflections (low zones) in 19 out of 25 known producing zones but delineate clearly the presence of a low zone in a rather small percentage of the total productive feet. The displacement log may be particularly useful in defining a productive zone where the true resistivity is low, on the order of one ohm-m, and where conventional log interpretation is not definitive. The displacement or profile log, however, does not replace either the conventional log or the contact log, and a contact-caliper log is almost essential to an understanding of the profiles.—*G. E. M.*

176–120. Worthington, A. E., and Meldau, R. F. Departure curves for the self-potential log: Jour. Petroleum Technology, v. 10, no. 1, Tech. Papers no. 4701 (Am. Inst. Mining Metall. Petroleum Engineers Trans., v. 213), p. 11–16, 1958.

The analog computer serves to model the reduction of the electrochemical and electrofiltration components of the *SP*, or self-potential, observed in electrical logging because of formation and borehole geometric and resistivity effects. The reductions are related to the ratios of bed thickness to borehole diameter (e/d), shale resistivity to mud resistivity (R_s/R_m), resistivity of the invaded zone to mud resistivity (R_i/R_m), and resistivity of the noninvaded zone to mud resistivity (R_t/R_m). Reduction or departure curves show the decrease of the electrochemical and electrofiltration potentials in relation to these ratios. Compared with the original analog data the departure curves show a root mean square deviation of 5.4 percent for 1,193 points. Identical situations set into analog form at different times show that the reproducibility of the analog was ±2 percent; several special setups agree within 2 percent with the analytical solutions of Doll. Twentythree charts containing families of departure curves are included.—*G. E. M.*

176–121. Gondouin, M., and Scala, C. Streaming potential and the SP log: Jour. Petroleum Technology, v. 10, no. 8, Tech. Papers no. 8023 (Am. Inst. Mining Metall. Petroleum Engineers Trans., v. 213), p. 170–179, 1958.

Laboratory and field experiments show that in the borehole a streaming or electrokinetic potential exists in shale as well as in mud cake, and depends upon the pressure difference across these materials.

In the laboratory, in order to avoid electrode polarization effects, a small alternating pressure difference, dP, of constant amplitude and frequency was superimposed upon a large static pressure difference to yield an alternating electrokinetic potential, dE_k. The results were expressed as dK_E/dP vs P. The method gave excellent results. As dP was known with good precision, the curve of E_k vs P could readily be constructed by integration of dK_E/dP. The streaming potential was found to be affected also by temperature, salinity, and the zeta function (valence of the cation).

Although the magnitude of the streaming potential is considerable, it is usually not greatly different in shale and mud cake. The *SP* opposite shale defines the shale base line, or zero reference potential; thus in logging the streaming potential is subtracted opposite shale as well as mud cake (or sands). The resultant electrokinetic contribution is often small and is evidenced by the large number of cases where a calculation of (formation) water resistivity according to the electrochemical *SP* agrees with production data. A statistical analysis of the extent of compensation between the streaming potential of shale as determined in the laboratory and of mud cake obtained from 31 field muds shows that on the average the contribution of the electrokinetic component lies between −5 to −10 mv. The wide variations between the electrokinetic properties of different shales and different mud cakes explain why in certain cases a very significant electrokinetic component of the *SP* is present.—*G. E. M.*

176–122. Doh, C. A., and Tixier, M. P. A new log: the induction-electrical log combination: Gulf Coast Assoc. Geol. Soc. Trans., v. 7, p. 325–334, 1957.

The induction-electric log is a combination of an *SP* curve, a short normal, and a focused induction log (40-inch spacing), with all three recorded simultaneously in a single run. The main advantages over the conventional electric logs are greater resolution; greater investigation than the 64-in. normal, and in many cases greater than the 18-ft lateral; more accurate determination of true resistivities, particularly in the low ranges; and the fact that the induction log is less affected by mud in the hole and by the resistivity of adjacent beds. (See also Geophys. Abs. 171–132.)—*V. S. N.*

176–123. True, H. W. Induction-electrical logging in Oklahoma: World Oil, v. 146, no. 4, p. 108–109, 112, 114–116, 1958.

Use of the induction-electric logging system in Oklahoma has shown it to be the most reliable method for determination of true formation resistivities. The induction-electric log minimizes the effect of the mud column, the invaded zone, and the effects of adjacent beds on the bed under study; provides accurate readings in low resistivity beds and in thin beds; gives excellent resolution under thin resistive streaks which are detrimental to conventional logs; accurately defines beds and makes determination of thin bed boundaries and oil-water contacts easier and more accurate. The principles of induction logging are discussed; field examples illustrating its application in Oklahoma and Texas are given, and comparisons are made with other logging systems (see also Geophys. Abs. 169–114).—*V. S. N.*

176–124. Al'pin, L. M. Transformatsiya krivykh zondirovaniya [Transformation of the curves of profiling]: Prikladnaya Geofizika, no. 19, p. 23–46, 1958.

Some 10 years ago Al'pin suggested several new arrangements of electric profiling and with his pupils worked out a complete theory of dipole profiling. The present study deals with the mathematical problem—the transformation of the results obtained from one electrode arrangement into the corresponding formulas of another arrangement. The transformations discussed can be used if the local conditions of profiling change so that another arrangement becomes more suitable; they consist of a rather lengthy series of elementary mathematical operations. The new forms of profiling were worked out especially for use in electric logging of drill holes where established procedures were not entirely successful.—*S. T. V.*

176–125. Hamilton, R. G. New slide rule simplifies electric log quantitative analysis: World Oil, v. 146, no. 4, p. 81–84, 1958.

A new slide rule calculator, the Arps-Hamilton Loganalyzer, for rapid quantitative analysis of electric logs is described in detail. The rule has 76 scales grouped into seven sections. It permits correction and instant readings of *Rm*, *Rmf* and *Rw;* gives parts per million, specific gravity, and grains per gallon of NaCl for *Rmf*, *Rw* or for a chemical analysis; determines the corrected *Rw* instantly from the apparent *Rwe* derived from the *SP* equation; and calculates water saturation, *Sw* percent, for a wide range of "*n*" coefficients, by either the Archie or Humble formation factor relationships. The interrelationship of the depth-temperature-gradient and *Rm*, *Rmf*, and *Rmc* scales allow instant read-

ings; and scales of section *D* allow flexibility and interchangeability of water saturation and formation factor. For each section examples are given of solutions of quantitative equations and empirical relationships.—*V. S. N.*

176–126. Gray, D. A. Electrical resistivity marker bands in the Lower and Middle Chalk of the London Basin: Great Britain Geol. Survey Bull., no. 15, p. 85–95, 1958.

Electrical resistivity profiles of large-diameter, water-filled boreholes drilled into Lower and Middle Chalk formations of the London Basin located 10 persistent horizons which could be used as marker bands. Tentative correlations were made between the marker bands and the horizons of the Chalk already established by the limited stratigraphic and paleontologic evidence available. The true stratigraphic correlation of the marker bands must be confirmed by future cored boreholes. A structure contour map was made of the base of one of the marker bands in Hertfordshire.—*V. S. N.*

176–127. Pflug, Hans D. Zur Auswertung von Schlumberger Diagrammen in der rhenischen Braunkohle [On the interpretation of Schlumberger diagrams in the Rhenish lignite]: Freiberger Forschungshefte, C45 Geophysik, p. 83–94, 1958.

Studies made in the Rhenish lignite district in order to determine whether the technological properties can be determined from borings in unopened deposits show that changes in coal facies are reflected in the electrical logs. The ash content of the coal seams can be deduced from the diagrams obtained by a combination of the normal electrode arrangement, microlog, and gamma-ray log. The briquetting qualities of a coal seam are shown by its resistivity, those difficult to briquet (finely ground and homogeneous material, showing marine influence) have low resistivity; those easy to briquet (largely the structural remains of plant tissue) offer high resistivity to electric current. Quantitative interpretation will depend on conversion of apparent resistivity into true resistivity; the curves of each borehole should be calibrated by laboratory measurements on two or three samples of the core.

Electric log diagrams can be useful in still another way in lignite areas: correlation of characteristic segments of the curves of neighboring boreholes gives the facies stratigraphy (lithologic rather than chronological stratigraphy). Coal seams, the result of shifting facies, often become younger or older laterally, but a combination of logging correlations and paleontological methods should yield good results.—*D. B. V.*

176–128. Dlabac, Mikuláš. Kladné výchykly v křivce přirozených potenciálů (*PS*) elektrokarotážního měřeni v místech stratigrafickych hiátů v Miocénu vnitroalpské vídeňské pánve [Positive kicks in the self-potential (*SP*) curve of electrical logging corresponding to stratigraphic hiatuses in the Miocene of the Inner Alpine Vienna Basin (with German summary)]: Slovenská Akad. Vied Geol. Práce, v. 12, p. 27–33, 1958.

Small positive kicks (intensity up to 15 mv) in the *SP* logs obtained at various places in the Slovakian part of the Inner Alpine Vienna Basin were observed corresponding to stratigraphic gaps, particularly the Pannonian-Sarmatian contact and at the boundary between the Bolivino-Bulimina and Sandschaler zones in the Upper Tortonian. The resistivity curves are straight at these places, but the *SP* curves appear to reflect all discontinuities except where sedimentation

ended and began with sand layers. The cause is attributed to weathering, for example enrichment in gypsum.—*D. B. V.*

176–129. Butakov, G. P. Elektrokarotazh pri poiskovom i razvedochnom burenii v Irkutskom uglenosnom basseyne [Electrical logging in the prospecting and exploration of drill holes in the Irkutsk coal basin]: Razvedka i okhrana nedr, no. 12, p. 36–44, 1957.

The results of electrical logging conducted since 1951 in different coal fields of the Irkutsk coal basin are presented. The program of well logging usually consisted of determining the curves of apparent resistivity, using one and two electrodes, standard and inverted. The curves of spontaneous and induced potentials were regularly determined also. A detailed description of measuring arrangements used in different cases are given as well as the petrographic characteristics of the drill holes. No general method of interpretation of the curves obtained could be arrived at owing to differences in the geology of different coal fields; successful interpretation could be made of the curves obtained from drill holes located in coal fields of similar geology, thus eliminating the need for core sampling. This cuts the cost of the investigation of one meter of drill hole from 6.34 rubles to 2.0 rubles. The article contains numerous curves with parallel description of the geology of various fields.—*S. T. V.*

Ono, Yoshihiko; Murozumi, Masayoshi; and Homma, Ichirō. On the application of resistivity method for horizontally stratified layer problems (some notes on geoelectrical measurements at Tanashi and Tako). See Geophys. Abs. 176–115.

ELECTRICAL PROPERTIES

176–130. Keyvsar, Z. I. O svyazi otnositel'nogo soprotivleniya s poristost'yu, udel'noy poverkhnost'yu i pronitsayemost'yu porody [On the relationship of the specific resistivity of a rock to its porosity, specific surface and permeability]: Prikladnaya Geofizika, no. 19, p. 186–194, 1958.

The specific resistivity of a rock is closely related not only to its porosity but to the shape of the openings, which produce nonuniformity of the porous channels and their tortuosity, as well. There is no general relationship between the specific resistance and the specific surface or permeability of a rock, except in the case where water of low mineral content is contained in argillaceous formations, where the specific resistivity decreases due to the action of a greater specific surface. In the sandstones of the Volga River valley the correlation between their specific resistivity and the specific surface remains to be more precisely formulated. The method of determination of permeability of sandstones and siltstones from specific resistivity, suggested by Morozov cannot be recommended for use.—*S. T. V.*

176–131. Piskunov, L. I. O kolichestvennoy zavisimosti mezhdu dielektricheskoy pronitsayemost'yu i udel'nym elektrosoprotivleniyem gornykh porod [On the quantitative relation between the dielectric constant and the specific electric resistivity of rocks]: Akad. Nauk SSSR Izv. ser. geofiz., no. 9, p. 1133–1136, 1958.

Empirical formulas establishing the relationship between the value of dielectric constant and specific electric resistivity, suggested by several Russian geophysi-

cists, are analyzed. The validity of these formulas was tested on about a dozen minerals; it is shown that they are not applicable either to theoretical or to field investigations. Cracks or water filling the cracks affect both these physical constants considerably.—*S. T. V.*

176–132. Toporets, S. A. Vliyaniye mineralogicheskogo sostava mineral'nykh primesey na elektroprovodnost' kamennykh ugley [Influence of mineralogical composition of mineral impurities on the electrical conductivity of coals]: Akad. Nauk SSSR Doklady, v. 122, no. 2, p. 286–288, 1958.

Measurements of the electrical conductivity of coals show that the mineralogical composition of impurities has a significant effect on the electrical properties. In coals of intermediate rank, the presence of minerals of the kaolinite group and, mainly, of calcite and siderite, increases the resistivity; in anthracite, the conductivity of which is close to that of kaolinite, clay minerals have little effect or may even decrease the resistivity, but the carbonates increase it substantially.—*D. B. V.*

176–133. Jaszczewski, Z. Oporność właściwa próbek rdzeni wiertniczych [Specific resistivity of core samples]: Nafta (Poland), no. 5, p. 118–122, no. 6, p. 145–148, 1956.

This paper reports the results of laboratory experiments carried out for determining the physical and chemical properties of the layers in electrical logging of a borehole. Resistivity measurements on core samples made it possible to determine the porosity of the layers, nature of their saturating media, and the values of the coefficients and parametric relationship of the strata logged. The data obtained leave no doubt as to their usefulness when applied to the field conditions of electrical logging when apparent resistivity and distribution of self-potential are to be established. The possibility of constructing a simple device for determination of the "layer coefficient" and the "coefficient of resistivity increase" is suggested.—*A. J. S.*

176–134. Fritsch, Volker. Zum Problem der geoelektrischen Blitzgefährdung [On the problem of the geoelectric lightning risk]: Gerlands Beitr. Geophysik, v. 67, no. 4, p. 304–323, 1958.

A "lightning risk figure" is proposed, by means of which the chances of different areas being struck by lightning can be compared. The figure is based on statistics, mostly compiled for other purposes; the statistics on building damage are most reliable. Lightning risk depends on various geometrical, geophysical and other factors. Theoretical and experimental investigation of the problem, and comparison of Austrian statistics with the results of geoelectrical investigations, leads to the conclusion that the electrical properties of the ground influence the path of lightning; inhomogeneous structure, in particular therefore deformed zones, are most susceptible to lightning. Absolute height has no particular effect, but relative height does. (See also Geophys. Abs. 169–126.)—*D. B. V.*

EXPLORATION SUMMARIES AND STATISTICS

176–135. Patrick, Homer G. Geophysical activity in 1957; Geophysics, v. 23, no. 5, p. 953–971, 1958.

Worldwide activity in geophysical exploration by the petroleum industry decreased slightly in 1957; gains in the Eastern Hemisphere did not fully offset

the decline in the Western Hemisphere. According to reliable data received, an average of 1,122 crews of all types were active in 1957, as against 1,136 in 1956 (a record year) and 1,119 in 1955. Statistics for the world and for the United States and Canada are presented in tables and graphs.—*D. B. V.*

176–136. Odishaw, Hugh. International Geophysical Year: Science, v. 128, no. 3339, p. 1599–1609, 1958; and v. 129, no. 3340, p. 14–25, 1959.

The first part of this article outlines the scope of the IGY effort and summarizes some aspects of work dealing with the physics of the upper atmosphere, including solar and interplanetary medium relationships. The second part summarizes typical findings in the area of heat and water regime (meteorology, oceanography, and glaciology) and of the earth sciences (seismology, gravity, longitude and latitude determinations). The basic goal of the IGY, acquisition of data taken simultaneously at various points on the earth in order to give a planetary view of the phenomena and events in most of the major fields of geophysics, was reached; the observational program was prosecuted more effectively than anyone had hoped during the planning period. Flow of data between the three world centers indicates wholehearted cooperation in this phase also. Under a program designated International Geophysical Cooperation-1959, certain studies will be continued as a coordinated effort, and special committees will deal with oceanography, the Antarctic, and space science; the solar patrol and related world communication services will be continued, and a proposal for a world magnetic survey during a quiet solar period, some 4 or 5 years hence, has been endorsed by the International Council of Scientific Unions.—*D. B. V.*

176–137. Lyons, Paul L. Geology and geophysics of the Gulf of Mexico: Gulf Coast Assoc. Geol. Soc. Trans., v. 7, p. 1–10, 1957.

The Gulf of Mexico shows a gravity maximum unique on the face of the earth and a magnetic field which is relatively featureless. Topographically the Gulf is a funnellike depression; its deepest point, Sigsbee Deep, reaches 12,245 ft below sea level and is bordered by one very abrupt continental shelf off Yucatan. Geologically, as demonstrated by study of the seismic profile, the Gulf is a structural "high" in the earth's crust, with the Mohorovičić discontinuity rising very close to the surface. The lack of magnetic anomalies indicates that this crust has not been broken by igneous intrusion so that the Gulf may be classified as a true geologic craton. The northern flank of the Gulf, the coast area of North America, is a great geosyncline. It is concluded that the Gulf itself is an undisturbed portion of the earth's crust destined to sink further and to receive many thousands of feet of sediments which will be deposited in limited basins encroaching from the shore of the North American Continent.—*V. S. N.*

176–138. Moore, W. Lee. Geophysics along the Edwards Trend: Gulf Coast Assoc. Geol. Soc. Trans., v. 7, p. 55–64, 1957.

This is a brief discussion, copiously illustrated, of the effectiveness of gravity and seismic work in locating petroleum reserves in the area of the Edwards trend in south Texas.—*V. S. N.*

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176–139. Kailasam, L. N. Geophysical exploration of the coastal sedimentary belt of Madras State: Current Sci., v. 27, no. 12, p. 476–479, 1958.

Gravity and magnetic surveys were made in the South Arcot District of India as the beginning of a systematic investigation of the entire sedimentary coastal region of Madras State. Gravity observations were made with a Worden gravimeter, magnetic with a Watts vertical magnetometer.

A Bouguer map of part of the district shows three features of interest: a sharp decrease in values (gradient 7.5 mgal per mile) near the edge of the crystallines west of the town of Vriddachalam; a pronounced low in the region of the proved Neyveli lignite field; and a sharp increase (gradient 2 to 3 mgal per mile) to the east of the lignite field, with a high of 45 mgal near Porto Novo on the coast. The first may be interpreted as a near-vertical fault of the order of 3,200 ft, or as a pronounced downwarping of the basement. The second cannot be attributed to the lignite alone, but probably represents a deepening of the basement in the Neyveli area; quantitative interpretations indicate a thickness of sediments of at least 5,000 ft. The rise east of Neyveli appears to be a typically large isostatic regional anomaly, with superposed local anomalies. Although the gravity rise could be interpreted as a rise of the basement, the magnetic values continue their downward trend and suggest a basement depth of the order of 8,000 ft in the Tirttanagiri area near the coast.

Preliminary results of a seismic reflection traverse across the area confirm these thicknesses. Petroleum prospects in Madras State should now be considered as good.—*D. B. V.*

176–140. Sen'ko, P. K. Geofizicheskiye issledovaniya v Antarktide [Geophysical studies in the Antarctic]: Priroda, no. 7, p. 59–62, 1958.

Observations made by the geophysics team of the Russian Antarctic expedition are described with reference to seismology, earth's magnetic field, and the ionosphere (variations in which are correlated with those of earth currents). Two hundred earthquakes were recorded at the seismic station, which was equipped with two horizontal and one vertical Kirnos seismographs; most of their foci were located in the region of Tonga, Samoa, and the Fiji Islands, and not a single earthquake had its origin on the Antarctic continent. The prevailing period of microseisms was found to be between 6 and 10 sec during the winter and shorter, but with greater amplitude (up to 7 μ), during the summer. The absolute values of the elements of the earth's magnetic field were determined with the aid of a magnetic theodolite, quartz magnetometer, induction inclinator, and electrical *Z*-magnetometer. A local variation in the magnetic field was found near Mirnyy station; a peculiar instability in the vertical component of the field was discovered there, and explained by an anomalously dense electric current flowing along the coast.—*A. J. S.*

GENERAL

176–141. Favre, B. Cours de géophysique [Course in geophysics]: Paris, Inst. Français du Pétrole, 438 p. (in 2 volumes), 1956.

The first volume of this textbook consists of three chapters. The introductory chapter discusses the place of geophysics in the evolution of petroleum prospecting, defines the subject, classifies the methods according to the rock properties measured, and discusses the cost, choice of methods, and general principles involved in using the data obtained geophysically. The second and third chapters

deal with gravimetric and magnetic methods, respectively, giving the basic principles, apparatus, and presentation and interpretation of results.

The second volume does the same in chapters on electrical (direct current and telluric) and seismic (reflection and refraction) methods.—*D. B. V.*

176–142. Haalck, H[ans]. Lehrbuch der angewandten Geophysik, Teil II [Textbook of applied geophysics, Part 2]: Berlin, Gebruder Bornträger, 329 p., 1958.

The second volume of Haalck's textbook has been brought up to date by Buchheim, Haalck, Menzel, and Strobach. In its first three sections the book covers the theory and application of electrical methods (natural and impressed potential, and telluric currents) relative and absolute and electromagnetic measurements; seismic refraction and reflection methods and seismic instrumentation; and geochemical, radiometric, and geothermal methods. The last section is a supplement to volume one (see Geophys. Abs. 154–14785) on gravimetric and magnetic methods. A separate folder contains 20 seismograms and diagrams.—*A. J. S.*

176–143. Per'kov, N. A. Interpretatsiya rezul'tatov karotazha neftyanykh skvazhin [Interpretation of the results of logging of oil wells]: Moscow, Gostoptekhizdat, 382 p., 1958.

This book on interpretation of well logs has 17 chapters under five main headings. The first part is on electrical logging, with chapters on the physical principles, standard methods, lateral logging, and micrologging. The second part, on radioactive methods, has chapters on principles, gamma-ray logging, and the use of isotopes, neutron logging, and gamma-gamma logging. Part three, on other aspects of logging, concerns the methods of gas analysis, caliper, and temperature logging. The fourth part, on interpretation of logging diagrams, discusses lithology, recognition of reservoirs, recognition of oil- and gas-bearing strata, and examples of interpretation under specific geologic conditions. The final chapter deals with the determination of reservoir properties from logging data.—*D. B. V.*

176–144. Clifford, O. C., Jr. The revolution in petroleum exploration, 1955—: Geophysics, v. 24, no. 1, p. 1–11, 1959.

This is the text of the presidential address delivered before the 28th Annual International Meeting of the Society of Exploration Geophysicists in San Antonio, Tex., in October 1958. The three factors which have had the most profound effect on petroleum exploration are the development of magnetic tape recording, with electronic analysis of seismic data; the development of continuous acoustic logging devices; and the trend, not only on the part of American geologists and geophysicists but of all American labor, toward pricing itself out of the world market unless there are sharp increases in productivity.

Fuller and more effective communication is urged between laboratory and field, between geologists and geophysicists, between corporations, and across international and language barriers. As a step in this direction the immediate amalgamation of various professional groups into an international Institute of Exploration Geoscientists, having appropriate sections on petroleum and mining geology and geophysics, is urged. Exchange of knowledge and experience is necessary in order to make more effective use of new tools. Finally,

inhabitants of other countries should be trained in seismic and logging techniques; "here lies the path to world peace and world profit."—*D. B. V.*

176–145. Clifford, O. C., Jr. A hard look at our profession: oil finding: Geophysics, v. 23, no. 5, p. 930–941, 1958.

Statistics are quoted to show that the success ratio of technically guided test wells is actually decreasing in recent years. Lack of cooperation between geophysicists and geologists is blamed, and suggestions are made for improving the situation.—*D. B. V.*

176–146. Cook, John C. Some unorthodox petroleum exploration methods: Geophysics, v. 24, no. 1, p. 142–154, 1959.

Over a period of 3 years, more than a hundred new or little-known methods of seeking underground petroleum deposits were impartially evaluated. Most of these methods were the products of independent inventors. A large proportion of the methods proved to have little or no scientific foundation; nevertheless, the protagonists were afforded ample opportunity to prove the value of the methods by field performance. The results with every such method on which adequate data were accumulated were either negative or inconclusive.

The methods which possessed some degree of technical merit included a few worthy of careful scientific study. These belonged to the general fields of seismic improvements, geochemical and radioactivity techniques, and electrical techniques. Some of these methods have received a degree of attention from laboratories of major oil-producing companies. Several examples of unorthodox methods are described. Scientifically trained persons can often detect fallacious methods by the protagonists' gross misuse of technical language. However, a study of the principles involved and statistically valid field testing are more conclusive.—*Author's abstract*

176–147. Smellie, D. W. Geophysics in saturation prospecting: Canadian Mining and Metall. Bull., v. 52, no. 561, p. 46–49, 1959.

Smellie discusses briefly the airborne, surface, and underground techniques used in modern geophysics that have greatly extended the depth of exploration possible in the search for certain types of mineral deposits. In addition, structural information is often provided which may contribute to discovery of ore. Future success is dependent on improved instrumentation and on successful integration of geology and geophysics.—*V. S. N.*

176–148. Unz, M. Interpretation methods for geophysical exploration of reservoirs: Geophysics, v. 24, no. 1, p. 109–141, 1959.

Geophysical exploration methods can be valuable for the investigation of filled storage reservoirs. Impressed current circuits or natural ground potentials are analyzed for this purpose. General structural data are obtained from horizontal resistivity profiles. Ground bed details and seepage zones can be located by means of underwater equipotential surveys. Salinity and temperature measurements serve for the hydrological investigation of submerged springs and streams in natural lakes. The proposed interpretation methods can be readily adapted to specific local conditions.—*Author's abstract*

176–149. Jones, W. S. Logging techniques: Canadian Oil and Gas Industries, v. 12, no. 1, p. 61–63, 1959.

This is a review of developments in electric, radioactivity, and velocity well logging during the decade 1949–59.—*V. S. N.*

176–150. Jones, P. H., and Skibitzke, H. E. Subsurface geophysical methods in ground-water hydrology: Adv. Geophysics, v. 3, p. 241–300, 1956.

A review of recent developments in the use of well-logging techniques in ground-water hydrology, based on 64 papers given in the bibliography. Electrical logging ranks first in importance, but radioactivity, temperature, borehole-diameter, and flow-meter logging all have their particular uses.—*D. B. V.*

176–151. Taubenheim, Jens. Ein einfaches Korrelationsmass [A simple correlation measure]: Gerlands Beitr. Geophysik, v. 67, no. 4, p. 295–303, 1958.

A correlation measure is defined, which is easily evaluated by counting the points of the correlogram. This correlation measure has the advantage of not being changed by monotonous transformations of the variables correlated, so that the assumption of linear regression is not necessary. For a two-dimensional normal distribution, the present correlation measure becomes identical with the usual correlation coefficient. Since it is based on the medians, nonnumerical values may also be taken into account for the correlation analysis. Finally, the correlation measure may also be used for evaluating correlations between qualitative characteristics ("fourfold-table"). Pearson's χ^2-test may be conveniently used as a test of significance.—*Author's English summary*

176–152. Canadian Oil and Gas Industries. New for the explorer: Canadian Oil and Gas Industries, v. 11, no. 12, p. 49–51, 1958.

Brief descriptions are given of several new and improved instruments and vehicles which became available during 1958 for oil exploration: a new sea-gravimeter which permits continuous reading of the instrument while a ship is travelling a predetermined route or established grid; the TI-Worden gravity meter which has been expanded into three classes—the Master with an increased small dial range and full 90 degree latitude temperature compensation, the Prospector for operations under normal climatic conditions, and the Educator for training programs and gravity programs allowing wider tolerance in results; an optical analog computer designed to solve potential field equations through use of models, particularly useful for gravity and magnetic problems; the MS–15A seismic recorder, a one-package unit for field magnetic recording and monitoring; a seismic magnetic media transcriber, the OMNITAPE, designed for standardizing all types of magnetic tapes and discs now in popular use; a muskeg transporter; and an all-terrain vehicle.—*V. S. N.*

GEODESY

176–153. de Graaff-Hunter, J. Tactics of progressive geodesy: Bull. géod., no. 47/48, p. 28–36 (French translation p. 37–47), 1958.

This is the text of the presidential address delivered before the Association of Geodesy at Toronto on September 4, 1957. After a review of developments in the last 50 yr, it is stated that in the future the true form of the geoid—more

precisely of the actual surface where observations are made—must play a more important part. Electronic computers make it possible to handle problems impracticable in earlier days. The gravity problem is examined in detail. The broad aims of gravity surveying are twofold: to determine the form of the earth in relation to the adopted Reference System, and to check hypotheses of crustal structure and indicate underground anomalies of mass. The first is purely geodetic; it requires full data of gravity anomaly at the ground level, but no hypothetical assumptions as to internal densities. The second is geophysical and tentative.

de Graaff-Hunter has never been fully satisfied with the current gravity reduction systems, and some years ago proposed an alternative regional mass compensation represented by an equivalent surface layer of density on the geoid (see Geophys. Abs. 79–2826): for gravity at the surface cannot certainly discriminate between possible interior distributions. Gravity anomalies on that system, over a large area of 15×10^6 km^2 embracing a very wide range of topographic circumstances, compared favorably with Hayford anomalies; the cogeoidal rise was much smaller than for the other isostatic systems, whereas the center of mass and axis shifts were negligible. More recently this ideal layer of fictitious density has been replaced by physically smoothed topography without change of total mass. Such an earth model is bounded by a surface of gently and slowly varying slopes having easily computable effects on deflections and negligible effects on gravity. The mass transfers are superficial, in contrast to wholesale removal of all matter above the geoid, or its deficiencies in ocean areas, as in the current isostatic systems.

To implement this plan, world charts of average height are needed, the production of which would be a trivial task in relation to the laborious isostatic reductions, and would need to be done only once. With such charts, average height H would be read off according to the coordinates of a point; then the quantity AH (A=0.0340 if H is in feet or 0.112 if H is in meters) is added to the Bouguer anomaly to yield the gravity anomaly, Δg_B; thus the work of handling great masses of gravity data would be minimized. This same reduction should serve the purposes of other branches of geodesy, especially triangulation and deflections and perhaps also spirit-levelling, and of practical gravimetry as well.—*D. B. V.*

176–154. Bragard, Lucien. Recherches sur le géoide [Research on the geoid]: Soc. Royale Sci. Liège Mém., ser. 5, v. 1, no. 1, 204 p., 1958.

This thesis presents an original synthesis of the different methods of determining the geoid. The principal aim of dynamic geodesy is the study of three fundamental problems—the direct problem, deflection of the vertical, and the inverse problem. The first part comprises five chapters on the cogeoid, supposedly little different from the international ellipsoid of revolution F. The second part consists of a single chapter on the geoid. The final conclusion is that the geoid can be determined from the reference surface either directly or in two stages, the first stage being determination of the cogeoid from the reference surface and the second the determination of the geoid from the cogeoid by means of appropriate formulas. The direct determination is preferred; a prerequisite for this method is a map of the topographic relief as well as knowledge of the densities of this relief, determined from geologic borings.—*D. B. V.*

176–155. Kaula, W[illiam]. M. Reconciliation of Stokes' function and astrogeodetic geoid determinations: Jour. Geophys. Research, v. 64, no. 1, p. 61–71, 1959.

The combined application of astronomic, geodetic, and gravimetric data to computations of the geoid is discussed. The general principle observed is that any adjustment should weight all observations inversely as their variances. Two conditions are imposed: (1) Geoid heights and deflections computed by Stokes' theorem from gravity data must equal those derived by astrogeodetic means. (2) The five harmonics P_1, $P_1^1 \sin \lambda$, $P_1^1 \cos \lambda$, $P_2^1 \sin \lambda$, and $P_2^1 \cos \lambda$ must be absent from the adjusted gravity field. The ideal case is discussed, including provision for separate determinations of parameters by independent astronomic methods. Practical modifications are then introduced in turn: treating gravity anomalies as representative of areas; holding geodetic or astronomic observations constant; using a reduced number of astronomic stations; and comparing interpolated points of the astrogeodetic and gravimetic geoids. The most significant discrepancy from the ideal case of most practical solutions made heretofore appears to be in the weighting of the gravimetric data.—*Author's abstract*

176–156. Arnold, Kurt. Zur Bestimmung der gravimetrischen Geoidundulationen einschliesslich der Gleider von der Grössenordnung N_A [On the determination of the gravimetric geoid undulations including the terms of the order of magnitude N_A]: Gerlands Beitr. Geophysik, v. 67, no. 4, p. 251–255, 1958.

In order to determine the undulations of the geoid with a relative error less than the value of polar flattening, it is necessary not only to solve the boundary value problem of higher geodesy for the ellipsoid of rotation rather than for the sphere, but also to take into account the "elliptical" term in the reduction of gravity values.—*Author's German summary, D. B. V.*

176–157. Fischer, Irene. A tentative World Datum from geoidal heights based on the Hough ellipsoid and the Columbus geoid: Jour. Geophys. Research, v. 64, no. 1, p. 73–84, 1959.

From all astrogeodetic material available at present, geoidal heights were computed on the 1927 North American Datum for the western hemisphere from Canada to Chile, and on the European Datum for the eastern hemisphere from Great Britain to Japan and from Scandinavia to South Africa. Improved reference ellipsoids were determined under various conditions for each hemisphere by the least squares method. Triaxiality is refuted. The Columbus geoid, gravimetrically derived by W. A. Heiskanen, was used to connect the astrogeodetic systems of the two hemispheres. By minimizing the differences between the astrogeodetic and gravimetric geoid elevations at 75 points in the western hemisphere and 127 points in the eastern hemisphere, a theoretically absolute orientation based on the Hough ellipsoid was determined, leading to a tentative World Datum.—*Author's abstract*

176–158. Blitzer, Leon. Earth oblateness in terms of satellite orbital periods: Science, v. 129, no. 3345, p. 329–330, 1959.

A theoretical equation relating the earth's oblateness to the anomalistic and nodical periods and orbit parameters of an earth satellite is presented. In the absence of exact data on nodical periods, Vanguard prediction data are utilized to check calculation for the oblateness and to establish the validity of the method.

The value obtained for the oblateness parameter is $J=0.001631\pm0.000031$, corresponding to an earth oblateness of $1/297.6\pm2.7$ in comparison with the international value of 1/297.0 and O'Keefe's preliminary value of $1/298.3\pm0.1$, derived from the secular motions of the node and perigee of satellite $1958\beta_2$. In spite of the apparent agreement little significance can be attached to this figure because of the associated large statistical probable error; however, it is clear from these approximate calculations that a significant check on the validity of the theory has been obtained.—*D. B. V.*

176–159. O'Keefe, J[ohn] A., Eckels, Ann, and Squires, R. K. Vanguard measurements give pear-shaped component of earth's figure: Science, v. 129, no. 3348, p. 565–566, 1959.

Periodic variations in the orbit of earth satellite, $1958\beta_2$ can be explained by the presence of a third zonal harmonic in the earth's gravitational field that modifies the geoid toward the shape of a pear. The amplitude of the third zonal harmonic is calculated to be 0.0047 cm per sec^2 in the surface acceleration of gravity, or 15 m of geoid undulation.

Vening Meinesz and Heiskanen (see Geophys. Abs. 175–191) assume that the earth's gravitational field is very nearly that of a fluid in equilibrium; in any given area deviations from such an ellipsoid do not exceed about 30 milligal-megameter units. Determinations of the third-degree harmonic shows that this hypothesis is not justified. Each of the polar areas has a value of about 120 milligal-megameters, and each of the equatorial belts a value more than twice as great.

A very substantial load on the surface of the earth is indicated; this is calculated, following the arguments of Jeffreys, as 2×10^7 dynes per cm^2. Either stresses of approximately this magnitude exist down to the core, or stresses four times as great exist in the uppermost 700 km only. These stresses must be supported either by a mechanical strength larger than usually assumed for the earth, or by large-scale convection currents in the mantle.—*D. B. V.*

176–160. Lecar, Myron, Sorenson, John, and Eckels, Ann. A determination of the coefficient J of the second harmonic in the earth's gravitational potential from the orbit of satellite $1958\beta_2$: Jour. Geophys. Research, v. 64, no. 2, p. 209–216, 1959.

From the secular changes in the longitude of the node and the argument of the perigee, the coefficient J in the gravitational potential function

$$U=\left[\frac{\mu}{r}1+J\left(\frac{A_e}{r}\right)^2\left(\frac{1}{3}-\sin^2\phi\right)+\frac{K}{30}\left(\frac{A_e}{r}\right)^4(3-30\sin^2\phi+35\sin^4\phi)\right]$$

was determined to be $(1.6232\pm.0005)\times10^{-3}$. If the bounding equigeopotential surface of the earth is assumed to be an ellipsoid of revolution, this value of J implies a flattening f of $1/298.32\pm.05$.—*Authors' abstract*

176–161. Fischer, Irene. The impact of the ice age on the present form of the geoid: Jour. Geophys. Research, v. 64, no. 1, p. 85–87, 1959.

Comparison of the geoidal contour maps of North America and Europe with maps showing the extent of Pleistocene glaciation shows a remarkable correlation. In North America there are geoidal depressions in the Hudson Bay region, on the west coast, and in Alaska. Uplift near the center of the Hudson Bay depression has been estimated as 3 m per century. The Algonquin hinge line marking the boundary of the uplight roughly parallels geoidal con-

tour lines. The geoidal ridges coincide with boundaries between glaciers. In Europe the correlation is less striking, partly because the glaciers were much smaller. The confluence between the Fennoscandian ice sheet and Ural glaciers again appears as a geoidal ridge, but in the south and west there is no correlation as the geoidal contours suddenly veer to the south. The Scandinavian ice sheet was less thick towards the south and its impact on the form of the geoid there is not discernible.—*D. B. V.*

GEOTECTONICS

176–162. Wilson, J. Tuzo. Geophysics and continental growth: Am. Scientist, v. 47, no. 1, p. 1–24, 1959.

This is the text of a Sigma Xi National Lecture, 1957–58. The principal features of the earth are analyzed with the thought that the main internal movements of the earth may be relatively simple in character, that they are similar now to what they were in the past, that they should be subject to known physical laws, and that it may be possible to discern them if we consider all the evidence already available. It seems apparent that the continents have grown, each zone representing the former position of a part of an active mountain system, or in other words of a place where part of the continental fracture system once spewed out andesitic lavas. The present rate of emission of lava is of the right order of magnitude to have produced all the crust during geological time; this would produce more contraction than any reasonable amount of cooling of the earth. Such contraction best explains the building of mountains and continents. Continental drift is without cause. Convection currents may exist in the mantle but they cannot satisfactorily explain orogenesis. The ocean basins are the original crust only thinly covered with basalt. The midocean and continental fracture systems are the breaks which allow the earth to shrink; conservation of energy tends to keep them as far apart as possible. The earth has given birth to its own oceans, atmosphere, islands, and continents and is continuing to generate them at its usual rate.—*D. B. V.*

176–163. Belousov, V. V. O nekotorykh rezul'tatakh i perspektivakh tektonofizicheskikh issledovaniy [Some results and prospects of tectonophysical investigations]: Akad. Nauk SSSR Izv. ser. geol., no. 11, p. 3–20, 1958.

Geotectonic deformations are discussed and analyzed with the aid of models similar in viscosity η, density ρ, geometrical dimension l, duration time t, and other parameters. Two physical processes are considered similar if they can be described by identical dimensionless equations. For example, in reproducing slow plastic deformations of the earth's crust by a model where inertial forces and elastic phenomena can be disregarded, the similarity criterion can be represented as $C\eta = C\rho\ C_l\ C_t$, where C is the ratio of values of the appropriate parameters in nature and in the respective models. The phenomena of crustal folding, formation of ruptures in continuous media, and the consequent dislocations of crustal segments along fault planes are subject to model investigations based on the principle of the models' parametric similarity with the natural parameters of the crust. After giving a historical background to tectonophysical model investigations, Belousov describes the results obtained in this field by Russian geophysicists. He points out the haphazard manner in which tectonophysical research is being conducted in the United States, and

recommends a joint effort of geologists and physicists in planned, efficient, and long-term geotectonic assignments, including such investigations as the plasticity and strength of rocks within a wide range of temperatures and pressures, and their effect on the rate of deformation.—*A. J. S.*

176–164. Scheidegger, A[drian] E[ugen]. On the possible causes of continental drift, *in* Polar wandering and continental drift: A symposium, part 2: Alberta Soc. Petroleum Geologists Jour., v. 5, no. 7, p. 170–174, 1958.

Results of recent paleomagnetic investigations lend support to the theory of continental drift. As the classical theories of orogenesis, such as the contraction and convection current hypotheses, cannot satisfactorily explain continental drift, Scheidegger proposes a random force model with autocorrelation to best explain the drift velocities indicated by paleomagnetic studies. Convection currents may be the cause of the random forces but it may be best to assume an unknown cause.—*V. S. N.*

176–165. Wilson, Derek W. R. The orocline concept and continental drift—a commentary, *in* Polar wandering and continental drift: A symposium, part 2: Alberta Soc. Petroleum Geologists Jour., v. 5, no. 7, p. 174–178, 1958.

Analysis of oroclines, which are defined by Carey (Geophys. Abs. 163–201) as impressed strains post-dating the main period of orogenesis producing a bend in the orogen through an angle of rotation of at least 30° and sometimes as much as 180°, favors the occurrence of continental drift; that is, some oroclines appear to be pivotal points about which continental masses have moved. Three examples from Carey of known oroclines which form a total of 25 such pivotal points in mountain chains formed in Cretaceous or early Tertiary, are discussed in the light of supplementary and corroborating information such as Permian paleowind evidence and paleomagnetic measurements: the Pyrenean compression and the counterclockwise rotation of Spain, producing the Biscay rift sector; the Alaskan orocline, the apex of a 28° angle of rotation producing the Arctic Ocean rift and the North Atlantic Ocean; and the Baluchistan orocline between northwestern Indian and Iran, the apex of a 67° angle of rotation forming the Arabian Sea rift and produced by the counterclockwise rotation of India and the clockwise rotation of Africa. The only fixed feature of the earth is the attitude of its axis of rotation in space. Apparent movement of the poles through geologic time is assumed to be caused by movement of the crust with respect to the axis of rotation. Differential movement between continental segments of the crust is superimposed upon overall drift of the crust just as differential movement of smaller blocks occurs within the continental masses.—*V. S. N.*

176–166. Laming, D. J. C. Fossil winds, *in* Polar wandering and continental drift: A symposium, part 2: Alberta Soc. Petroleum Geologists Jour., v. 5, no. 7, p. 179–183, 1958.

Examination of the bedding of the wind-deposited Permo-Triassic red beds of England shows an easterly direction for the wind in contrast to the prevailing westerlies of today. Moreover, field evidence indicates that the dominant dune form in these Permo-Triassic sediments was the barchan, which today is developed only in those areas where the winds blow from the same

quadrant at least 75 percent of the year. The only climatic zones capable of producing such conditions are parts of the trade wind belts; thus the presence of barchans is strong evidence that this area once lay within the trade wind belt. This conclusion necessitates either the acceptance of the idea of crustal drift or of an appreciable warming of the world causing the climatic zones to migrate to higher latitudes. Other factors however indicate that unidirectional wind systems of the type known today could never have affected areas much beyond the present general limits of 15° to 30° latitude from the Equator. Therefore Britain and all other areas of extensive barchan development must have lain between those latitudes at the time of formation. Also rotation relative to the position of the pole must have taken place, since the dominant easterly direction common to Permo-Triassic Britain should be northeasterly to conform to the trade wind pattern with an original location north of the Equator. A clockwise rotation of 40° to 45° is required to bring the wind to a northeast direction.

Correlation is found in a study by Clegg, Almond, and Stubbs (Geophys. Abs. 157–39) on remanent magnetism of the Triassic Keuper marl of the English Midlands. Calculations from their figures indicate a latitude in the region of 16° north of the Equator for the English Midlands in Triassic time.—*V. S. N.*

176–167. Raasch, Gilbert O. The Baraboo (Wis.) Monadnock and palaeowind direction, *in* Polar wandering and continental drift: A symposium, part 2: Alberta Soc. Petroleum Geologists Jour., v. 5, no. 7, p. 183–187, 1958.

Examination of the distribution of wave-cut terraces, wave-built terraces, and waterworn coarse conglomerates at Baraboo Monadnock, which was a marine island group during most of early Paleozoic, makes it apparent that in early Paleozoic time the northern shores of Baraboo were almost constantly windward. As such constancy of wind direction in an open marine situation is found chiefly in the trade wind belts, it may be postulated that southern Wisconsin lay within a trade wind belt with prevailing wind direction of a few degrees east of north. Adding the factor of possible continental drift to current paleomagnetic evidence placing the Cambrian North Pole in mid-Pacific north of the Equator, it is apparent that the Cambrian wind belt at Baraboo might have lain in the Southern Hemisphere.—*V. S. N.*

176–168. Maksimova, S. V. Gipoteza peremeshcheniya materikov i zoogeografiya [Continental drift hypothesis and zoogeography]: Priroda, no. 5, p. 21–30, 1958.

The Wegener continental drift theory is criticized from the point of view of paleontological distribution of several families of animals as compared with their present distribution in the southern continents, northern continents, and Australia and Madagascar in particular. Maksimova considers continental drift inadequate to explain the divergences between paleontological and historical data of fauna distribution. Contrary to Wegener's view, Maksimova asserts that during the Eocene North America and North Asia were joined in the region of the Bering Strait, and that Africa and Europe were joined across the Mediterranean.—*A. J. S.*

176–169. Ehara, Shingo. Geotectonics of the Pacific concerning the Japanese Islands, Part 1: The Fossa Magna, the Shichito and the Ogasawara salients: Geol. Soc. Japan Jour., v. 59, no. 692, p. 173–200, 1953.
Part 2: Geotectonics of Shikoku in reference to the Nankai Trench and the Nankaido earthquake: ibid., v. 59, no. 698, p. 510–526, 1953.
Part 3: Geotectonics of the Kurile Islands with reference to Hokkaido: ibid., v. 60, no. 701, p. 50–57, 1954.
Part 4: Geotectonics of the Kitakami Mountain land in reference to the Japan Sea movement: ibid., v. 60, no. 701, p. 58–66, 1954.
Part 5(?): Geotectonics of northeastern Honshu, Hokkaido, and the Chisima Islands with reference to the Nippon Trench and the Chisima deep-earthquake zone: ibid., v. 63, no. 737, p. 82–99, 1957.
Ehara, Shingo, and Sawata, Shuniji. Geotectonics of the Pacific with reference to southwestern Japan, Part 1: Distribution of the two tectonic regions in Shikoku, manifesting the Pacific and the Japan Sea movement: ibid., v. 61, no. 717, p. 231–239, and no. 719, p. 396–404, 1955.
Ehara, Shingo. Geotectonics of the Pacific with reference to southwestern Japan, Part 2: Geotectonics of the Kii Peninsula in connection with the subjacent igneous mass, occupying the greater part of it: ibid., v. 62, no. 725, p. 61–70, 1956.
Geotectonics of the Pacific with reference to southwestern Japan, Part 3: Geotectonics of central Honshu, the Transverse Rift (Itoigawa-Nirazaki-Sagaminada-Shichito deep line) and the principal deep earthquake zone: ibid., v. 62, no. 729, p. 289–301, 1956.
Geotectonics of the Pacific concerning the Asiatic-Austral continental islands: Geotectonics of the Yap-Palau echelon brought about by the Pacific movement: ibid., v. 63, no. 745, p. 545–564, 1957.
Geotectonic movements in the Pacific, under way since the beginning of the Miocene: ibid., v. 64, no. 748, p. 13–28, 1958.
Geotectonics of the Pacific concerning southern China: ibid., v. 64, no. 755, p. 399–412, 1958.

A series of papers discussing the geotectonics of the island arcs, fore-deeps, and continental margins bordering the Pacific basin, particularly the western Pacific area, and interpreting the structures in the light of two major opposing forces: the overthrusting forces from the continental masses and the underthrusting forces from the Pacific basin.—*V. S. N.*

176–170. Svyatlovskiy, A. Ye. Noveyshiye dvizheniya zemnoy obolochki i vulkanizm v rayone Kurilo-Kamchatskoy ostrovoy dugi [Very recent movements of the earth's shell and volcanism in the region of the Kurile-Kamchatka island arc]: Akad. Nauk SSSR Lab. Vulkanologii Trudy, no. 13, p. 89–98, 1958.

The Kurile-Kamchatka arc, in the northwestern part of the circumpacific belt, shows the twofold division characteristic of island arcs. In the Kuriles, the Greater Kuriles represent the inner arc, the Lesser Kuriles the outer. In Kamchatka the double tectonic belt is more complex; in eastern Kamchatka the outer arc is represented by the capes of the east coast, the inner by the eastern volcanic area, and in the central Kamchatka the outer zone is formed by the Eastern Range, the inner by the volcanoes of the central Kamchatka de-

pression and by the northern part of the Central Range. The geosynclinal evolution of the arc is described, with its accompanying volcanism, and compared to older geosynclinal areas.—*D. B. V.*

176–171. Vacquier, Victor. Measurement of horizontal displacement along faults in the ocean floor: Nature, v. 183, no. 4659, p. 452–453, 1959.

Displacements of 84 nautical miles along the Murray Fracture zone and of 138 nautical miles along the Pioneer Ridge between the Mendocino and Murray Fractures on the Pacific Ocean floor, measured by means of total magnetic intensity surveys (see Geophys. Abs. 176–285) reveal an unsuspected mobility of small blocks of oceanic crust. The amount of distortion accompanying the left lateral slip along the Pioneer Ridge was less than 10 percent over a length of 90 miles, implying a remarkable freedom of movement of one crustal block with respect to the other.—*D. B. V.*

176–172. Birkenmajer, K. Remarks on the pumice drift, land-uplift and the recent volcanic activity in the Arctic basin: Acad. Polonaise Sci. Bull. sér. chim. géol. et géog., v. 6, no. 8, p. 545–549, 1958.

Tentative isobases are drawn showing land uplift of the Svalbard archipelago in the Arctic during the last 350 yr, based on pumice levels and driftwood and whalebone criteria. The point of maximum recent uplift seems to lie east of the archipelago, probably in the central part of the Barents Sea shelf.—*D. B. V.*

GLACIERS

176–173. Bader, Henri. United States polar ice and snow studies in the International Geophysical Year, *in* Geophysics and the IGY: Am. Geophys. Union Geophys. Mon. no. 2, p. 177–181, 1958.

The results of polar snow and ice studies during the International Geophysical Year are expected to be of interest far beyond glaciology in its narrower sense. Observations of recent and present temperature fluctuations will yield information on recent climatic changes and present trends in regions where meteorological studies are poor. Identification of annual layers is much easier in Greenland, where melting occurs in the summer, than in Antarctica; but a reliable, though expensive, method based on oxygen isotopes has been developed which indicates the temperature at which the snow was formed.

Tritium content can be used to date layers prior to 1954, when the natural balance was upset by nuclear tests. Contamination of the atmosphere by nuclear tests or industrial activity can be followed qualitatively and quantitatively in these snow layers, and natural objects such as volcanic ash, meteorites, spores and bacteria are perfectly preserved for study.—*D. B. V.*

176–174. Miller, Don J. The surface velocity of the Yakataga Glacier, Alaska: Jour. Glaciology, v. 3, no. 22, p. 125–130, 1957.

The surface velocity of Yakataga Glacier, in the Robinson Mountains on the north coast of Alaska, was calculated from observation of the displacement of a distinctive rockfall moraine and other less conspicuous features on the surface of the glacier. The position of the rockfall in 1938 was established from an oblique aerial photograph, in 1944 from a pace-compass map, in 1948 and 1954 from vertical aerial photographs and in 1952 from the photographs taken by the author. The average rate of advance of the glacier from 1938 to 1954 was

114 m per yr. The average velocity from 1948 to 1954, determined from the various positions of features shown in the vertical aerial photographs, was slower than the velocity from 1938 to 1948 and ranged from a maximum of 90 m per yr, at a station 14 km above the terminus, to zero at a station 2.3 km above the terminus. The technique of photogrammetric measurement of surface velocity by using natural features on the surface of a glacier has wide application in Alaska where many glaciers have been rephotographed from the air over an interval of several years.—*V. S. N.*

176–175. Förtsch, O[tto], and Vidal, H. Seismo-glazialogische Studien an einem Gletscherfleck (Brandner Gletscher im Rätikon) [Seismoglaciologic studies on a glacier spot (Brandner glacier in the Rätikon)]: Zeitschr. Gletscherkunde und Glazialgeologie, v. 4, no. 1–2, p. 35–45, 1958.

Seismic refraction measurements were made on the Brandner glacier (at the foot of Schesaplana, highest peak of the Rätikon in Austria, almost on the Swiss border) in order to determine the elastic behavior and thickness of the ice or "firn" (snow of preceding years) and shape of the underlying bedrock. The Brandner is a glacier of nivation type, "glacier spot" in German terminology.

Wide variations in longitudinal velocity (between 3,000 and 3,600 m per sec) in 25 seismic profiles indicate that hard thin ice horizons ("Harst-horizons") alternate with loose firn-ice and firn-snow layers. Longitudinal velocity in the surface firn-snow horizons was 1,000 m per sec. Average velocity in bedrock was 4,200 m per sec. Thickness is about 20 to 25 m over the whole glacier; average error in calculation of ice thickness should not exceed 3 to 4 m. A map of bedrock contours was drawn and volume of ice (+ firn) calculated as 0.027 km^3, corresponding to 22×10^6 m^3 of water.—*D. B. V.*

176–176. Borovinskiy, B. A. Opyt primeneniya geofizicheskikh metodov pri issledovanii stroyeniya lednika Tuyuksu [Experience with application of geophysical methods in the investigation of the structure of Tuyuksu glacier]: Akad. Nauk Kazakh. SSR Vestnik, no. 5(158), p. 40–44, 1958.

A study of the high altitude Tuyuksu glacier in the Kazakh S.S.R. was undertaken during the summer of 1957 and winter of 1958. Due to the difficulty of transporting heavy seismic equipment, electric and magnetic methods were used to determine the thickness and structure. The electrical prospecting was conducted in the usual manner with the potentiometer EP–1, and the magnetic with the magnetometer M–2. Magnetometric and geoelectric profiles of the glacier were established. The maximum depth of the glacier ice was found to be about 150 m.—*A. J. S.*

176–177. Imbert, Bertrand. Détermination de l'épaisseur de glace en Terre Adélie [Determination of the thickness of ice in Adélie Land]: Acad. Sci. Paris Comptes Rendus, v. 248, no. 4, p. 576–579, 1959.

In order to determine the thickness of the Antarctic ice cap, a seismic reflection survey was made south of the Dumont d'Urville base in Adélie Land. Twenty-seven stations were occupied along a 480-km profile. The mean altitude of bedrock was —40 m. As longitudinal wave velocities in ice have been found to vary with temperature, the values used ranged from 3,840 to 3,900 m per sec, corresponding to temperatures fluctuating between —20°C and —43°C. The

profile of the ice surface was found to be elliptical, and friction of ice against the bottom to decrease linearly with the distance from the coast.—*D. B. V.*

176–178. Murauchi, Sadanori; Tateishi, Tetsuo; and Matumoto, Tosimatu. Seismic prospecting of the Antarctic iceberg and fast ice near the Syowa Base [in Japanese with English abstract]: Antarctic Rec., no. 5, p. 40–50, 1958.

Seismic surveys were made of an iceberg and of pack ice in the vicinity of Syowa Base, the Japanese Antarctic base for the IGY, at lat 69°00′ S. and long 39°36′ E. A comparison was made between the velocity distribution curve of the iceberg and that of a continental ice sheet and it was found that the low velocity layer typical of the ice sheet in Greenland and in Adélie Land was not as prominent in the iceberg. In the pack ice the longitudinal velocity was found to be 2,150 m per sec which is considerably slower than that of Arctic pack ice (generally 2,400 to 2,910 m per sec). This low velocity is attributed to the condition of the ice in Antarctic summer, when melt water probably permeates a large part of the total thickness. From the reflection wave the sea depth was estimated as about 110 m.—*V. S. N.*

GRAVITY

176–179. Dicke, R. H. Gravitation—an enigma: Am. Scientist, v. 47, no. 1, p. 25–40, 1959; reprinted from Washington Acad. Sci. Jour., v. 48, no. 7, p. 213–223, 1958.

In 1938 Dirac noted that one of the Eddington numbers is proportional to the age of the universe and concluded that the gravitational constant G varies inversely with the age of the universe. This hypothesis is understandable from the point of view of Mach's Principle, in which the inertial mass of a particle is determined by distant matter (in contrast to Einstein's theory, in which the inertial mass is a purely local property of the particle). The equation $GM/Rc^2 \approx 1$ (where M is the mass in the visible part of the universe, R is the Hubble radius of the universe, and c is the velocity of light) implies that G is constant only if M/R is constant as the universe evolves. This picture of gravitation has several advantages: the dichotomy between gravitation and ordinary forces has disappeared, gravitation is not a property of the vacuum, local interactions between particles can be treated in accordance with the general relativity principle, and an action at a distance principle is not needed.

The history of the solar system seen through the eyes of astronomers and geologists may enable fundamental conclusions to be drawn regarding physical interactions in the past. A serious lack of observational data keeps one from drawing a clear portrait of gravitation; it may well be the most fundamental and least understood of the interactions. (See also Geophys. Abs. 176–4 and 180.)—*D. B. V.*

176–180. Dicke, R. H. New research on old gravitation: Science, v. 129, no. 3349, p. 621–624, 1959.

In 1872 Mach suggested that the inertial force does not arise from motion relative to space but has its origin in the acceleration of a particle relative to distant matter; and equivalently, in the coordinate system with the particle at rest, the acceleration of distant matter is the source of the inertial force acting on a particle. There is every reason to assume that this inertial field is not some new

type of field but merely the gravitational field of distant matter. It follows from Mach's principle that the gravitational constant G probably varies (see Geophys, Abs. 176–4).

If the gravitational constant is a field variable, observable changes in G may occur in three important ways: through the expansion of the universe, through the effect of nearby matter, and by motion relative to distant matter. In Dirac's cosmology the above equation is satisfied if G varies inversely with time. The only other atomic constant which could be expected to vary strongly with time is the weak-coupling constant which determines the rate of decay of π- and μ-mesons as well as β-decay of radioactive nuclei (see Geophys. Abs. 176–4). The problem of the constancy of the atomic constants is directly related to the fundamental postulates of the theory of general relativity. Mach's principle seems to support the validity of the weak form of the equivalence principle but not the strong form. The usual interpretation of Einstein's theory may not be completely correct; the fundamental facts about gravitation, especially the strong principle of equivalence, should be tested by the improved modern experimental techniques.—*D. B. V.*

176–181. Fajklweicz, Z[bigniew]. On a Cracovian method of determining the regional gravity field: Acad. Polonaise Sci. Bull., v. 6, no. 5, p. 349–354, 1958.

In the determination of the character of the regional gravity field by a least squares fitting of polynomials to the data, the solution of a system of normal equations is required. Solution by ordinary matrix methods usually requires a high-speed computer. Solution by the Cracovian method illustrated in this paper is effected rapidly on an ordinary desk calculator. Cracovians are arrays of numbers similar to ordinary matrices, but differing in the method of multiplication. A catalogue of inverses of the Cracovian of coefficients for grids best suited to the purposes enables one to calculate regional gravity in a short time.—*R. G. H.*

176–182. Pick, Miloš. Über eine neue Methode zur Herstellung von Karten topographischer Korrektione [A new method of preparing maps of topographic corrections]: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 4, p. 334–344, 1958.

In the method described for preparing regional maps of topographic corrections for the territory of Czechoslovakia, an anomaly equation in the following form has been proposed: $\Delta g = g - \gamma_o - \frac{\partial \gamma}{\partial H} H_P - \Delta g_e$, where γ_o is normal gravity acceleration on the standard reference spheroid, H_P is the altitude of a point P on the earth's surface with respect to sea level, and Δg_e is the gravity effect of external masses at the point P. The Bouguer plate is replaced by a sector layer of a sphere the radius of which is equal to the external radius of the Hayford zone O_2. The Bullard difference B between the gravity effect of the Bouguer plate and the corresponding spherical sector layer is equal to $C_o - 2\pi f \sigma H_P$ (C_o is the gravity effect of the sector layer, σ is the density). Substituting this value of B for Δg_e in the above equation produces the following formula:

$\Delta g = g - \gamma_o - \frac{\partial \gamma}{\partial H} H_P - 2\pi f \sigma H_P - B + \Delta g_e^c$, where Δg_e^c is the vertical component of the gravity effect (or mass-defect) of the external masses with regard to the surface of point P. The gravity effect of the local relief on the regional map is

reduced by a statistical method, and the following general formula is derived for the calculation of gravity anomalies on a regional scale: $\Delta g = g - \gamma_o + (0.3086 - 0.0419\,\sigma) H_P - B + \Delta g_e^c$ where $\Delta g_e^c = \Delta g_\Sigma + f(H_P) + F(\phi_P, \lambda_P)$; Δg_Σ is the local component of the topographic correction. For areas of low relief the general anomaly formula can be made considerably simpler.—*A. J. S.*

176–183. Andreyev, B. A. Strukturno-metallogenicheskiye zony i gravitatsionnyye anomalii [Structural-metallogenic zones and gravity anomalies]: Akad. Nauk SSSR Doklady, v. 121, no. 6, p. 1063–1064, 1958.

The Pacific Ocean ore belt is considered to consist of two zones, the oceanic and the continental. The structural difference between these zones is expressed by the thinning of the sialic layer at the transition of the earth's crust from the continent to the ocean. Such a decrease in the thickness of sial causes gravity anomalies (Bouguer) which are nearly zero or negative over the continent and hundreds of milligals over the ocean. Andreyev suggests correlating the variations in these Bouguer anomalies with a further subdivision of the metallogenic zones into the regions of chromium, nickel, copper, gold, silver, lead-zinc sulfides, mesocratic mercury, lead-zinc lodes, molybdenum, tungsten, and leucocratic tin. He also suggests deep seismic profiling for establishing more accurate boundaries of known and new metallogenic zones.—*A. J .S.*

176–184. Talwani, Manik, Worzel, J. Lamar, and Landisman, Mark. Rapid gravity computations for two-dimensional bodies with application to the Mendocino submarine fracture zone: Jour. Geophys. Research, v. 64, no. 1, p. 49–59, 1959.

Expressions are derived for the vertical and horizontal components of the gravitational attraction due to a two-dimensional body of arbitrary shape by approximating it to an n-sided polygon. These expressions are put in forms suitable for solution by a high-speed digital computer. As an example of the application of this method, the crustal section across the Mendocino fracture zone is deduced from the gravity anomalies. Assuming the crust to consist of a single homogeneous layer, overlain by water and sediment, it is found to be about three km thicker to the north of the fracture zone than to the south of it.—*Authors' abstract*

176–185. Vyskočil, Vincenc. Einfluss des vertikalen Dichtgradienten auf die zweiten Ableitungen des Gravitationspotentials [Effect of the vertical density gradient on the second derivatives of the gravitational potential]: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 4, p. 322–333, 1958.

Values of the second derivatives of gravity potential V_{zz} and V_{xx} are derived for two-dimensional bodies whose density is a function of depth. The calculations are based on the assumption that the regular variation of density can be expressed by a power series. Numerical examples are calculated on the assumption that density variation with depth is linear or quadratic.

It is shown that it is not necessary to use precise relationships of the included anomalous masses in determining the value of V_{zz} and V_{xx}. As a rule it is sufficient to calculate these values by means of simplified relationships which are valid for anomalous masses in the case of constant density, if the effective density of the body is taken into account at the same time.—*D. B. V.*

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176–186. Cunietti, M[ariana], and Inghilleri, G[iuseppe]. Estudio sperimentale della influenza della temperatura sulla deriva du gravimetri Worden [Experimental study of the effect of temperature on the drift of Worden gravimeters]: Rev. Geofísica, v. 16, no. 63–64, p. 341–379, 1957.

A Spanish version of a paper originally published in Italian in the Bolletino di Geodesia e Scienze affini, v. 15, no. 3, p. 287–311, 1956 (see Geophys. Abs. 173–200).—*D. B. V.*

176–187. Abel'skiy, M. Ye. Opredeleniye momenta inertsii i tsentrobezhnogo momenta krutil'nykh vesov gravitatsionnogo variometra S–20 [The determination of the moment of inertia and centrifugal moment of the torsion weight of the gravitational variometer S–20]: Akad. Nauk SSSR Izv. ser. geofiz., no. 7, p. 921–922, 1958.

The numerical values of the moment of inertia K and of the centrifugal moment M of a torsion weight of a variometer enter into the calculation of the second derivatives of the gravitational potential and are usually given by the manufacturer on the rating plate of the instrument, as it is difficult to compute these characteristics when the instrument is fully assembled. Abel'skiy suggests a method of experimental determination of these values, when this becomes necessary. He starts from the equations defining the moments K and M, $K=\int (x^2-y^2)\ dm$, $M=\int xz\ dm$. These integrals are to be taken over the entire volume of the balance beam. The values of K and M in the system of coordinate axes with the same zero point and forming an angle α with the first system will be: $K=\int x_1^2 \cos^2 \alpha\ dm$, $M=\int x_1^2 \sin \alpha \cos \alpha\ dm$. From these equations we have $M=K \tan \alpha$. On the other hand $K=\tau \frac{T^2}{4\pi^2}$ where τ is the torsional rigidity of the fiber supporting the instrument and T the period of its vibration; in the variometer investigated $\tau=89.314$ g per cm^2 per sec^{-2}, therefore $K_1=8{,}850$ g per cm^2, $M_1=13{,}250$ g per cm^2; and $K_{II}=8{,}730$ g per cm^2, $M_{II}=13{,}080$ g per cm^2. The same problem can be solved in the polar system of coordinates; such a solution is also given.—*S. T. V.*

176–188. Woollard, George P[rior]. Gravity observations during the IGY, *in* Geophysics and the IGY: Am. Geophys. Union Geophys. Mon. no. 2, p. 198–202, 1958.

This is an outline of the objectives of the United States gravity program for the International Geophysical Year. These include check of the accuracy of the national gravity bases; more precise measurement of the shape of the earth; intercomparison measurements for standardizing instruments; development of a world network of gravimeter bases; gravity observations at sea and on Arctic ice floes; measurement of Antarctic ice thickness; and earth tide studies integrated with those of other countries.—*D. B. V.*

176–189. Morelli, Carlo, and Rice, Donald A. Gravimetric ties, Europe-America: Rev. Geofísica, v. 16, no. 63–64, p. 381–390, 1957.

A Spanish version of a paper originally published in English in Bullétin geodésique, no. 38, p. 35–41, 1955 (see Geophys. Abs. 170–184).—*D. B. V.*

176–190. Thompson, George A. Gravity measurements between Hazen and Austin, Nevada: a study of Basin Range structure: Jour. Geophys. Research, v. 64, no. 2, p. 217–229, 1959.

A line of gravimeter stations, with side loops, was extended from the pendulum base stations at Mystic and Truckee, Calif., eastward through Hazen, Fallon, Eastgate, and Austin in Nevada, crossing the area displaced by faults in 1954. Regionally the Bouguer anomaly is about —160 mgal from Hazen eastward to the Stillwater Range decreasing farther eastward to —215 mgal near Austin, a change that can be explained by isostatic compensation for the 1,700-ft increase in average elevation. Low density sediments and volcanic debris abundant in the basins and parts of the mountains makes the average density of the elevated landmass abnormally low; 10 to 15 percent of the compensation for this high region is in the superficial materials themselves. The Basin Ranges show no signs of being individually compensated.

Locally, each basin has a negative Bouguer anomaly relative to the adjacent ranges, reflecting thick volcanic and sedimentary fill. Dixie and Fairview valleys, in which the 1954 displacements occurred, are characterized by local negative anomalies of about 30 mgal. Their bedrock floors lie below sea level. The 1954 faulting is thus the latest of many displacements that produced not only the visible relief of 5,000 ft but also a buried relief of comparable magnitude. If the total structural relief was produced by displacements comparable to that of 1954, the extension across Dixie and Fairview valleys amounts to about 1½ miles in 15 million yr; if this is a fair sample, the rate of distension in the Basin and Range Province is about 1 ft per century.

At the time of the 1954 faulting the Bouguer anomaly either did not change or decreased algebraically by no more than 1.0 mgal.—*D. B. V.*

176–191. Saxov, Svend [E.]. Gravity in western Greenland from 66° N to 69° N: [Denmark] Geod. Inst. Skr., ser. 3, v. 29, 31 p., 1958.

An account is given of a detailed gravity survey, using a Worden gravimeter, on the west coast of Greenland between Strømfjord and Diskobugten Sounds, with the principal facts for each station tabulated. Analysis of the Bouguer anomaly map shows positive anomalies in the coastal regions and negative anomalies around the middle of the fiords, with a rise in values from the middle of the fiords towards the ice cap. The relationship between gravity and land uplift in Fennoscandia, Denmark, Iceland, and North America is discussed. Observations of land uplift in Greenland have been made only in the vicinity of Diskobugten but additional stations are being established.—*V. S. N.*

176–192. Bull, C. A gravity survey of a glacier-dammed lake in North Greenland: Royal Soc. Edinburgh Proc., v. 67, pt. 1, p. 42–53, 1957–58.

A gravity survey has been made of a glacier-dammed lake in Dronning Louise Land, North-East Greenland. Corrections for the effect of the local topography and the regional Bouguer anomaly are made to the values of the acceleration due to gravity measured at about 230 points on the lake and its shores. From the differences between the corrected values at the lake stations and those of the shores, depths of water under the lake stations are calculated, and a contour map of the lake bottom is drawn. A submerged shelf, 75 m below the present lake level, persists around the western part of the lake. This may be the shoreline of a preglacial lake.—*Author's abstract*

176–193. Crenn, Yvonne, Metzger, Joseph, and Richenmann, Julien. Relations de la carte gravimétrique du centre de l'Afrique occidental française avec les grandes unités géologiques [Relationships of the gravimetric map of the center of French West Africa with the major geologic units]: Acad. Sci. Paris Comptes Rendus, v. 248, no. 8, p. 1200–1203, 1959.

The isostatically reduced gravity map of the central part of French West Africa is based on 8,000 measurements made in 1953–58 with one Worden and two North American gravimeters. The contour interval is 10 mgal, and isostatic anomalies were calculated according to the Airy hypothesis with a depth of compensation of 30 km.

The anomalies reflect the structure of the Paleozoic and older rocks even where these are covered. The map as a whole is separated into two zones by a line of strong gravity variation about at the 0° meridian, representing a Precambrian fracture in the basement along which basic rocks have been intruded. West of this line several units are distinguished from north to south: the Taoudenni basin, characterized by a regular anomaly of the order of —30 mgal in a region of outcropping Silurian to Carboniferous sediments; the Mopti-Hombori positive regional anomaly over a geosyncline of Paleozoic and Precambrian schists; and the Djibo-Ansogo negative regional anomaly, of the order of —20 to —30 mgal, interpreted as a thick granitic layer at the edge of the geosyncline. East of the line of fracture there is no outstanding structural feature, merely a northsouth trend of anomalies reflecting the direction of folds in the basement.—*D. B. V.*

176–194. Nosske, Gerhard, and Heynig, Rolf. Geophysikalische Untersuchungen im Gebiet Erdeborn [Geophysical investigations in the Erdeborn region]: Freiberger Forschungshefte, C45 Geophysik, p. 28–39, 1958.

Electrical resistivity profiling and gravity surveys were made in the vicinity of Erdeborn, Germany, where considerable damage has been done by subsidence of the ground (attributed to natural solution of underlying Stassfurt salts, much accelerated by water in mines). The electrical measurements gave no more concrete information than the geomorphology. By clarifying the tectonic origin of the subsidence and locating lines of deformation, repeated gravimeter and torsion balance measurements show that there can be no question of the danger to the village and its inhabitants, but the possibilities of fissuring and formation of very small cavities along the lines of deformation are too numerous and the effects too slight for these phenomena to be completely brought out by these methods.—*D. B. V.*

176–195. Kopayev, V. V., and Pavlovskiy, V. I. Opyt primeneniya gravimetrii dlya izucheniya geologicheskogo stroyeniya kristallicheskogo fundamenta v tsentral'noy chasti rayona Kurskoy magnitnoy anomalii [A test of the application of gravimetry to the study of the geologic structure of the crystalline basement in the central portion of the Kursk magnetic anomaly]: Razvedka i okhrana nedr, no. 7, p. 38–46, 1957.

The Kursk magnetic anomaly is the most important in European Russia, extending over a vast area and in several places coming close to important industrial centers. The industrial development of this area planned for the near future led to the organization of numerous geophysical surveys with a

view to finding the most advantageous location of iron mines. The results of several gravimetric surveys of the central portion of the Kursk anomaly are discussed here. The geologic structure is very complex. Numerous ridges of ferriferous quartzites rise to a height up to 100 m relative to the Precambrian basement surface. Comparison of gravimetric anomalies with the results of magnetic surveys and with exploratory drilling data has shown that most of the positive gravity anomalies are located over the areas of ferriferous quartzites. This is explained by the fact that the density of the quartzites is to 3.4 g per cm^3, whereas the surrounding granites have a density of only 2.65 g per cm^3. Several local anomalies are interpreted geologically.—*S. T. V.*

176–196. Balavadze, B. K. Variometricheskiye nablyudeniya v yugo-zapadnoy chasti Kolkhidy i rezul'taty ikh interpretatsii [Variometric observations in the southwestern part of Kolkhida, and the results of their interpretation] : Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 16, p. 223–230, 1957.

Quantitative interpretation of gravimetric observations carried out in the southwestern part of Kolkhida in the Georgian S.S.R. between 1938 and 1957 together with borehole information, has helped to establish the geological profile of the area, to trace the axis of the asymetrical Omparet anticline, to determine depth of the basement of the Miocene deposits and other geological data. Certain problems pertaining to quantitative interpretation of the second derivatives of gravity potential are discussed.—*A. J. S.*

Kosminskaya, I. P., Mikhota, G. G., and Tulina, Yu. V. The structure of the earth's crust in the Pamir-Alay zone according to the results of deep seismic profiling. See Geophys. Abs. 176–236.

176–197. Hayakawa, Masami; Matsuda, Takeo; Sugiyama, Tomonori; and Suda, Yoshiro. Model *UW–2R* marine gravimeter, manufactured by North American Geophysical Co., and submarine gravity survey in the northern part of Ariake-kai, Kyūshū District, with this gravimeter [in Japanese with English summary] : Japan Geol. Survey Bull., v. 9, no. 4, p. 75–86, 1958.

Tests of the UW–2R marine gravimeter conducted in Tokyo Bay, Japan, showed that the time required for observation in the case of a 1–2 km interval is about 30 minutes and that for satisfactory observations slight instrumental improvements are necessary. A more detailed survey made of northern Ariake Bay, Saga and Fukuoka Prefectures, Kyushu, delineated a gravity low trending ENE–WSW along the north coast of the bay and a gravity high to the south, trending east-west along a line between Kurosaki, Omuta City and Oki Island.—*V. S. N.*

176–198. Yokoyama, Izumi, and Tajima, Hirokazu. Gravity survey on the Kuttyaro caldera by means of a Worden gravimeter: Nature, v. 183, no. 4663, p. 739–740, 1959.

Lake Kuttyaro, in eastern Hokkaido, Japan, fills the western half of a circular caldera about 20 km in diameter, one of the largest in the world. A gravity survey made in March 1958 on the frozen surface of the lake shows a relatively low Bouguer anomaly (about 46 mgal) concentrated at the center of the caldera. The anomaly is independent of minor structures of the ground surface and lake bottom, therefore must be related to larger-scale subterranean structure.

Analysis of the distribution of anomalies shows that coarse material (pumice) about 0.3 to 0.5 g per cm^3 less dense than the surroundings is accumulated at a depth of 3 to 4 km beneath the lake. The eruption must clearly have been so violent that the region from the surface to a depth of 3 to 4 km was completely devastated.

The gravity evidence thus supports the concept of collapse origin of the Kuttyaro caldera, accompanying the eruption of tremendous amounts of pumice ("Krakatoa type"). In calderas formed by the subsidence of rock masses without eruption of pumice ("glencoe type"), high Bouguer anomalies should be observed; Mihara caldera, one of the latter type, in fact does show a high of about 15 mgal (see Geophys. Abs. 171–184). The actual mechanism of subsidence or collapse is still an unsolved problem.—*D. B. V.*

176–199. Robertson, E. I., and Reilly, W. I. Bouguer anomaly map of New Zealand: New Zealand Jour. Geology and Geophysics, v. 1, no. 3, p. 560–564, 1958.

The Bouguer map of New Zealand exhibits two major negative gravity anomalies. The Rangitikei-Waiapu Anomaly, which intersects the axial ranges of the North Island, indicates a crustal downwarp which is not in isostatic equilibrium. This anomaly is closely parallel to the zone of intense seismicity, to the Taupo-White Island volcanic belt, to the Kaimanawa-Huiarau-Raukumara Ranges, to the thick Upper Pliocene sediments, and to the Hikurangi Trench; and it appears to be an expression of an active tectonic belt related to the Tonga-Kermadec-Hikurangi Trenches. The Rimutaka-Ruahine axial ranges are apparently not underlain by mountain roots.

The Alpine Anomaly in the South Island is considered to be the gravitational expression of the crustal roots of the Southern Alps and the mountains southwest of Blenheim; the magnitude of the anomaly suggests that this region is approximately in isostatic equilibrium.—*Authors' summary*

Lensen, G. J. Measurement of compression and tension: some applications. See Geophys. Abs. 176–54.

HEAT AND HEAT FLOW

176–200. Valle, P[aolo] E[milio]. Sulla variazione del punto di fusione con la pressione [On the variation of the melting point with pressure]: Annali Geofisica, v. 17, no. 2, p. 145–148, 1958.

The rate of change of the melting point with pressure is calculated, on the basis of the classical theory of solids, for lithium, sodium, potassium, and iron. Comparison with experimental data shows rather satisfactory agreement.—*D. B. V.*

176–201. Latynina, L. A. Teplovaya konvektsiya v obolochke zemli [Heat convection in the earth's mantle]: Akad. Nauk SSSR Izv. ser. geofiz., no. 9, p. 1085–1098, 1958.

Heat convection in a pseudo-viscous fluid is analyzed in the light of Griggs' hypothesis. The mantle is assumed to be a spherical layer of viscous fluid rigidly restrained at its upper boundary by the crust and free at its lower boundary with the core. The upper and the lower boundaries are assumed to be plane and at constant temperature. Convection may be caused either by the presence of heat sources distributed evenly along the horizontal, or by heat flow along

the vertical. Under the most probable physical conditions, the first case can bring about convection current velocities not exceeding one mm per year and shearing stresses not greater than 10^7 dynes per cm^2.

If the vertical distribution of heat upsets the thermal equilibrium and therefore produces convection currents, their velocities may be as great as one cm per year and the stresses as 10^7 dynes per cm^2. If the fluid has a certain strength, that is, is not sufficiently viscous, the vertical temperature gradient may become much greater than the adiabatic gradient; in this case the convection which finally is produced is more intense, but is unstable (transient), with a period of acceleration followed by one of retardation.

Calculations based on the assumption that an ultra-adiabatic temperature difference of 1,000°C exists in the mantle (for a convective layer 400 km thick, 400°C) lead to the conclusion that if convection entrains the greater part of the mantle, velocity at its most intense would amount to 1 m per yr, involving shearing stresses of 10^8 dynes per cm^2, uplift or subsidence of the crust of the order of 5 km, and a time interval from initiation of convection to the maximum development of about 100 million years; but if convection involves only a narrow layer (400 km), the maximum velocity would be 2 cm per yr, shear stresses 10^7 dynes per cm^2, uplift or subsidence about 200 m, and corresponding time interval about one million years.—*S. T. V.*

176–202. Uffen, Robert J. On the origin of rock magma: Jour. Geophys. Research, v. 64, no. 1, p. 117–122, 1959.

The remarkable correlation between the locations of ocean trenches, eugeosynclines, gravity anomalies, volcanic islands, and earthquake foci suggests a common origin. These are frequently interpreted as being due to compressive failure of the outermost crust. Yoder's hypothesis, that the materials of the crust have been locally remelted by a drop in melting temperature to below the ambient temperature on release of pressure, has been extended here to include remelting on release of pressure during compressive failure rather than tensile failure. The range of mean pressure and corresponding melting ranges for likely constituents of crust and mantle have been estimated for two cases, case A, where the maximum shear stress the material can stand (S) is 3,000 bars, and case B, where $S=3{,}000+100\ h$ bars (h=depth). For case A, basaltic material at the base of the continental crust could have a melting temperature as high as 1,120°C, dropping to 1,080°C on compressive failure or even to 1,040°C if tension were superimposed on the hydrostatic pressure; for case B the corresponding values would be 1,160°C, 1,080°C, and 1,000°C respectively.

This hypothesis of magma generation is quantitatively feasible, but unfortunately our present data, particularly on actual temperature distribution in the earth, are inadequate. It might be possible to reverse the problem and seek information on the depth of origin of various magmas from other sources, thus eliminating earth models whose computed temperature distributions for the present age of the earth do not agree.—*D. B. V.*

176–203. D'yakonov, D. I. Geotermiya v neftyanoy geologii [Geothermal measurements in petroleum geology]: Moscow, Gostoptekhizdat, 277 p., 1958.

This book begins with a short review of the development of geothermal measurements. The second chapter outlines the theoretical basis (thermal regime of surface and deep layers of the crust, the natural regional and local heat fields).

Chapter three deals with borehole temperature measurements and chapter four with interpretation of geothermal data (thermal properties of rocks, geothermal gradients, heat flow). The fifth and longest chapter discusses the application of these data to the solution of problems in petroleum geology (lithology, structure, hydrology of oil fields), with an analysis of the geothermal characteristics of different parts of the U.S.S.R. A bibliography of 224 items is given. A supplement gives three extensive tables listing the thermal properties of some rocks, ores, minerals, and metals (6 pages); borehole temperatures, geothermal gradients (°C per 100 m), geothermal "step" (m per °C), and other data obtained in different regions of the U.S.S.R. (52 pages); and geothermal characteristics of lithologically homogeneous borehole sections in various parts of the U.S.S.R.—*D. B. V.*

176–204. Somerton, Wilbur H. Some thermal characteristics of porous rocks: Jour. Petroleum Technology, v. 10, no. 5, p. 61–64, 1958.

Measurements of heat content of eight samples of volatile-free sedimentary rocks at temperatures of 260°F, 440°F, 620°F, 800°F, and 980°F, including sandstone, siltstone, shale, and limestone, yielded heat capacity values showing a maximum difference of 10 percent among the samples. The heat content of the rocks, variously saturated with methane, water vapor and water, was calculated as the sum of the heat contents of the rock and of the fluid contents. It was found that water vapor or gas saturation has little effect on the heat capacity, whereas water saturation increased heat capacity by 35 percent or more. Liquid saturation increases the thermal conductivity markedly over air saturation; the amount of increase is dependent upon the thermal conductivity of the saturating liquid. Calculations show that thermal diffusivity is very sensitive to temperature changes, decreasing with increased temperature.—*G. E. M.*

176–205. Benseman, R. F. The calorimetry of steaming ground in thermal areas: Jour. Geophys. Research, v. 64, no. 1, p. 123–126, 1959.

A portable calorimeter that measures heat output from the steaming ground found in areas of natural thermal activity is described. With a minimum of disturbance to the site, heat flow is measured in a range from 10 to 70×10^{-3} cal per cm^2 sec with an accuracy better than 10 percent. Below this range, the accuracy decreases. The relationship of heat output to the soil temperatures measured at a depth of 35 cm is shown for measurements at 27 different sites.—*Author's abstract*

176–206. Oreshkin, P. T. Opytnyye varianty vysokotemperaturnogo termistora [Experimental variants of a high temperature thermistor]: Akad. Nauk SSSR Zhur. Tekh. Fiziki, v. 28, no. 7, p. 1408–1412, 1958.

Using an aluminum oxide tablet as the semiconductor in several variants of his thermistor design, Oreshkin found that the sensitivity and stability of his model thermistors depends on the method of firing and on the admixtures introduced into the semiconductor during the firing. It was also noted that prolonged firing reduces the conductivity of the semiconductor. When an aluminum oxide tablet was fired at 1,500°C for 40 to 50 hr the conductivity decreased by factor of 10. A 1,000-ohm change in resistance of the semiconductor results in a shift of 1°C in the graduation curve. The results of the experiments indicate that Oreshkin's thermistor can be used for an interval between 1,000°C and 1,600°C or even to 1,800°C for short-time duty.—*A. J. S.*

176–207. Bullard, E. C., Maxwell, A[rthur] E., and Revelle, R[oger]. Heat flow through the deep sea floor: Adv. Geophysics, v. 3, p. 153–181, 1956.

This is a review of recent research on heat flow through the ocean floors, based on 44 papers given in the bibliography. Methods of measurement and local disturbances are discussed, measured values for the Pacific, Atlantic, and Mediterranean are summarized, and sources of heat and convection are considered.—*D. B. V.*

176–208. Boldizsár, Tibor. Ergebnisse irdischer Wärmestrommessungen in Ungarn [Results of terrestrial heat flow measurements in Hungary]: Freiberger Forschungshefte, C45 Geophysik, p. 95–99, 1958.

Careful systematic measurements of temperature and heat flow have been made in shafts and deep boreholes in Hungary, the first measurements of terrestrial heat flow in Europe. The average value in the Hungarian basin is $2.170 \pm 0.230 \times 10^{-6}$ cal per cm^2 per sec, two to two and a half times higher than the average value at the surface (1.0 to 1.2×10^{-6}). This is a great disadvantage in deep mining; at 1,000 m depth, for example, the natural rock temperature is already 55°C. to 60°C. (See also Geophys. Abs. 166–238, 168–178).—*D. B. V.*

176–209. Babynets' [Babinets], A. Ye. Heotermichni osoblyvosti rehioniv Ukrayins'koyi RSR [Geothermal features of different regions of the Ukrainian SSR]: Akad. Nauk Ukrayin. RSR Dopovidi, no. 1, p. 46–50, 1957.

Babynets' has investigated different regions of the Ukrainian S.S.R. and found great differences in the thermal regime of individual regions, probably caused by local structural differences. The lowest geothermal gradient was found in the region of the Ukrainian shield—8.3°C per km. The highest geothermal gradient was observed in the vicinity of Davilove, 34°C per km at depths less than 1,000 m, and as much as 37.7°C per km at depths exceeding 1,000 m. Numerous data on temperature of different localities at different depths are given in the article. (See also Geophys. Abs. 173–222.)—*S. T. V.*

176–210. Uyeda, Seiya, Yukutake, Takesi, and Tanaoka, Iwao. Studies of the thermal state of the earth. The first paper: Preliminary report of terrestrial heat flow in Japan: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, no. 3, p. 251–273, 1958.

Determination of terrestrial heat flow in Japan has been attempted for the first time. Geothermal gradient, uncorrected, in the Sasago tunnel, Yamanasi Prefecture, central Japan, is 2.71°C per 100 m and the mean thermal conductivity of the rocks penetrated by the tunnel is 7.61×10^{-3} cal per cm sec °C, giving the amount of heat flow of 2.06×10^{-6} cal per cm^2 sec. This and a few other preliminary results indicate that heat flow in Japan is greater than the global average determined so far, i.e., 1.2×10^{-6} cal per cm^2 sec. It seems, however, in spite of the active seismicity and volcanism of the Japanese Islands, unlikely that the order of magnitude of heat flow is different from the global average, except in areas close to active volcanoes.—*Authors' summary*

176–211. Ueji, Torajiro. Study of the underground temperature gradients of several wells at Arima spar district, near Kobe, Japan [in Japanese with English abstract]: Jour. Geography (Tokyo), v. 67, no. 1 (707), p. 31–40, 1958.

The temperature gradient was determined for 10 wells in the Arima spar district, Kobe, Japan, ranging in depth from 160 to 300 m. Although the average temperature gradient was found to be 11.7°C per 30 m of depth, an isothermal contour map at the 120-m level showed a temperature range from 50°C to 120°C.—*V. S. N.*

176–212. Watanabe, Kazue. Contribution to the thermodynamic analysis on the heat source of Obama hot springs in the vicinity of Unzen volcano district [in Japanese with English abstract]: Jour. Geography (Tokyo), v. 67, no. 3 (709), p. 127–152, 1958.

Excessive consumption of water (60,000 tons daily with heat energy of 4.6×10^9 kcal) from the Obama hot springs in Nagasaki Prefecture, Japan, for salt-making purposes caused a decrease in the rate of flow and in borehole temperature of the rocks. Temporary restriction in usage is permitting a slow recovery of discharge and temperature rates; an analysis of these rates has led to the conclusions that the heat energy of the magma producing the heat is estimated as 0.26×10^{14} kcal, and the volume of the magma is 0.06 km^3 (a sphere with radius of 200 m). Present Cl′ content is 12,000 ppm, twice as high as before, and the percentage of juvenile water has decreased from 67 to 15 percent with corresponding increase in the proportion of vadose water from 33 to 85 percent.—*V. S. N.*

176–213. Soma, Tokuzo. On the underground temperatures and radioactivities at one meter depth in the Misasa Hot Spring area [in Japanese with English summary]: Okayama Univ. Balneological Lab. Repts., no. 20, p. 55–61, 1958.

Temperature readings and radioactivity counts were made in thirty holes at a depth of one meter on the north and south banks of the Mitoku River, Tottori Prefecture, Honshu, Japan. Results are shown on sketch maps. Temperature readings ranged from 19.6°C to 42.2°C with an average of 24°C; α-tracks ranged from 0.25 to 46.1 per sec-cm^2 with an average of 14.6 α-tracks per sec-cm^2.—*V. S. N.*

176–214. Studt, F. E. The Wairakei hydrothermal field under exploitation: New Zealand Jour. Geology and Geophysics, v. 1, no. 4, p. 703–723, 1958.

Since exploitation of the Wairakei, New Zealand, hydrothermal field, heat flow has increased to a peak output of 2.2×10^5 kcal per sec, or 3.1×10^9 Btu per hr, almost double the natural heat escape. In this paper arguments based on a long series of temperature, pressure, and water level measurements in the drill holes show that heat is being withdrawn from storage in the rocks and ground water, which will limit the life of the field; but the data also suggest that heat supply from below the hot Waiora aquifer may be increased by suitably placed boreholes.

Natural heat escape is not necessarily a sure guide to power potential of a field, for in a province that is active both seismically and volcanically there is no justification for assuming constancy of conditions for any length of time. If the increased heat supply to the aquifer can be obtained, it may come either

from storage at a lower level, in which case its life would be limited like that of the stored heat above, or through increased flow from the ultimate source at depth, in which case for practical purposes it may be considered to be permanent. Either would be a valuable addition to the high-pressure resources of the Wairakei field. Faulting complicates the problem; the very fault which must be drawn on to increase the heat supply may bring in cold water as well as hot.—*D.B.V.*

176–215. Miroshnikov, L. D. Podzemnyye vody—istochnik teplovoy energii [Underground water as a source of thermal energy]: Priroda, no. 9, p. 89–91, 1958.

Hydrothermal resources of the world and of the U.S.S.R. in particular are discussed. Heat inherent in the deep layers of the earth's crust, volcanic heat, exothermal oxidation processes in the upper crust, and the heat developed by underground coal combustion supply thermal energy to underground water; brought to the surface this energy may be used for power generation and other uses in populated places. The dynamic energy of thermal springs, and the valuable minerals dissolved in the water can also be utilized.—*A. J. S.*

INTERNAL CONSTITUTION

176–216. Levin, B. Yu. Proiskhozhdeniye i sostav Zemli [Origin and composition of the Earth]: Akad. Nauk SSSR Izv. ser. geofiz., no. 11, p. 1323–1331, 1957.

A review of recent work in various countries tending to confirm Schmidt's cosmogonic theory of a cold origin for the earth (see Geophys. Abs. 164–188). In this concept the earth is becoming hotter due to radioactivity, and the core formed slowly as a result of physicochemical and gravitational differentiation of the matter in the outer layers. The mean composition of the earth is probably very close to the mean composition of meteorites.—*D. B. V.*

176–217. Jacobs, J. A. The interior of the earth: Adv. Geophysics, v. 3, p. 183–239, 1956.

A review of advances made in knowledge of the interior of the earth in the past few years, based on a survey of 127 papers, most of them original. The composition and constitution of the earth, thermal history, and magnetic field are treated in three chapters, and special attention is given in the concluding remarks to the problems of reversals of the earth's main geomagnetic field and polar wandering.—*D. B. V.*

176–218. Bullen, K. E. Aspects of research on the earth's interior, with special reference to seismology: Australian Jour. Sci., v. 21, no. 4, p. 93–99, 1958.

This is the text of an address read to Section A of the Australian and New Zealand Association for the Advancement of Science at the Adelaide Congress in August 1958, reviewing research on the nature of the earth's interior since the time of Newton and ending with particular reference to seismological research in Australia and New Zealand.—*D. B. V.*

176–219. Gutenberg, B[eno]. The structure of the earth as viewed in 1957: Scientia, ser. 16, 5 p., 1958.

Changes in our views about the structure of the earth during the past 20 yr are summarized. The hypothesis that in some of the crustal layers and

in the upper 100 km of the earth's mantle the velocity of elastic waves may decrease slightly with depth as a consequence of the increase in temperature has been confirmed for several regions and has removed some earlier discrepancies. The transition from the earth's mantle to the core is abrupt, probably from solid rock to nonsolid metal, that from the outer to the inner core is gradual. The inner core is possibly solid. The calculated energy of earthquakes, about 10^{25} ergs for the largest shocks, is now probably accurate within a factor of ten. Heat generated by radioactive material in the earth may be the main source for the processes which ultimately produce earthquakes. Evidence is accumulating that at least large portions of the earth's crust have shifted considerably during geological history.—*Author's abstract*

176–220. Saukov, A. A. Evolutsiya geokhimicheskikh usloviy v istorii Zemli [The evolution of geochemical conditions during the earth's history]: Priroda, no. 2, p. 10–16, 1958.

The chemical elements which comprise the earth migrate continuously due to geochemical processes which take place throughout geological time. Some elements are dissipated into space surrounding the earth, others accumulate in the hydrosphere and lithosphere to form mineral deposits. Such factors as the electric charges of atomic nuclei, their radii, atomic weight of isotopes, and valences have remained constant and do not produce changes in the earth's chemistry. Temperature, pressure, and concentration of elements in one or another geochemical system vary considerably. Even the average percentages of the elements change due to atomic transformation and cosmic exchange. Although ordinary rock in the earth contains some of all known chemical elements (one km^3 of rock of average composition contains 130 million tons of iron, 260,000 tons of copper, 100,000 tons of tin, 10,000 tons of uranium, 13 tons of gold, and so forth), some elements are continually increasing in amount (Ca, Sr, Pb, Ar), some tend to disappear from the earth (H, Ne, He, K, Rb, Kr, Xe, Rn, Ra, Ac, Th, Pa, U), and 13 new elements have been made by man. Therefore the chemical composition of the earth changes, a fact which has to be taken into account by geophysicists looking into the historical perspective of the earth's elastic and other physical parameters.—*A. J. S.*

176–221. Kapustinskiy, A. F. K teorii Zemli [On the theory of the earth]: Akad. Nauk SSSR, Voprosy geokhimii i mineralogii, p. 37–71, 1956.

In this volume of collected papers dedicated to the memory of Russian Academician A. E. Fersman, Kapustinskiy expounds his theory of the trizonal structure of the earth (see Geophys. Abs. 175–237). To avoid arbitrariness and bias in his solution of the problem, Kapustinskiy uses four methods of approach: thermodynamic, chemical, seismological, and quantum-mechanical; he considers the solution to be correct when it satisfies the requirements of all four methods, and the requirements of radiogeology in addition.

From the known thermodynamic equation $(\partial S/\partial v)_T = (\partial_p/\partial_T)_v$, and from experimental data which indicate that a pure condensed body increases its pressure p when heated isochorically, Kapustinskiy concludes that the effect of compression on entropy is equivalent to the effect of cooling, since it follows from the above equation that when $(\partial_p/\partial_T)v \to 0$, $(\partial S_p \partial v)_T \to 0$. Developing this argument on the Nernst principle in relation to the variations of free energy ΔF and heat content ΔH, Kapustinskiy arrives at his "fourth principle of thermodynamics" which can be expressed as follows: $\Delta F = \Delta H$ when $v \to 0$, that is the caloric and thermal properties of a body become independent of its volume when

volume of the body being compressed approaches 0; no body can be compressed to a state where all nuclei of its constituent atoms are in a close geometrical contact (Kapustinskiy considers such a state as *an absolute zero volume*); and when a body of a pure crystalline phase is compressed to such a "zero volume," the entropy of the body becomes zero.

Radical change in the chemical properties of compressed atoms is another feature of Kapustinskiy's hypothesis. He modifies the law of periodicity of elements by assuming that the outer electrons of atoms subject to high pressure in the interior of the earth are forced into the interior of the atoms, which therefore acquire different chemical properties. He constructs a five-period table effective in the eclogite mantle instead of the normal seven-period table of elements valid for the pressures which prevail on the surface of the earth and in its crust, and subjects the atomic organization of electrons in the earth's mantle to the Pauli principle. Consequently he suggests an electron-isomeric transformation of atoms of "degenerate chemistry" within the compressed silicate systems of the mantle, and considers the latter to be crystalline in structure.

The core of the earth is considered to be isothermal, consisting of metallized elements completely stripped of their atomic electrons. The thermal capacity of the core is negligible; this leads to a constant temperature of about 2,000°C throughout the core, when its metallic heat conductivity is taken into consideration.—*A. J. S.*

176–222. MacDonald, Gordon J. F., and Knopoff, Leon. On the chemical composition of the outer core: Royal Astron. Soc. Geophys. Jour., v. 1, no. 4, p. 284–297, 1958.

The chemical composition of the outer core is computed on the assumption that the average composition of the earth is the same as that of the chondritic meteorites. This assumption is consistent with the present rate of heat production in the earth. If the mantle is assumed to be made up of a 400-km shell of material of eclogite composition underlain by one of dunite composition, the chondritic model requires a core of iron silicide $(Fe,Ni)_{1.6}Si$.

The representative atomic number $\overline{Z}$ of this compound would be 22.8; this is consistent with the theoretical value of about 22 computed on the basis of Bullen's density distribution. The electrical conductivity of the iron silicide should be a third to a tenth that of pure iron for conditions in the core; this also is consistent with the requirements of the dynamo theory of the magnetic field.—*D. B. V.*

176–223. Wager, L. R. Beneath the earth's crust: Adv. Sci., v. 15, no. 58, p. 31–45, 1958.

An excellent review of current theories on the nature and origin of the materials composing the mantle, and the significance to petrology if material from a deep borehole to the mantle, the drilling of which has been planned by the International Union of Geodesy and Geophysics, proves to be similar to Alpine-type peridotites.—*V. S. N.*

176–224. Ringwood, A. E. The constitution of the mantle—III. Consequences of the olivine-spinel transition: Geochim. et Cosmochim. Acta, v. 15, no. 3, p. 195–212, 1958.

Evidence on the chemical composition of the mantle is reviewed. Based upon studies of the inclusions in kimberlite pipes, intrusion of peridotites in orogenic regions, and the compositions of stony meteorites and kimberlite, it is suggested

that the average composition of the mantle may approximate that of a garnet peridotite. However, the upper mantle immediately below the *M*-discontinuity may be poorer in sialic material and close to normal dunite-peridotite in composition.

When garnet peridotite is subjected to high temperatures and pressures a series of transitions dominated by the olivine-spinel transition occurs. Besides the olivine-spinel transition, pyroxene may invert to spinel plus coesite, whilst garnet and coesite may dissolve in the spinel at higher temperatures to form a highly disordered defect solid solution. The data in Parts I and II show that these changes should occur under the *P-T* conditions present in the upper 1,000 km of the mantle and take place over an appreciable depth range. The position and extent of this transition range depends upon the assumed temperature distribution in the upper mantle. By choosing a suitable temperature distribution, the transition region can be made coincident with region C (Bullen) in which phase changes and inhomogeneity have been inferred on other grounds.

It is found that the proposed transition phenomena are capable of explaining the known data on seismic velocity distribution, elasticity and density in the mantle. The temperature distribution required to make the phase transition region coincident with region C is supported by recent studies of the temperature dependence of electrical conductivity in the mantle. Both convection and conduction mechanisms of heat transfer may give rise to this temperature distribution.

A specific model for the mantle is proposed.—*Author's abstract*

176–225. Meijering, J. L., and Rooymans, C. J. M. On the olivine-spinel transition in the earth's mantle: Koninkl. Nederland. Akad. Wetensch. Proc., ser. B, v. 61, no. 5, p. 333–344, 1958.

The mantle is treated as a one-component, two-component, and ternary silicate system in order to determine which best interprets the transition zone. The first is found unsatisfactory. The second, based on the system Mg_2SiO_4–Fe_2SiO_4, better interprets the limits of the transition zone but fails in predicting further details such as the distribution of the volume effect over the zone. Fair agreement is expected if the mantle is considered as a ternary system, although this is still an oversimplification; other high-pressure phases may well play a role, and the transition zone may accordingly contain several kinks.

Treatment of the mantle as a system of more than one component does not appear to entail any difficulties with respect to the convection theory, as the loss of balance between rising and subsiding columns would presumably be a gross effect; integrated over the transition zone, the specific heat and volume effects depend only on conditions at its boundaries and not on the course of the transformation within it. If the heat of the transformation exceeds 100 cal per g, convection currents cannot be expected to break through the transition layer; the estimate of the transformation entropy obtained in this paper is much less; therefore Vening Meinesz' conclusion that the transition layer is a strong source of instability leading to convection currents (see Geophys. Abs. 172–143) is not affected.—*D. B. V.*

176–226. Shimazu, Yasuo. A chemical phase transition hypothesis of the origin of the *C*-layer within the mantle of the earth: Nagoya Univ. Jour. Earth Sci., v. 6, no. 1, p. 12–30, 1958.

Shimazu presents a chemical decomposition hypothesis to explain the peculiar physical states observed in the earth's mantle at depth of 400 to 1,000 km

(Bullen's *C*-layer). This is essentially the same theory as presented in Zisin, ser. 2, v. 11, no. 1, 1958 (see Geophys. Abs. 174–230).—*V. S. N.*

176–227. Ewing, Maurice. The crust and mantle of the earth, *in* Geophysics and the IGY: Am. Geophys. Union Geophys. Mon. no. 2, p. 186–189, 1958.

Three major problems about the crust-mantle system are the foci of much present research; these are the origin of the crust, mechanics of crustal deformation, and possibility of continued interchange of matter between mantle and crust. Lines of investigation of these problems are outlined. At the present time it is very difficult to judge which of the new results must be accommodated into our structure of geophysical knowledge, and which must be reexamined, reinterpreted, and perhaps rejected.—*D. B. V.*

176–228. Båth, Markus. Seismic exploration of the earth's crust. Recent developments: Geol. Fören. Stockholm Förh., v. 80, no. 3, p. 291–308, 1958.

This is a review of recent developments in the seismic exploration of the earth's crust. Crustal structure can be determined from the records of near earthquakes and controlled explosions, from surface wave dispersion (both group velocity and phase velocity methods), and from channel waves. The boundaries between continents and oceans are of particular interest; here properties vary over short distances, hence, investigations are more difficult and must be made in more detail.—*D. B. V.*

176–229. Byerly, Perry. Subcontinental structure in the light of seismological evidence: Adv. Geophysics, v. 3, p. 106–152, 1956.

This is a review of the development of seismological investigation of subcontinental crustal structure before and after 1940, based on a survey of 98 papers. There is now general agreement as to the order of depth of the *M* discontinuity in various regions, even if the exact nature of the material above it is in doubt. The velocity below *M* has been found variously as 7.5 to 8.4 kmps.—*D. B. V.*

176–230. Ewing, Maurice, and Press, Frank. Determination of crustal structure from phase velocity of Rayleigh waves. Part 3: The United States: Geol. Soc. America Bull., v. 70, no. 3, p. 229–244, 1959.

Variations in phase velocity of Rayleigh waves from the Samoa earthquake of April 14, 1957, are reported for the United States. These variations are correlated with topography and Bouguer gravity anomaly on a continental scale, demonstrating regional isostatic compensation. The correlation of phase-velocity variations with crustal-thickness changes is justified, and permits specification of the mechanism of compensation as the regional Airy system.

Regional average crustal thicknesses are: Peninsular Ranges and Southwestern Desert, 40 km; Basin and Range Province, 48 km; Rocky Mountains, 47 km; Interior Plains, 35 to 41 km; Appalachian Mountains, 40 km.—*Authors' abstract*

176–231. Kosygin, Yu. A. Vazhnyy metod izucheniya nedr [An important method of study of the earth's interior]: Priroda, no. 8, p. 21–26, 1958.

Exploratory boreholes over wide areas of continental platforms and reaching the Precambrian basement, distinct from mineral prospecting boreholes,

are being used to investigate the geological and geophysical nature of the upper part of the crust. These boreholes provide data for geotectonic maps and provide a basis for more accurate interpretations of geophysical data obtained independently. A team of specialists in geology, geophysics, and related fields cooperatively investigate each borehole. The profile is thoroughly studied from macro- and microscopic analysis of core samples. Structure and composition of the samples are described in detail; the age of the rocks is determined from paleontological and paleobotanical studies; chemical and luminescent analyses are made; electrical and radioactivity logging reveals thin deposits which usually escape notice by other methods; densities and magnetic properties of the cores are determined, temperature gradient is logged, and so forth.

A composite monograph resulting from such studies of a single exploration borehole is prepared for all future geological, geophysical, and hydrological prospecting in the area. Gravimetric measurements deep in the holes, and study of secular variation of the internal heat flow are planned.—*A. J. S.*

176–232. Richards, T. C. Measurement of the thickness of the earth's crust in the Albertan Plains area of western Canada, *in* Polar wandering and continental drift: A symposium, part 2: Alberta Soc. Petroleum Geologists Jour., v. 5, no. 7, p. 188–189, 1958.

A brief version of the paper published under the same title in Nature, v. 182, no. 4632 (see Geophys. Abs. 174–235).—*V. S. N.*

176–233. Koryakin, E. D. O glubinnom stroyemi zemnoy kory v oblasti Atlanticheskogo okeana [The deep structure of the earth's crust in the region of the Atlantic Ocean]: Akad. Nauk SSSR Izv. ser. geofiz., no. 12, p. 1477–1484, 1958.

This is a review of the work of geophysicists, mostly American and British, who have been studying the crust under the Atlantic Ocean and its seismological characteristics. The text is illustrated by several maps and numerous profiles. (See Geophys. Abs. 132–9796; 145–12744; 150–13852; 160–132.)—*S. T. V.*

176–234. Ewing, John, and Ewing, Maurice. Seismic-refraction measurements in the Atlantic Ocean basins, in the Mediterranean Sea, on the Mid-Atlantic Ridge, and in the Norwegian Sea: Geol. Soc. America Bull., v. 70, no. 3, p. 291–318, 1959.

Seismic-refraction measurements in the western basins of the North Atlantic Ocean show that an average crustal section consists of ½ to 1 km of low-velocity sediments and 4 to 6 km of oceanic crustal rock in which the seismic velocity is about 6.5 kmps. There is good evidence from sub-bottom reflections and shear waves that in many places there is a layer with a velocity between 4.5 and 5.5 kmps and a thickness of 1 to 2 km between the low-velocity sediments and the 6.5 kmps layer, although it is not usually detected by refracted arrivals. These layers are underlain by the mantle which has an average seismic velocity near 8 kmps. Measurements in the eastern basins show a similar crustal section, but the velocity below the deep discontinuity appears to be lower (7.7 to 7.8 kmps).

Measurements in the Mediterranean Sea show only low-velocity sediments underlain by a refracting layer in which the average velocity is about 4.5 kmps.

On the Mid-Atlantic Ridge the sediments are underlain by two refracting layers with velocities averaging 5.6 and 7.4 kmps respectively. The results indicate that the ridge has been built by the upwelling of great amounts of basalt

magma along a tensional fracture zone. Presumably the extensional forces and the supply of basalt magma come from convection currents deep in the mantle. Measurements in the Norwegian and Greenland seas show results very similar to those on the Mid-Atlantic Ridge, and, from this and the extension of the belt of active seismicity, it appears that the ridge structure continues through the Norwegian and Greenland seas into the Arctic Ocean.

The results of a few stations on the continental shelf of North America, Britain, and Norway are presented and compared with previously published results in these areas.—*Authors' abstract*

176–235. Balavadze, B. K., and Tvaltvadze, G. K. Stroyeniye zemnoy kory v Gruzii po geofizicheskim dannym [The structure of the earth's crust in the Georgian S.S.R. from geophysical data]: Akad. Nauk SSSR Izv. ser. geofiz., no. 9, p. 1075–1084, 1958.

The structure of the earth's crust in the Georgian S.S.R. has been studied since 1941 by seismic and gravimetric methods. Seismic studies were made in different areas by the method of deep seismic profiling, by the refraction correlation method, and by recording of elastic waves produced by artificial explosions. Gravitational observations were made over the entire republic and in the adjoining regions to the north.

Georgia is a mountainous country of variable geological structure, therefore the results of local crustal studies are valid for only a limited area. The results of studies by several geophysicists may be summarized as follows: crustal thickness ranges from 41 to 67 km, with the greatest thickness under the central part of the Great Caucasus Ridge (around the Elbrus and Kazbek mountains); the minimum thickness is under the Dzirul massif. The approximate boundaries of the crustal layers in Georgia are as follows: sedimentary, from 0 to 8 km; granitic, from 14 to 35 km; and basaltic, from 22 to 33 km.—*S. T. V.*

176–236. Kosminskaya, I. P., Mikhota, G. G., and Tulina, Yu. V. Stroyeniye zemnoy kory v Pamiro-Alayskoy zone po dannym glubinnogo seysmicheskogo zondirovaniya [The structure of the earth's crust in the Pamir-Alay zone according to the results of deep seismic profiling]: Akad. Nauk SSSR Izv. ser. geofiz., no. 10, p. 1162–1180, 1958.

This article presents the results of crustal studies by the method of deep seismic profiling in the Pamir-Alay zone, which includes the Alay and Transalay ridges and the northern arches of the Pamir Mountains. The main object of these studies was determination of the deep structure of the area and its relationship to the gravitational field. The results show that this method is applicable in high mountain regions with complex structure. The surface of the basalt layer and the Mohorovičić discontinuity were located. In the central part of the depression surrounded by the highest summits the thickness of the crust was found to be more than 70 km, with a granitic layer of 40 km; in the northern part the thickness of the crust is 45 to 50 km, with a granitic layer of 15 to 20 km.

The analysis of the cross section of the crust in the Pamir-Alay zone and its comparison with those obtained in northern Tien Shan and western Turkmen S.S.R. lead to the general conclusion that in the transition zone from platform to mountain regions a significant increase in crustal thickness is

observed. Comparison of the results of deep seismic profiling with the gravitational field shows that the greatest negative Bouguer anomaly in the U.S.S.R. (−450 mgal) is related to the dip from north to south of both deep boundaries, the surface of the basalt layer and the Mohorovičić discontinuity, and that the gravitational field is mainly determined by the form and the depth of the Mohorovičić discontinuity.—*S. T. V.*

176–237. Usami, Tatsuo; Mikumo, Takeshi; Shima, Etsuzo; Tamaki, Ituo; Asano, Shuzo; Asada, Toshi; and Matuzawa, Takeo. Crustal structure in the northern Kwanto District by explosion-seismic observations. Part 2. Models of crustal structure: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, pt. 3, p. 349–357, 1958.

Data obtained from the observations described in the first part of the paper (see Geophys. Abs. 176–92) are used to make five models of crustal structure along the section between Hokota and Nozori, Japan. Each model has some advantages and some disadvantages. The one finally adopted as the simplest and best explanation of the observed travel times assumes three horizontal layers having P-wave velocities of 5.5, 6.1, and 7.7 kmps. This gives thicknesses of 6 km and 19 km for the first and second layers respectively. The depth of the Mohorovičić discontinuity here thus is 20 to 30 km, much smaller than the 50 km calculated about 30 yr ago, which has been used as the standard of crustal structure for Japan. From this and from investigations in the Tohoku district (see Geophys. Abs. 173–256) it is concluded that the depth of the Mohorovičić discontinuity in northeastern Honshu is about 20 to 30 km; this agrees with an earlier determination (see Geophys. Abs. 158–216, 166–246). The foci of earthquakes near Tukuba are known to be deeper than 30 km, therefore they lie below the crust.—*D. B. V.*

176–238. Evison, F. F., Ingham, C. E., and Orr, R. H. Thickness of the earth's crust in Antarctica: Nature, v. 183, no. 4657, p. 306–308, 1959.

The existence of a true Antarctic Continent is confirmed by dispersion of seismic surface waves, from which a crustal thickness of about 35 km is calculated. Waves from the earthquake of September 9, 1957, were recorded at Scott Base and at Hallett station after traversing about 2,000 km of Antarctica. Records at Mirny station indicated a crustal thickness of 9 km beneath the Indian Ocean. Preliminary analysis of records of another Indian Ocean shock on August 4, 1957, also indicates a thickness of 35 km.—*D. B. V.*

ISOTOPE GEOLOGY

176–239. Lang, Walter B. The origin of some natural carbon dioxide gases: Jour. Geophys. Research, v. 64, no. 1, p. 127–131, 1959.

The stable carbon isotope ratios in carbon dioxide issuing from vents or springs or encountered in exploratory borings in different parts of the United States and Mexico have been determined in the mass spectrometer. They all fall within the range of C^{12}/C^{13} ratios representative of carbon derived from marine limestones. The isotopic evidence thus confirms the field evidence that the carbon dioxide probably originated from breakdown of limestone in contact with or near igneous intrusions. The isotope ratios do not give evidence of fractionation. There are places where the regional geology does not explain what became of the remaining calcium oxide.—*D. B. V.*

176–240. Walker, E[dward] C., Cuttitta, F[rank], and Senftle, F[rank] E. Some natural variations in the relative abundance of copper isotopes: Geochim. et Cosmochim. Acta, v. 15, no. 3, p. 183–194, 1958.

The relative isotopic abundance of copper has been measured in a number of minerals and a few plant materials. Suites of samples from Michigan and the Colorado Plateau have been examined in more detail to determine if local variations due to isotopic exchange or diffusion could be found. The relative isotopic abundance of copper in specimens from several other localities was also determined. The variations noted were small but in some cases were felt to be significant because they were larger than the experimental error (0.1 percent in the ratio). A total spread of −1 to +8 parts per mil compared to the standard was found in the specimens tested.—*Authors' abstract*

176–241. Friedman, Irving, and Smith, Robert L. The deuterium content of water in some volcanic glasses: Geochim. et Cosmochim. Acta, v. 15, no. 3, p. 218–228, 1958.

The deuterium-hydrogen composition (relative to Lake Michigan water=0.0) of water extracted from coexisting perlite and obsidian from eleven different localities was determined. The water content of the obsidians is generally from 0.09 to 0.29 percent by weight, though two samples from near Olancha, California, contain about 0.92 percent. The relative deuterium concentration is from −4.6 to −12.3 percent. The coexisting perlite contains from 2.0 to 3.8 percent of water with a relative deuterium concentration of −3.1 to −16.6 percent. The deuterium concentration in the perlites is not related to that in the enclosed obsidian. The deuterium concentration in the perlite water is related to the deuterium concentration of the modern meteoric water and the perlite water contains approximately 4 percent less deuterium than does the groundwater of the area in which the perlites occur. The above relations hold true for perlites from northern New Mexico, east slope of the Sierra Nevada, California Coast Range, Yellowstone Park, Wyoming, and New Zealand. As the water in the obsidian is unrelated to meteoric water, but the enclosing perlite water is related, we believe that this is evidence for the secondary hydration of obsidian to form high water content perlitic glass.—*Authors' abstract*

176–242. Miller, Donald S., and Kulp, J. Laurence. Isotopic study of some Colorado Plateau ores: Econ. Geology, v. 53, no. 8, p. 937–948, 1958.

A number of selected uranium ore specimens from several localities have been analyzed for uranium and lead in both pitchblende and galena phases by isotope dilution techniques, and the lead isotopic abundance determined. It is shown that the hypothesis of hydrothermal deposition of uranium accompanied by old radiogenic lead from the basement at one time about 60 million years ago does not satisfy the isotopic data. A new hypothesis is presented which requires local sources with high *U/Th* and *U/Pb* ratios, variable radon leakage, suitable ground water movement, and deposition at the site of H_2S at low temperature. This hypothesis can explain the age discordances and the lead isotope abundances in galena. It is possible from the isotopic data to have all deposition occurring within the last five million yr but it does not preclude other periods of deposition such as in Laramide time. The isotopic ages are apparent ages only and bear no direct relation to the time of deposition. The isotopic ratios, however, provide information which may be used to restrict theories of origin.—*Authors' abstract*

176–243. Starik, I. [Ye.], Starik, F. Ye., and Mikhaylov, B. A. K voprosu o smeshchenii izotopnykh sootnosheniy v prirodnykh obrazovaniyakh [On the question of shift of isotopic ratios in natural formations]: Geokhimiya, no. 5, p. 462–464, 1958.

U^{234}/U^{238} ratios of material leached from uranium minerals by dilute solutions of sodium carbonate were measured with an alpha counter. For two samples of uraninite the ratio was observed to be about 20 percent higher than the ratio obtained in leaching the same material with dilute nitric acid. The effect is not observed on samples of pitchblende.—*H. F.*

176–244. Baranov, V[ladimir] I., Surkov, Yu. A., and Vilenskiy, V. D. O sushchestvovanii izotopnykh sdvizov v prirodnykh soyedinennyakh urana [On displacement in isotopic composition of natural uranium compounds]: Geokhimiya, no. 5, p. 465–472, 1958.

U^{234}/U^{238} ratios in leach and residue of natural uraniferous materials (uranium black, uraniferous bitumen and albitized phosphorite tuff) were measured with a 50-channel alpha spectrometer with an accuracy of 1 to 2 percent. The leaching media were hydrochloric acid with hydrogen peroxide and potassium citrate with hydrogen peroxide. The samples were sized into three sieve fractions (1 mm and 0.15 mm size limits). Changes up to 30 percent are observed in the U^{234}/U^{238} ratio, with the leach usually but not always enriched in the lighter isotope. Differences are observed for the different size fractions. The results show that the uranium isotopic compositions may change as a result of secondary processes. The method may be applied to the study of the origin of uranium deposits.—*H. F.*

MAGNETIC FIELD OF THE EARTH

176–245. Herzenberg, A. Geomagnetic dynamos: Annales Géophysique, v. 14, no. 4, p. 522–525, 1958.

It is shown that it is possible to postulate a pattern of motions in a homogeneous sphere of isotropic conducting material such that the whole arrangement acts as a steady dynamo producing a magnetic field extending outside the sphere. Therefore the possibility that the geomagnetic field is due to a dynamo in the core cannot be ruled out by any general theorem. The proof is rigorous; a model consisting of two eddies in the core provides an existence theorem. It is not suggested that actual motions are as simple.—*D. B. V.*

176–246. Herzenberg, A., and Lowes, F. J. The "eddy model" of the non-dipole field and the secular variation: Annales Géophysique, v. 14, no. 4, p. 526–534, 1958.

Bullard's eddy model has been extended to allow for the effect of the stationary conducting material surrounding the eddies, and the boundary of the surrounding conductor. Considerations of the available power and an electromagnetic saturation effect show that eddies capable of producing the non-dipole field must have radii of several hundred kilometres. To enable the varying field of such large eddies to reach the surface of the core it is necessary to postulate hydromagnetic propagation.—*Authors' abstract*

176–247. Jardetzky, W. S. Polar wandering, shifting of the earth's axis and dipole variations: Annales Géophysique, v. 14, no. 4, p. 502–505, 1958.

It has been pointed out that an aperiodic pole shift must be separated from displacements of the earth's axis. Polar wandering during geologic time can be explained by gliding of the solid shell over a fluid core. The fact that the main dipole is not located on the axis of rotation and that the position of the magnetic poles is asymmetric with respect to the equator seem to indicate an additional torsion in the earth's interior. The existence of a primary torsion is indicated by the distribution of the main features of the crust.—*D. B. V.*

176–248. Nodia, M. Z. K metodike issledovaniya mikro-territorial'noy i mikro-temporal'noy vekovoy variatsii magnitnogo polya Zemli [On the methods of study of microterritorial and microtemporal secular variation of the earth's magnetic field]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 14, p. 7–13, 1955.

Nodia proposes that a "microterritorial network" of field magnetic stations, 10 to 20 km apart, be organized, which would record secular magnetic variation annually or semi-annually ("microtemporally" instead of at 3- to 5-yr. intervals. The purpose of such a program is to correlate anomalies of magnetic secular variation with tectonic processes and seismic activity at the respective locations. He recommends a systematic study of local secular magnetic variations which are unaffected by anomalous gradients (vertical and horizontal) due to underground magnetically polarized rocks. Since the cause of secular magnetic variation of the earth's field is not yet known, the suggested empirical correlation of secular magnetic variation and geophysical processes from tens to hundreds of kilometers deep may serve as a basis for prediction of earthquakes.—*A. J. S.*

176–249. Singer, S. F. Geophysical effects of solar corpuscular radiation: Annales Géophysique, v. 14, no. 4, p. 433–437, 1958.

Magnetic storms, aurorae and cosmic ray variations are explained from a unified theoretical point of view. The sudden commencement of magnetic storms seems to be due to ionospheric currents initiated by solar corpuscular radiation. The main phase of storms is explained in terms of an extraterrestrial ring current set up by the drifting motion of trapped solar particles. These trapped particles are also accelerated to high enough energies to cause aurora; the acceleration proceeds mainly by Fermi collisions with magnetohydrodynamic waves (which give rise to geomagnetic micropulsations). Decreases in cosmic ray intensity which accompany magnetic storms are produced by a diffusive deceleration process in interplanetary space.—*Author's abstract*

176–250. Romaña, Antonio. El estudio de las variaciones rápidas del campo magnético terrestre [The study of the rapid variations of the earth's magnetic field]: [Spain] Inst. Geol. Minero notas y comun., no. 50, pt. 2, p. 345–362, 1958.

A review of the types of rapid variations of the earth's external magnetic field and investigations in progress during the IGY.—*D. B. V.*

176–251. Hennequin, Jacques. Sur une réalisation de l'expérience de Packard et Varian [On a carrying out of the experiment of Packard and Varian]: Acad. Sci. Paris Comptes Rendus, v. 248, no. 7, p. 996–998, 1959.

A nuclear precession magnetometer has been constructed for the Center of Geophysical Studies in France, following the suggestion of Packard and Varian as developed by Waters and Francis (see Geophys. Abs. 175–307). The instrument is described briefly with schematic diagrams. Preliminary tests have been made, paving the way for use of the instrument in measurements of the geomagnetic field at Chambon-la-Fôret.—*D. B. V.*

176–252. Bryunelli, B. Ye., Nizyayev, D. A., and Kanonidi, Kh. D. Stabilizator magnitnogo polya [A magnetic field stabilizer]: Akad. Nauk SSSR Izv. ser. geofiz., no. 7, p. 917–920, 1958.

At present, precise magnetic measurements must be made at points sufficiently remote from urban and industrial centers due to the intense disturbances usually found there. A description is given of a magnetic stabilizer capable of preserving the intensity of the geomagnetic field even under very unfavorable local conditions. An instrument similar to a magnetometer is used, having a built-in photoelectric attachment instead of a measuring scale. This is so adjusted that upon deflection of the magnetometer beyond a certain limit, a beam of light falls on a photosensitive element; this produces a current which is sent into a Helmholtz coil. It is essential to create conditions of proportionality between the variation of the magnetic field and the intensity of the correcting current. A description is given of several devices built on this principle. In the geomagnetic laboratory of the University of Leningrad variations of the magnetic field, ranging from 60 to 100γ before the installation of the magnetic stabilizer, were reduced to ± 2 to 3γ. In the Scientific Arctic Institute of Leningrad a stabilizer was installed in a room facing a street with heavy electric street car traffic, causing magnetic field variations as high as 1,500γ; after the installation, this variation did not exceed $\pm 5\gamma$.—*S. T. V.*

176–253. Chargoy, A., and Alvarez, M. G. de. Análisis de modelos que describen el campo magnético terrestre hasta 1955 [Analysis of models which describe the geomagnetic field to 1955]: Mexico Univ. Inst. Geofísica Anales, v. 3, p. 137–156, 1957.

Several models are analyzed mathematically in order to determine which best describes the secular variation of the geomagnetic field according to data available up to 1955. The three main cases considered are those of a dipole residing in the earth's geographic center O; a dipole and quadrupole both residing in the geographic center O; and an eccentric dipole and quadrupole both residing in the geomagnetic center C. The two latter are found to be equally valid. To determine which is preferable, it will be necessary to carry out the laborious analysis of the octupole terms; this will be treated in another paper.—*D. B. V.*

176–254. Berishvili, G. P. K izucheniyu osnovnykh kharakteristik geomagnitnykh bur's vnezapnymi nachalami [A study of basic features of geomagnetic storms of sudden commencement]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 16, p. 39–51, 1957.

This is a study of sudden commencements of geomagnetic storms, based on the magnetograms for a complete cycle of solar activity from 1933 to 1945 recorded

in the Georgian S.S.R. at Karsan' (φ=36.4°, λ=122.0°) up to 1935, and at Dusheti (φ=36.7°, λ=122.1°) from 1935 on. It was found that the daily distribution of *SC* has a minimum centered around 08 hr, and the main afternoon and night maxima are separated by a minimum centered around 16 hr. A table and a graph give the annual distribution of *SC*'s indicating the main maximum at the beginning of July and the main minimum early in November. The secular distribution of *SC* follows the mean relative number of sunspots with a slight lag. It was also found that the probability of *SC* storms increases with intensity. A theoretical discussion leads to the conclusion that *SC*'s represent the initial effects of magnetic disturbances caused by electric currents induced in the surface layer of a neutral heliocorpuscular, geoactive stream under the influence of the earth's permanent magnetic field.—*A. J. S.*

176–255. Berishvili, G. P. K voprosu ob izuchenii povtoryayemosti geomagnitnykh bur' [On the question of the study of recurrence of geomagnetic storms]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 13, p. 21–43, 1954.

The 27-day recurrence features of geomagnetic storms for the complete cycle of solar activity of 1933–45 are analyzed; data are summarized in tables and graphs. The experimental probability P_k of a storm recurrence is determined and compared with the probability of chance recurrence. The recurrence tendency is clearly evident for strong magnetic storms.—*A. J. S.*

176–256. Khvedelidze, N. S. Ob odnoy osobennosti irregularnykh variatsiy [On a characteristic of irregular variations]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 16, p. 63–76, 1957.

From the analysis of the data from the Srednikansk, Irkutsk, South Sakhalin and Tbilisi magnetic observatories on 23 magnetic storms during 1946–47, it is concluded that the irregular component D_1 is caused by short-duration electromagnetic processes taking place in the ionosphere in the auroral zone and outside the ionosphere in that region of the solar corpuscular stream which is in the proximity of the earth.—*A. J. S.*

176–257. Katsyashvili, N. A. Nekotoryye osobennosti S_q-variatsiy *H* v Tbilisi [Certain features of S_q-variations in *H* at Tbilisi]: Akad. Nauk Gruzin. SSR, Inst. Geofiziki Trudy, v. 16, p. 53–61, 1957.

A study of S_q-variations based on the data from the Karsan' and Dusheti magnetic observatories in the Georgian S.S.R. for the period 1933–45 (see Geophys. Abs. 176–255) shows that the amplitude of S_q-variation in *H* changes greatly and irregularly from day to day, and is higher in the summer than in winter; that the overall level of S_q-variation decreases with an increase in solar activity; and that the form of S_q-variations in *H* changes greatly at Tbilisi, whereas S_q-variations in *D* and *Z* have a stable form with a definite maximum and minimum.

The S_q-variation at Tbilisi is explained by the fact that the centers of electric currents in the higher atmosphere shift from lat 40° N. in winter to lat 30° N. in summer in the northern hemisphere, and from lat 40° S. in winter to lat 50° S. in summer in the southern hemisphere. Since Tbilisi is situated at 40° N., even a slight shift of these centers should affect the S_q-variations in *H* at Tbilisi. From the analysis of seasonal S_q-variations in *H*, Katsyashvili concludes that the centers of electric currents in the higher atmospheric layers are shifted to the south during the years of minimum solar activity compared to their position during maximum solar activity.—*A. J. S.*

176–258. Slaucitajs, Leonidas. El conocimiento geomagnético de la Antartida sudamericana [Geomagnetic knowledge of the South American Antarctic]: Inst. Antartico Argentino, pub. no. 3, 114 p., 1958.

Results of geomagnetic investigations in the Antarctic Peninsula and adjacent islands and Weddell Sea from the 19th century (Ross expedition, 1839–43) through 1956, inclusive are tabulated. Values of magnetic elements as observed by each expedition are listed; daily variation, disturbances, and secular variation are analyzed. The latest Argentine magnetic fieldwork is described in considerable detail.—*D. B. V.*

MAGNETIC PROPERTIES AND PALEOMAGNETISM

176–259. Kalashnikov, A. G. Issledovaniye magnitnykh svoystv gornykh porod i geologicheskikh tel, kak osnova dlya interpretatsii magnitnykh anomaliy [Magnetic properties of rocks and geologic bodies as a basis for the interpretation of magnetic anomalies]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 14, p. 15–36, 1955.

Methods of measurement of magnetic properties of rocks and the magnetic field of models of geologic bodies are discussed. The field of an anomaly H_a can be expressed as a function of coordinates in the following form: $H_a=F(\varphi, K, J_r, P, t, T)$, where φ is form factor, K is magnetic susceptibility, J_r is vector of remanent magnetization, P is pressure, t is temperature, and T is the vector of the earth's magnetic field. In problems of physical magnetostatics, parameters J_r, P and t cannot be neglected, as the remaining parameters are not sufficient to determine the depth of the disturbing body. Along with the development of methods for determination of H_a, K, and J_r in terms of the form of the disturbing body, experimental studies of basic geophysical and geochemical factors as they affect the magnetic parameters of geologic bodies are discussed, and instruments used are described; they include the magnetic torsion balance proposed by Curie and modified by Kalashnikov, the "permeability meter" (see Geophys. Abs. 151–14096), and a modification of the "permeability meter" for automatic magnetic logging of uncased boreholes, that has been completed in a model form.

Two aspects in the study of remanent magnetization of rocks are discussed, methods and instruments for measuring J_r in rocks, and the physical conditions under which J_r is produced in the rock. Remanent magnetization can be produced in two ways: by thermomagnetization slightly below the Curie point, and by deposition of ferromagnetic particles in water. The first process is considered to be the cause of secular variation of the geomagnetic field. When the isotherm of 530°C to 580°C (the latter being the Curie point for magnetite) at a depth between 25 to 50 km sinks or rises, the intensity of magnetization of magnetite at that depth changes and produces secular changes in the earth's magnetic field.

The effect of pressure on remanent magnetization is evident from experimental results indicating that compression of magnetite, basalt, and diorite decreases their magnetic susceptibility (see Geophys. Abs. 151–14024). Under the influence of the vertical motions and lateral pressure which exist in the earth's crust, the susceptibilities of rocks are changed. This in turn affects their magnetization and the magnetic field at the earth's surface. If earthquakes result from tectonic movements of the crust, one may expect a tectono-

magnetic effect the variation of which may contribute to prediction of earthquakes.

The Z and H_a curves for magnetic bodies of various φ and J_r are given (see also Geophys. Abs. 175–288).—*A. J. S.*

176–260. Zidarov, D. Détermination du moment magnétique de gisements de minérai de fer [Determination of the magnetic moment of iron ore deposits]: Bolgar. Akad. Nauk Doklady, v. 11, no. 2, p. 77–80, 1958.

Zidarov shows in this paper that the magnetic moment M of a homogeneous magnetized body T can be determined, given the vertical component $\partial U/\partial z$ of the gradient of magnetic potential U of the body. The numerical values of the integrals $\int_{\sigma_1} U d\sigma_1 = 2\pi M \cos \widehat{\vec{j}z_1}$, and $\int_{\sigma_2} U d\sigma_2 = 2\pi M \cos \widehat{\vec{j}z_2}$ (where z_1 and z_2 are normals to planes σ_1 and σ_2 respectively, $\widehat{\vec{j}z_1}$ and $\widehat{\vec{j}z_2}$ are the angles between the vector of magnetization $\vec{j}$ and z_1 and z_2, respectively) can be determined experimentally with the aid of a parallelepiped K′, described in the paper.—*A. J. S.*

176–261. Ponomarev, V. N., and Zakharchenko, V. F. Ispol' zovaniye izmereniy magnitnogo polya v shurfakh dlya opredeleniya namagnichennosti gornykh porod v usloviyakh ikh yestestvennogo zaleganiya [The use of measurements of the magnetic field in prospect pits for determination of the magnetization of rocks in their natural occurrence]: Razvedka i okhrana nedr, no. 9, p. 33–35, 1958.

In magnetic surveys of ore bodies it often is necessary to eliminate the effect of surrounding magnetic rocks on the intensity of observed anomalies. A method is suggested here for direct determination of magnetization of these rocks in place, rather than on a number of samples as is usually done. Vertical intensity measurements are made in shallow boreholes or prospect pits, and the magnetization along the Z-axis (I_z) is calculated from the formula $I_z = \frac{\Delta Z \sqrt{a'^2+1}}{4\pi}$ (where $\Delta z = z$ max $- z$ min, $a' = a/h =$ ratio of diameter of pit to depth). This formula includes remanent as well as induced magnetization. An example is given.—*S. T. V.*

176–262. Avchyan, G. M. Ob opredelenii magnitnoy vospriimchivosti na astaticheskom magnitometre Dolginova [On the determination of magnetic susceptibility with the astatic magnetometer of Dolginov]: Prikladnaya Geofizika, no. 19, p. 195–215, 1958.

A critical analysis of the results obtained from magnetic measurements with Dolginov's astatic magnetometer as well as criticism of structural elements of this instrument and the theory of its operation lead to the following conclusions: when determining magnetic susceptibility of a rock, the specimen placed against the pole of the magnet, becomes obliquely magnetized; the formula derived by Dolginov for the field pattern of cylindrical specimens and coils is valid only for points located on the axis of the cylinder meeting the pole of the magnet; in view of the comeasuribility of the specimen with the magnet as well as the great heterogeneity of the field acting upon just one of the poles, it is impossible

to consider this field as producing the rotating moment on the entire magnet; the rotating moment of the magnet is produced by the component of the field which is perpendicular to the axis; this component is the result of the addition of the fields produced by the moments M_x and M_y of the specimen; if the specimen is magnetized along the axis of the cylinder, the component $M_y=O$. The field pattern of the specimen and of the calibrating coil not being identical, it becomes necessary when computing the calibration coefficients to use a correction formula given by Avchyan.—*S. T. V.*

176–263. McDougall, Ian, and Green, Ronald. The use of magnetic measurements for the study of the structure of talus slopes: Geol. Mag., v. 95, no. 3, p. 252–260, 1958.

By means of measurements of the direction of magnetization, talus may be distinguished from rock which has remained *in situ*. A criterion has been developed for the conditions under which the boundary between talus and rock *in situ* can be identified. This method is particularly useful when the upper portion of the rock *in situ* is broken and weathered and it has been applied with success to a scarp in the dolerite of the Western Tiers in Tasmania. Here the results suggest that in the upper part of the talus the jointed blocks have definitely fallen into a sub-horizontal position, whereas at lower levels they are only slightly tilted.—*Authors' abstract*

176–264. Griffiths, D. H., King, R. F., and Wright, A. E. An assessment of the difficulties involved in using Quaternary varved sediments for paleomagnetic studies of the secular variation: Annales Géophysique, v. 14, no. 4, p. 515–518, 1958.

For sufficiently precise descriptions of secular geomagnetic variation, paleomagnetic results must have a circle of confidence of no more than two or three degrees; that is, there must be no unknown sources of random or systematic error greater than those of sampling and measurement. Field and laboratory studies of varved sediments show that for these materials such sources of error do exist, and give some indication of their nature and magnitude. The most important variables are grain size, dip of bedding plane, and bottom currents during deposition. Variation of inclination error with grain size seems to be smaller in natural conditions than in laboratory experiments, seldom exceeding 5°. Bedding error shows a marked inverse relationship to grain size, but again seems to be less in nature than in the laboratory. Except for the finest material used (3μ mean diameter), bedding errors are approximately equal to bedding tilts. (See also Geophys. Abs. 171–261.)—*D. B. V.*

176–265. As, J. A., and Zijderveld, J. D. A. Magnetic cleaning of rocks in paleomagnetic research: Royal Astron. Soc. Geophys. Jour., v. 1, no. 4, p. 308–319, 1958.

It has been observed that the remanent magnetism of rocks is often the resultant of two magnetizations: firstly a magnetization with low coercive force, mostly directed by the local present Earth's field; and secondly a magnetization with high coercive force which shows the direction of the field from the period of the rock formation.

It is shown that it is possible to remove the disturbing magnetization of low coercive force while saving a good deal of the fossil magnetization with the aid of partial demagnetization. This was carried out by a combination of alternating fields and heating.

Generally a demagnetization with alternating fields up to 300 oersted (effective) at a temperature of 150°C appeared to be sufficient to clean the rocks.—*Authors' summary*

176–266. Nagata, Takesi, and Kobayashi, Kazuo. Experimental studies on the generation of remanent magnetization of ferromagnetic minerals by chemical reactions: Japan Acad. Proc., v. 34, no. 5, p. 269–273, 1958.

It has been suggested by Nagata and Watanabe, Blackett, Doell, Martinez and Howell, and others (see Geophys. Abs. 146–12916, 166–284, 170–243, 171–262) that remanent magnetization can occur naturally in rocks when chemical reactions or crystallization take place in their ferromagnetic minerals under the influence of a magnetic field. Nagata and Kobayashi have demonstrated by laboratory experiments that magnetically stable remanent magnetization can be produced by reducing Fe_2O_3 to Fe_3O_4 in a magnetic field. Fe_2O_3 powder was reduced at 340°C for 20 hr in a hydrogen atmosphere in a magnetic field varying from 0.5 to 40 oersteds. It is shown that the intensity of the chemical remanent magnetization changes linearly with increasing intensity of the applied magnetic field up to 40 oersteds. To distinguish the chemical remanent magnetization from the thermoremanent and isothermal remanent magnetization precisely and to examine the stability of the remanent magnetization, demagnetization by an alternating magnetic field and thermal demagnetization were carried out; it was found that the chemical remanent magnetization is extremely stable compared with the isothermal remanent magnetization, and changes with temperature in almost the same manner as does the thermoremanent magnetization.—*V. S. N.*

176–267. Grabovskiy, M. A., and Brodskaya, S. Yu. Normal'noye namagnichevaniye i termonamagnichevaniye anizotropnykh gornykh porod [Normal magnetization and thermomagnetization of anisotropic rocks]: Akad. Nauk SSSR Izv. ser. geofiz., no. 8, p. 977–988, 1958.

The results of an experimental study on the behavior of magnetically anisotropic rocks subjected to normal and thermal magnetization are presented. A sharp distinction was found between the magnetic properties along the layers formed by the magnetic components of the rock and those transverse to them. Thermal magnetization of anisotropic rocks produces an insignificant enhancement of magnetic characteristics. The increase of remanent magnetization transverse to the ferromagnetic layers during thermomagnetization may be so large that it may exceed the remanent magnetization of anisotropic rock in the direction of the layers during isothermal magnetization. If the ferromagnetic layers run normal to the total vector of the magnetic field, the body will be practically nonmagnetized in the direction of the field, and the magnetic anomaly becomes almost unnoticeable in spite of a high magnetite content. If the layers of the body are parallel to the direction of the total vector of the magnetic field, the induced as well as the remanent magnetization increase substantially, and the magnetic anomaly becomes more intense. If the formation of the ferromagnetic rock takes place without any influence of temperature, the process described can account for the magnetization of an anisotropic stratified rock. If on the other hand the formation of such rock takes place during thermomagnetization, then its temperature drops from the Curie point to the temperature of the surroundings; this produces an intense increase of magnetization both in the direction of the ferromagnetic layers as well as perpendicular to them, and therefore the total magnetization of the rock will be oblique.—*S. T. V.*

176–268. Stott, P. M., and Stacey, F. D. Magnetrostriction and palaeomagnetism of igneous rocks: Nature, v. 183, no. 4658, p. 384–385, 1959.

Tests were made with a specially constructed nonmagnetic press and heating system on a number of igneous rocks from eastern Australia for which paleomagnetic data have been reported, in order to determine whether thermoremanent magnetization acquired under stress will show irreversible deflections when the stress is removed. Twenty cylindrical specimens covering a wide range of rock types, ages, and geologic environments were placed in the press with their axes in the magnetic meridian and heated to 650°C in a nitrogen atmosphere, held there for 15 min and then allowed to cool for several hours under an axial load of 500 kg per cm^2; a duplicate set were given the same heat treatment without stress.

Within the limits of the experiment, both stressed and unstressed rocks acquired moments in the direction of the field in which they cooled. It is concluded that large systematic errors due to magnetostriction are most improbable in igneous rocks of the types normally used for paleomagnetic purposes.—*D. B. V.*

176–269. Stacey, F. D., and Lovering, J. F. Natural magnetic moments of two chondritic meteorites: Nature, v. 183, no. 4660, p. 529–530, 1959.

Substantial magnetic moments have been found in three chondrite meteorites, and thermal demagnetization measurements have been made on two of them (Homestead and Mount Browne) to obtain information about the origin of these moments. The results show that these meteorites have not been substantially heated or chemically changed after arrival on earth; since they have thermoremanent or chemical magnetization, their natural moments therefore must have been induced by extraterrestrial fields. It seems likely that the required fields originated in the meteorites themselves. Either they had fluid conducting cores, contrary to the usual concept, or else fluid cores are not necessary for generation of magnetic fields of terrestrial type. A choice between these alternatives may be made when we know whether the moon has a magnetic field, as it is highly unlikely that the moon has a fluid conducting core.—*D. B. V.*

176–270. Granar, Lars. Magnetic measurements on Swedish varved sediments: Arkiv Geofysik, v. 3, no. 1, p. 1–40, 1959.

This paper presents measurements of the natural remanent magnetization and anisotropy of susceptibility of glacial clay (10,000 yr old) from central Sweden and glacial and postglacial river sediments (0–2,400 yr old) from northern Sweden. The observed vectors of magnetization group around the present geomagnetic field vector in a manner suggesting secular variation similar to that found at present; but because of rather large random as well as systematic scatter of individual observations (probably due to such factors as currents, slope, magnetic instability upon drying), no definite conclusions as to geomagnetic variations can be drawn until further work is done on contemporary sediments.

All sediments investigated showed an excess of susceptibility in a plane, generally horizontal. Part of the anisotropy is thought to be due to bottom currents.—*D. B. V.*

176–271. Patterson, J. R. Address by Professor S. K. Runcorn on palaeomagnetism, *in* Polar wandering and continental drift: A symposium, part 1: Alberta Soc. Petroleum Geologists, v. 5 [6], no. 6, p. 140–144, 1958.

This is a general review of current knowledge of paleomagnetism and its use in interpreting the geologic past, and includes discussion of the origin of fossil magnetism in igneous and sedimentary rocks, the relationship of the magnetic and geographic poles, the use of paleomagnetism to locate the position of the geographic poles relative to continental masses in the geologic past, and the necessity of assuming continent drift to explain the discrepancy between polar positions for each continent at any one point in geologic time. In concluding his summary of Runcorn's address, Patterson adds his own observation that from evidence to date the poles and continents wandered but little during the sedimentary periods but great earth movements occurred between these periods. If further paleomagnetic data continue to confirm such movements, opinion may swing back to the old idea of catastrophism interspersed with uniformitarianism.—*V. S. N.*

176–272. Deutsch, E. R. The value of rock magnetism to the earth sciences, *in* Polar wandering and continental drift: A symposium, part 1: Alberta Soc. Petroleum Geologists, v. 5 [6], no. 6, p. 144–152, 1958.

This paper is primarily a review of the pioneering work of others in the development of the paleomagnetic method and includes discussions of the discovery of magnetism; early work on pottery and lavas; the discovery of thermoremanence; the reliability of igneous rocks, particularly basalt, as indicators of paleomagnetism; paleomagnetism and magnetic stability of sedimentary rocks; reversals of magnetization; and the application of rock magnetism to the basic problems of polar wandering, continental drift, and the origin of the earth's magnetic field. Fundamental conclusions from paleomagnetism concerning basic geological and geophysical phenomena must await the completion of detailed world-wide studies of rocks representative of all geological systems. Criteria exist for assessing the reliability of this method in any particular application and apart from theoretical implications, the data obtained should provide a basis for a new method of dating rocks. An excellent list of references is included.—*V. S. N.*

176–273. Creer, K. M., Irving, E., Nairn, A. E. M., and Runcorn, S. K[eith]. Palaeomagnetic results from different continents and their relation to the problem of continental drift. Annales Géophysique, v. 14, no. 4, p. 492–501, 1958.

Polar wandering curves for the different continents are compared. Assuming that the direction of the axis of rotation is fixed throughout geologic time (allowing for precession and nutation), paleomagnetic measurements determine the latitude and orientation of a site with respect to that axis. Indeterminacy in longitude can be reduced by working back from the present position, assuming minimum movement between geologic periods in each case. This indeterminacy will only be further reduced when paleomagnetic data are obtained for the whole geologic column of all continents. Further indeterminacy is caused by reversals of the geomagnetic field. It is not yet possible to separate polar wandering, or movements of the whole crust with respect to the axis of rotation, from continental displacements.—*D. B. V.*

176–274. DuBois, P. M. Palaeomagnetism and geological correlation: Annales Géophysique, v. 14, no. 4, p. 509–514, 1958.

Preliminary paleomagnetic results from a number of late Precambrian formations suggest certain tentative geological correlations which appear to be essentially in harmony with known geologic facts.—*D. B. V.*

176–275. Opdyke, N. D., and Runcorn, S. K[eith]. Palaeomagnetism and ancient wind directions: Endeavour, v. 18, no. 69, p. 26–34, 1959.

There appears to be agreement between trade wind directions recorded in eolian sandstones and paleomagnetic pole positions for North America and Europe in late Paleozoic and early Mesozoic times. The Upper Triassic Botucatu sandstone of South America is now being studied.

Paleowind studies are a promising line of research. Extended to all parts of the world, they might tell much about past patterns of atmospheric circulation and climate. As the latitudinal extent of the trade wind belt depends on the climatic state of the earth and on its rotation, information on this extent would provide an indirect method of determining the speed of rotation in the past (see also Geophys. Abs. 176–66 and 67).—*D. B. V.*

176–276. Gough, D. I., and Niekerk, C. B. van. A study of the palaeomagnetism of the Bushveld gabbro: Philos. Mag., v. 4, no. 37, p. 126–136, 1959.

Data are presented on the natural remanent magnetization at five sites in the Main Gabbro zone of the Bushveld Complex. It is found that the directions of magnitization would agree more closely if the rock at each site were rotated about the pseudo-stratification so as to make its dip zero. This indicates that the gabbro became magnetized before the crustal subsidence which formed the basin took place, and that the remanent magnetization has been stable since before the subsidence. This stability is further demonstrated by the highly consistent directions of magnetization making a large angle with the present field.

The mean north magnetic pole computed from the five sites lies at lat 23° N., long 36° E. The paleomagnetic results show that the South African crust when the Bushveld Complex was intruded, 2×10^9 yr ago, must have had considerable strength, as it supported the load of gabbro without subsidence for at least the time it took for the intrusion to cool to the Curie temperature of its ferrimagnetic constituents; this time is estimated, on reasonable assumptions, to be of the order of 10^5 yr.—*D. B. V.*

176–277. Deutsch, E. R. Recent palaeomagnetic evidence for the northward movement of India, *in* Polar wandering and continental drift: A symposium, part 1: Alberta Soc. Petroleum Geologists, v. 5 [6], no. 6, p. 155–162, 1958.

The results from a magnetic survey of the trap rocks of India are discussed as an illustration of the paleomagnetic method (for full details see Geophys. Abs. 166–281, 172–168 and 169). Results of examination of the two trap series concerned, the Deccan and Rajmahal, lead to the supposition that India lay considerably south of the equator during the period of extrusion (Jurassic), and that it subsequently drifted northward to its present position. This conclusion is examined in the light of drift of the entire crust relative to the poles (polar wandering), drift of India relative to other land masses but with the poles in their present position (continental drift), or a combination of both. Comparison of past polar positions, derived from paleomagnetic results, of India with those

for other continents reveals discrepancies which can be explained only by such a combination. If continental drift and polar wandering proceeded simultaneously, India has averaged a northward movement through 0.4° to 0.9° of latitude per million years since the Jurassic period.—*V. S. N.*

MAGNETIC SURVEYS

176–278. Rosa, Klement. Príspevok k metodike riešenia priamej úlohy magnetického prieskumu [Contribution to the methods of solution of the direct problem of magnetic prospecting]: Slovenská Akad. Vied Geol. Práce, v. 14, p. 170–199, 1958.

After formulating the direct problem of magnetic prospecting, Rosa discusses a solution of certain systems of partial differential equations with two unknown functions (of induced potential inside and outside the body) of stipulated boundaries. To solve these systems of equations, two auxiliary functions are introduced as a solution of the inner and outer Neumann's problems for a finite plane, as these functions are tied up with the induced potential sought. An example is given for a spherical body in a homogeneous field and in a dipole field. In conclusion an application of the method is given to a solution of the direct problem of magnetic exploration of an infinitely long elliptic cylinder.—*A. J. S.*

176–279. Bulashevich, Yu. P. Magnitnoye pole gorizontal'nogo plasta s neodnorodnym raspredeleniyem magnitnykh mineralov [Magnetic field of a horizontal layer with uneven distribution of magnetic minerals]: Akad. Nauk SSSR Ural. Filial, Gorno-Geol. Inst. Trudy, no. 30, geofiz. sbornik no. 2, p. 100–104, 1957.

The problem stated in the title is solved under the assumption that an infinite horizontal stratum is magnetized vertically. Periodic magnetic oscillations are superposed on this homogeneous magnetization. These oscillations take place in a direction perpendicular to the stratum. The vertical and the horizontal components of the resulting magnetic field of the layer are computed for these conditions. It is shown that as a result of the mutually compensating action of bands having different polarity the magnetic field decreases exponentially with height.—*S. T. V.*

176–280. Matsaberidze, V. S. Sposob priblizhennogo vychisleniya magnitnogo polya kosonamagnichennykh tel proizvol'noy formy [A method of an approximate calculation of the magnetic field of obliquely magnetized bodies of arbitrary form]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 13, p. 5–19, 1954.

An approximate calculation of H and Z for a vertically magnetized body is shown. Examples of H and Z master charts are given. In the treatment of an obliquely magnetized cube, Matsaberidze shows that Z-maximum in this case is shifted to the edge of the body and that the positive extremum of Z exceeds the minimum extremum of H.—*A. J. S.*

176–281. Baranov, Vladimir [I.]. Die Berechnung magnetischer Felder mittels der Gravimetrie [The calculation of magnetic fields by means of gravimetry]: Freiberger Forschungshefte, C45 Geophysik, p. 45–51, 1958.

Baranov applies his method of "pseudo-gravimetric anomalies" (see Geophys. Abs. 169–241) to the inverse problem in magnetometry. The magnetic anomalies

at an arbitrary geographic latitude are calculated from the known anomaly at the pole, starting from the well-known relationship between the magnetic potential V and the Newtonian potential $U: J \cdot \rightarrow U = f\sigma V$, where J is the vector of magnetization, σ the density, f the gravitational constant.—*D. B. V.*

176–282. Orlov, G. G. Nomogramma dlya opredeleniya glubin zaleganiya zalezhey po tochkam peresecheniya krivykh proizvodnykh potentsiala, snyatykh na raznykh vysotakh [A nomograph for the determination of the depth of occurrence of deposits from the points of intersection of the curves of potential derivatives, measured at different heights]: Akad. Nauk SSSR Ural. Filial, Gorno-Geol. Inst. Trudy, no. 30, geofiz. sbornik no. 2, p. 105–110, 1957.

A nomograph is presented for the determination of the depth of disturbing masses from the curves of potential derivatives; the basic features are as follows: the distance along the profile between the points of intersection of Z–curves is independent of the scale used in the construction of these curves, if these points are obtained at two or more heights; consequently the depth of the deposit can be determined even in the field from the instrumental readings. The determination of the depth of the deposit from the points of intersection, in the case of a magnetic survey made on the earth's surface, is independent of the choice of the normal field if the measurement of the potential derivatives is made at two or more heights simultaneously. Work with the chart consists of only a few operations and is very simple. The nomograph makes it possible to evaluate errors arising from the fact that the dimensions of the disturbing body are usually unknown. It can be used efficiently in choosing the net of observations and in estimating the rate of decrease of the potential derivatives with depth. This is valid for a finite or infinite disturbing body.—*S. T. V.*

Ponomarev, V. N., and Zakharchenko, V. F. The use of measurements of the magnetic field in prospect pits for determination of the magnetization of rocks in their natural occurrence. See Geophys. Abs. 176–261.

176–283. Research Group for Proton Magnetometer (Japan). A proton magnetometer [in Japanese with English summary]: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, pt. 3, p. 433–446, 1958.

The nuclear precession magnetometer constructed for station use by the Japanese Research Group for Proton Magnetometer is described. The principle is more or less the same as that described in many references. Protons in 200 cc of water are magnetized by a coil wound around the bottle. When the current in the coil is switched off, precession of protons around the earth's magnetic force is excited. By using the magnetizing coil as the pickup coil as well, the induced electromotive force is introduced to the narrow-band amplifier. As the frequency of precession is slightly less than 2,000 cycles per sec in central Japan, beat frequency can easily be recorded by mixing the signal with the standard oscillator containing quartz oscillators. A two-component pen-writing oscillograph is used for recording. With the aid of the 40 cycles per sec standard frequency which is also supplied from the standard oscillator and is recorded on the same paper, the beat frequency is readily counted with an accuracy of 0.05 cycle per sec.—*D. B. V.*

176–284. Henderson, John R., Jr., and Zietz, Isidore. Interpretation of an aeromagnetic survey of Indiana: U.S. Geol. Survey Prof. Paper 316–B, 37 p., 1958.

A total intensity aeromagnetic map covering the entire state of Indiana on a scale of 1:500,000 with a 50-gamma contour interval was constructed from 92 larger scale county maps. A structure contour map of the Precambrian crystalline basement was developed by use of mathematical depth determinations on 79 isolated, well-defined magnetic anomalies. The theoretical Precambrian basement is similar in structural trends to the geologically mapped top of the Trenton limestone (Middle Ordovician) and is also in excellent agreement with depths to basement rocks as determined by deep drilling. The basement contours indicate a major northwest-trending ridge about 50 miles wide in the northeast corner of the state that is partly confirmed by gravity anomalies and by seismic reflection profiles.

The magnetic anomalies in the southern and southwestern parts of the state appear to be related to the structures that controlled the accumulation of oil.—*A. J.*

176–285. Mason, R. G. A magnetic survey off the west coast of the United States between latitudes 32° and 36° N., longitudes 121° and 128° W.: Royal Astron. Soc. Geophys. Jour., v. 1, no. 4, p. 320–329, 1958.

The results of a survey, in which the magnetometer was towed behind a ship making detailed hydrographic surveys with closely spaced and accurately surveyed lines in the area between lat 32° and 36° N., long 121° and 128° W. off the California coast, have been interpreted by techniques developed for airborne magnetic surveys. The survey showed a series of narrow anomalies of about 400 γ amplitude trending north-south for 300 miles over a substantially flat abyssal plain. The anomalies arise at shallow depths. The most obvious and acceptable explanation is that the excess material represents lava flows which have spread out over the floor of the ocean, possibly filling preexisting troughs or depressions produced by the weight of the accumulating flows. In extent and thickness the flows would rank with the largest continental lava fields such as the Columbia River basalts. An alternative explanation is that the excess reflects the topography of the upper surface of the crust, brought about by marginal folding or by faulting. In either case these anomalies indicate lines of weakness in the ocean floor which were active prior to the formation of the Murray fracture zone, which interrupts their pattern in such a way as to suggest a right lateral displacement of about 84 nautical miles.—*D. B. V.*

Vacquier, Victor. Measurement of horizontal displacement along faults in the ocean floor. See Geophys. Abs. 176–171.

Cantos [Figuerola], J[osé], Borrego [González], J[oaquin], and Gea, Rufino. Electrical and magnetic investigation on the Valduengo Dam, at Jerez de los Caballeros (Badajoz). See Geophys. Abs. 176–111.

176–286. Jeczmyk, Barbara. Wstepne sprawozdanie z prac geologicznych przeprowadzonych w 1954 r. na obszarze Głuchałazów w celu zbadania przyczyn anomalii magnetycznych [Preliminary report on geological research carried on in 1954 in the Głuchołazy area for the purpose of investigating the causes of the magnetic anomalies

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(with Russian and English summaries)]: [Poland] Inst. Geol. Biul., no. 126, p. 443–456, 1958.

Boreholes and test pits made in two strong magnetic anomalies in the Głuchołazy area of Poland (the northeastern continuation of the Jeseniki area of anomalies in Czechoslovakia) show that the area is of no economic interest with regard to the possibility of iron deposits.—*D. B. V.*

176–287. Mel'nichuk, M. I. Opyt provedeniya rabot po ismereniya vtorykh proizvodnykh magnitnogo potentsiala tel [The experience in making measurements of second derivatives of the magnetic potential of bodies]: Razvedka i okhrana nedr, no. 9, p. 26–32, 1958.

During the year 1956 experimental determinations of the magnetic potential were made in the Saksagan district of the Krivoy Rog basin in the Ukraine. These determinations consisted in the measurement of the vertical and horizontal components of the magnetic field and their gradients Z'_z, H'_x, and Z'_x. Curves of the components of the field intensity and their gradients were constructed from the measured values. Similar curves were computed theoretically for a sphere, a horizontal cylinder, a thin slab, a plate of finite width deeply buried in the ground, and other simple figures. An approximate interpretation of the magnetic profile can be obtained by comparison of the measured with the theoretical curves. It is concluded that the method of gradients, particularly the vertical gradient of the vertical component, is very useful in the interpretation of shallow ore bodies, in planning prospecting and mining operations, and in areas of complex structure.—*S. T. V.*

MICROSEISMS

176–288. Veshnyakov, N. V. O nekotorykh oshibkakh opredeleniya azimuta mikroseysm po metody troynykh stantsiy [On some errors in the determination of the azimuth of microseisms by the method of tripartite stations]: Akad. Nauk SSSR Izv. ser. geofiz., no. 8, p. 1020–1025, 1958.

It has long been found that errors in the determination of the direction of approach of microseisms from a cyclone can be as much as 90° or more. This paper analyzes the errors which can be made in measuring the time of propagation of the incoming waves along the sides of a triangle formed by three stations of a tripartite installation.

The angle α, formed by one of the sides of the triangle and the wave surface, is introduced. The greatest error which can be admitted in the determination of this angle, $\Delta\alpha$, must not exceed 2° for a cyclone 3,000 km distant; even in this case the accuracy in the determination of distance d is only ±100 km. Therefore the error in measurement of the time interval between the arrival times at the component stations must not exceed 0.006 sec. This imposes the necessity of using only very precise and well-matched instruments. For instance, a difference in the damping constants between two seismographs of only 0.1 can produce an error of some 70° in the value of the azimuthal angle. The simplest method of increasing the accuracy of the determination of the azimuth is increase the length of the sides to 6 or 7 km (half the least wave length). This can reduce the error to 5° or even less. It is also very important to keep the instruments well adjusted and tuned.—*S. T. V.*

176–289. Rykunov, L. N., and Prosvirin, N. M. Ob iskazhenii azimutov na istochnik mikroseysm vyzyvayemom usloviyami ikh rasprostraneniya [The distortion of the azimuths toward the source of microseisms produced by the conditions of their propagation] : Akad. Nauk SSSR Izv. ser. geofiz., no. 8, p. 1026–1028, 1958.

Searching for the sources of error which occasionally appear in tripartite determinations of the source of microseisms, Rykunov and Prosvirin analyze the hypotheses of Stoneley and Darbyshire concerning the refraction of Rayleigh waves traveling along the bottom of the ocean, due to velocity changes produced by depth variations. These changes in velocity produce a bending of the wave trajectory, resulting in the erroneous determination of the source from which the waves propagate. Using Biot's formulas for the determination of wave velocity with varying depth and the known law of sources Rykunov and Prosvirin compute the trajectories of different microseismic waves. Sometimes a station cannot record waves coming from certain points of the ocean; this occurs when a wave emerging from the ocean hits the shore at an angle exceeding that of total reflection.—*S. T. V.*

176–290. Pasechnik, I. P., and Fedoseyenko, N. Ye. Elektrodinamicheskiy microbarograf s gal'vanometricheskoy registratsiyey [An electrodynamic microbarograph with galvanometric recording] : Akad. Nauk SSSR Izv. ser. geofiz., no. 1, p. 121–130, 1958.

Microfluctuations of atmospheric pressure influence the level of the background of microseisms, posing a limit to the sensitivity of seismic receivers. This effect is especially noticeable in deep seismic surveying. Also of interest is the question of the cause of the acoustic waves which often accompany earthquakes. This paper describes the construction and operation of microbarographs designed by Pasechnik and Fedoseyenko. Two slightly different models of the instrument were built. The principal element of the one is a hermetically sealed chamber 28,000 cm^3 in volume with one side made of a thin (0.1 mm) bronze membrane. The displacement of the middle point of this membrane is measured by an electrodynamic transducer and recorder by the usual means. The second, similar to those used by Gutenberg and Benioff and others in different countries, is lighter and better adapted to field use.

Tests have proved the efficiency of both instruments for use in seismic stations and in the field. Numerous observations of barometric microfluctuations are discussed. Both instruments are well suited for use in the investigations of the causes and origin of microseisms.—*S. T. V.*

176–291. Monakhov, F. I., and Dolbikina, N. A. Struktura mikroseysm [The structure of microseisms] : Akad. Nauk SSSR Izv. ser. geofiz. no. 8, p. 937–945, 1958.

This is a report on the study of the composition of microseisms observed at the Yalta seismic station. Using an azimuthal instrumental arrangement consisting of eight vertical seismographs inclined at an angle of 45° and installed in a circle at 45° intervals, completed by a vertical seismograph of high sensitivity, Monakhov has shown that microseisms observed in Crimea are caused by the presence of cyclones either over the Black Sea or over the North Atlantic Ocean off the Norwegian coast. The Black Sea microseisms have periods of slightly more than 3 sec., those from the Atlantic Ocean of 6 to 8 sec. Love waves are almost com-

pletely absent; Rayleigh waves not complicated by interference effects constitute only 5 percent of the microseisms related to Black Sea cyclones and 15 percent of those originating from the North Atlantic. Most of the waves are complex in character, especially those from the Black Sea, probably due to reflection from the shores. The planes of vibration of the Rayleigh waves are mainly oriented toward the sources of microseisms, and in most cases form angles with the vertical.—*S. T. V.*

176–292. Kostina, A. F. Osvyazi mikroseysmicheskikh kolebaniy, nablyudayemykh v Krymu, s meteorologicheskoy obstanovkoy nad Chernym Morem [The correlation between microseismic vibrations observed in the Crimea and meteorologic conditions over the Black Sea]: Akad. Nauk SSSR Izv. ser. geofiz., no. 8, p. 1029–1032, 1958.

The relations between the microseismic storms observed in the Crimea during 1955–56 and meteorological conditions over the Black Sea and over the North Atlantic Ocean have been studied. Comparison of the entire process of the generation of microseismic storms, their gradual growth, and total duration shows a great similarity between the microseisms generated by cyclones or low pressure areas over the Black Sea and those generated by cyclones over the North Atlantic Ocean, the only difference being the shorter period of the Black Sea microseisms. There were also cases observed when Crimean microseisms were caused by the simultaneous action of the Black Sea and North Atlantic cyclones.—*S. T. V.*

176–293. Savarenskiy, Ye. F., Lysenko, L. N., and Kompanets, M. V. O mikroseysmakh ozera Issyk-Kul' po nablyudeniyam seysmicheskoy stantsii v Rybach'yem [On the microseisms of Lake Issyk-Kul according to the observations of the seismic station at Rybache]: Akad. Nauk SSSR Izv. ser. geofiz., no. 8, p. 1015–1019, 1958.

This is a preliminary report on the theoretical analysis of microseisms observed at the Rybache seismic station at the western end of Issyk-Kul, one of the larger lakes of Russian Asia, some 200 km long and 30 km wide.

The analysis was based on the studies of Longuet-Higgins and Miche. The observations confirm the idea that microseisms are produced by standing waves which cause periodically variable pressure on the bottom of the ocean or lake. On Issyk-Kul standing waves can be also produced by the interference of simple waves and those reflected from the precipitous shores. The frequency, amplitudes, and other characteristics of the observed microseisms corroborate their earlier results obtained from the theory.—*S. T. V.*

RADIOACTIVITY

176–294. Riezler, W., and Kauw, G. Natürliche Radioaktivität von Gadolinium 152 and Hafnium 174 [Natural radioactivity of gadolinium-152 and hafnium-174]: Zeitschr. Naturforschung, v. 14a, no. 2, p. 196, 1959.

Nuclear emulsion experiments with samples of natural gadolinium-152, enriched from 0.2 to 14.96 percent with gadolinium-152 from Oak Ridge, showed a group of 40 α-tracks with a mean range of 5.8 μ, corresponding to an α-particle energy of 1.7 Mev.; from these the decay constant was calculated as $\lambda=7.3\times10^{-16}$ yr^{-1}, and the half life as $T=9.5\times10^{14}$ yr.

Similarly, a sample of natural hafnium-174 was enriched from 0.18 to 10.14 percent; the results show an α-particle group having a range of 8.5 μ, corresponding to an energy of 2.5 Mev. From 10 α-tracks the decay constant was calculated to be $\lambda=4.3\times10^{15}$ yr. Investigations on the hafnium are still in progress.—*D. B. V.*

176–295. Malyshev, V. I. Opredeleniye koeffitsiyentov radioactivnogo ravnovesiya kak metod izucheniya migratsii urana, ioniya, radiya [Determination of radioactive equilibrium coefficients as a method of study of uranium, ionium, and radium migration]: Sovetskaya Geologiya, no. 7, p. 138–147, 1958.

Using Baranov and Kuz'mina's method (see Geophys. Abs. 162–161), Malyshev has analyzed a number of uranium ore specimens for their content of β-radiating uranium X_1 (Th^{234}) and α-radiating ionium (Th^{230}) for the purpose of investigating the quantitative relationship of uranium, ionium, and radium, and from the correlation found to derive an idea of the migration of these elements in the hypergene zones of deposits. From the quantitative correlation found between uranium, ionium, and radium, subzones of different characteristics can be distinguished and intensity of migration determined. The coefficients of radioactive equilibrium between the isotopes are presented graphically; their study helps in finding the zones of hypergenesis of uranium deposits. The mean quadratic error in determining the mean arithmetical ratio of ionium to uranium was ±10 percent.—*A. J. S.*

176–296. Picciotto, E. [E.]. Mesure de la radioactivité de l'air dans l'Antarctique [Measurement of the radioactivity of the air in the Antarctic]: Nuovo Cimento, v. 10, no. 1, p. 190–191, 1958.

This is a preliminary report on measurements of atmospheric radioactivity made by the Belgian Antarctic Expedition of 1957–1958. Mean artificial radioactivity was found to be 2×10^{-14} counts per m^3. Natural nuclides ThB (Pb^{212}) and RaB (Bi^{214}) were measured directly; the latter can be considered to be in equilibrium with atmospheric radon. A nuclide having a half life greater than 10 days, provisionally attributed to polonium, was also detected. Measured values were: RaB $< 10^{-12}$ counts per m^3, ThB $< 5\times10^{-14}$ counts per m^3, and Po$=10^{-16}$ counts per m^3. Both the artificial and natural radioactivity are very low; the latter is comparable to that measured above oceans, and several times weaker than the mean radioactivity over other continents. The absence of radon indicates that the time of diffusion across the ice cap is much longer than 3.8 days.

The presence of Po and therefore of RaD (Bi^{210}) opens interesting possibilities for ice chronology during the last hundred years, supplementing those offered by tritium.—*D. B. V.*

176–297. Adamczewski, Ignacy. O zanieczyszczeniach promieniotwórczych naturalnych i sztucznych powietrza i wody [On natural and artificial radioactive contamination of the air and water]: Acta Geophys. Polonica, v. 6, no. 3, p. 243–259, 1958.

The effect on human beings of radioactive contamination of air and water from nuclear tests is compared with that of natural radioactivity. The mean natural contamination from the earth's crust, water, and gases is tabulated. The necessity for systematic registration of intensity of artificial radioactivity

is stressed, and a simple method proposed by Kowal for measuring the radioactivity of dust in the air and in atmospheric precipitations is described.—*D. B. V.*

176–298. Roubault, Marcel, Coppens, René, and Jurain, Georges. Sur la teneur en radon des eaux froides de certaines régions de France [On the radon content of the cold waters of certain parts of France]: Acad. Sci. Paris Comptes Rendus, v. 248, no. 5, p. 715–717, 1959.

Field measurements of the radon content of natural waters were made in various parts of France with the aid of a truck-borne laboratory. Analyses were made of 344 cold well and spring waters currently being consumed by humans and animals. A large number showed high radon contents.

In a region some kilometers south of a strongly uraniferous zone, ⅔ of the wells had radon contents exceeding the tolerable dose (40×10^{-10} counts per liter); ⅙ had more than 10 times the limit. In a second area far from any uranium deposit, ¾ of the springs were over the limit of toleration, 1/10 by 10 times that amount. In the third, a mountainous area having no exploitable uranium concentration, ⅓ of the springs were over the limit, but none by as much as 10 times.

Geological and geochemical interpretation will be given later. In the meantime, it is suggested that the "tolerable dose" be reexamined, inasmuch as these waters have always been drunk by the populations of these regions with no apparent ill effects.—*D. B. V.*

176–299. Chkhetiya, M. A., and Chkhenkeli, Sh. M. Radioactivnost' mineral' nykh istochnikov Tbilisi [Radioactivity of mineral waters at Tbilisi]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 16, p. 97–99, 1957.

The radioactivity of mineral waters was investigated in 1939 and 1941 by means of radioactivity measurements of gas from borehole no. 2, spring waters, and a well in the Kirov district of Tbilisi in the Georgian S.S.R. The thermal waters were found to be less radioactive than spring waters; in the former the radioactivity varied between 0.2 and 3.3 emans in the latter between 0.3 to 12.3 emans. These results are in agreement with Burgser's data obtained with a fontactoscope in 1912.—*A. J. S.*

176–300. Kebuladze, V. V., and Torozova, L. I. Radioaktivnost' Borzhomskikh i Suramskikh mineral'nykh vod [Radioactivity of the Borzhomi and Surami mineral waters]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 13, p. 132–135, 1954.

The results of radiometric studies of possible changes in the delivery rate and radioactivity of mineral waters of Borzhomi and Surami due to explosions carried out in the area are presented. It was found that the radioactivity of the waters varied between 0.1 to 5.5 emans independently of the explosions, and that the radon concentration in the spring gas was approximately twice that in the spring water.—*A. J. S.*

Soma, Tokuzo. On the underground temperatures and radioactivities at one meter depth in the Misasa Hot Spring area. See Geophys. Abs. 176–213.

176–301. Hayase, Ichikazu. Radioactivity of the Japanese granitic rocks [in Japanese]: Jour. Geography (Tokyo), v. 66, no. 3 (705), p. 146–158, 1957.

Hayase gives a brief historical review of the development of measurement of radioactivity in rocks and the general results obtained from such measurements by scientists throughout the world. In general, measurements of radium in rocks of Japan and other countries show that radium is higher in acidic than in basic rocks, and that the content varies locally according to petrographic province and according to rock facies within the province. Effusive rocks show no typical correlation between radium content and age or order of eruption. In Japan rocks from the same volcano have some consistency in radium content, and uranium-radium equilibrium studies indicate that even recent lavas contain radium in amounts nearly in equilibrium with uranium.

Review of results of radium measurements by various Japanese scientists on two granites from stocks and two batholithic granites shows that although there is a marked variation in the radium content within one district, the stock-type granites are more radioactive than the batholithic granites. Volcanic rocks are found to be less strongly radioactive than granites; probably radioactive substances are lost in the former through eruptions and hot spring activities.

Most of the radioactive measurements on granites in Japan have been made in the Inner Zone of southwest Japan in Honshu and Shikoku. The radioactive characteristics are discussed and compared for three major granite zones in this area. The methods of measurement of radioactivity most applicable to granites; the mode of occurrence of radioactive materials in granites; the radioactivity of subterranean air, ground water and hot springs in granite regions; and the pleochroic halos characteristic of biotites in granites and pegmatites and their use in determining relative ages are discussed. See also Geophys. Abs. 160–169, 162–202, 172–206, 174–300, and 175–345.—*V. S. N.*

176–302. Hussein, Hussein Abdel-Mohsen. Étude sur quelques phosphates égyptiens. Teneur en phosphate et radioactivité [Study on some Egyptian phosphates. Phosphate content and radioactivity]: Soc. géol. France Bull., v. 8, no. 3, p. 289–294, 1958.

The uranium content of samples from the Kosseir and Sebaiya phosphate deposits in Egypt, determined by means of radioactivity measurements with a Geiger-Müller counter and nuclear emulsion plates, ranges from 20 to 140 ppm. This is approximately proportional to the phosphate content. No correlation with grain size was found.—*D. B. V.*

Oakley, Kenneth P., and Rixon, Arthur E. The radioactivity of materials from the Scharbauer site, near Midland, Texas. See Geophys. Abs. 176–20.

RADIOACTIVITY SURVEYING AND LOGGING

176–303. Voskoboynikov, G. M. Intensivnost' γ-islucheniya v odnorodnoy izluchayushchey srede [The intensity of γ-radiation in a homogeneous radiating medium]: Akad. Nauk SSSR Ural. Filial, Gorno-Geol. Inst. Trudy, no. 30, geofiz. sbornik no. 2, p. 162–172, 1957.

An evaluation of the intensity of radiation of γ-rays from sources evenly distributed in a homogeneous medium of different composition is presented. A

relationship is established between the recorded intensity of radiation and the chemical composition of the medium and the type of the indicator used. The following characteristics of the γ-radiation are established for a homogeneous medium. The recorded intensity of the γ-radiation in a diffusing medium depends essentially on the material of the cathode of the indicator; with increasing atomic number of this material, the recorded intensity increases. The intensity of radiation sharply decreases as the equivalent atomic number ($\bar{z}$) of the medium increases; as $\bar{z}$ varies from 6 to 82 the intensity decreases 5 times when a copper meter is used and 11 times when a lead meter is used (N, the number of disintegrations per unit of time per gram of radioactive substance, remaining constant). The specific intensity of radiation from a heavy radioactive element distributed in a medium decreases as its content increases. The decrease of the specific intensity must be taken into account if the content of uranium or thorium reaches some tenths of a percent. Observation of γ-radiation with different meters does not make for a reliable determination of the nature of the radioactive substance.

The change of the recorded intensity of radiation with the variation of $\bar{z}$ manifests itself primarily in the change of intensity of soft radiation with quantum energy less than 0.25 Mev. At the same time hard rays maintain their intensity; therefore the ratio of soft to hard components of radiation can be used to indicate the enrichment of the rock by heavy metals. The separation of the soft and hard components can be best made with aluminum luminescent indicators.—*S. T. V.*

176–304. Bulashevich, Yu. P. Ekvivalentnost' ob"emnogo i poverkhnostnogo izlucheniya [The equivalence of volumetric and surface radiation]: Akad. Nauk SSSR Ural. Filial, Gorno-Geol. Inst. Trudy, no. 30, geofiz. sbornik no. 2, p. 146–151, 1957.

A short discussion of the phenomenon of gamma-radiation from different bodies is presented. Computations of the gamma-field can be greatly simplified by replacing volumetric radiation by surface radiation. The procedure is illustrated by several examples.—*S. T. V.*

176–305. Ishmametov, K. K. Opyt primeneniya radiometricheskikh metodov pri geologicheskom kartirovanii, poiskakh i razvedkakh nekotorykh poleznykh iskopayemykh [Experience with the application of radiometric methods to geologic mapping and to exploration and investigation of some useful minerals]: Razvedka i okhrana nedr, no. 2, p. 54–56, 1957; German version in Zeitschr. angew. Geologie, v. 3, no. 7, p. 315–317, 1957.

A brief report is presented on the application of radiometric methods of exploration in the solution of different geologic problems. As the radioactivity of lithologic complexes does not change much within individual regions, it is important even during the preliminary survey to pay attention to the γ-activity of different formations. The duty of the geophysicist should be to keep a log of the γ-activity and relate it to the changing geology of the profile. A sharp change of the γ-activity indicates a new formation.

In the geologic survey of the southern Urals radiometric methods have been used in prospecting for phosphorites, titanium, syenite porphyry, and other valuable minerals. The article gives several curves of the γ-activity of rocks as a function of the P_2O_5 or radioactive mineral content.—*S. T. V.*

176–306. Chkhenkeli, Sh. M. Interpretatsiya nekotorykh vidov emanatsionnykh anomaliy [Interpretation of certain types of emanation anomalies]: Akad. Nauk Gruzin. SSR, Inst. Geofiziki Trudy, v. 12, p. 73–81, 1953.

A formula is derived for the concentration of an emanation over a lode, and transformed for preparing master charts. The permissible error is determined, and conditions for an unambiguous determination of the values of the diffusion coefficient and depth of the lode are set.—*A. J. S.*

176–307. Homilius, J., and Lorch, S. On the theory of gamma ray scattering in boreholes: Geophys. Prosp., v. 6, no. 4, p. 342–364, 1958.

This paper deals with the theory of the gamma-ray scattering method, which is applied to determinations of density, mainly in boreholes. For homogenous soil, the following statements can be made: intensity of scattered radiation decreases almost exponentially with distance $\bar{a}$ between the source and the center of the counter; intensity increases initially with density to a maximum at density < 1 and then decreases, the exact position of the maximum and degree of decrease depending on $\bar{a}$, size of counter, and energy of quanta; volume sampled by the instrument can be described by the distribution of scattering centers. The described behavior is confirmed by experiment.—*D. B. V.*

176–308. McLendon, Dan H. Radioactivity logs for gas location: World Oil, v. 148, no. 2, p. 79–81, 1959.

The radioactivity log is the best log available for ease of interpretation and accuracy in locating LPG-brine interfaces, points of gas entry into a borehole, and potentially productive gas zones. It is the only log capable of recording lithology and formation fluids behind a pipe and thus it is possible in sand country to run combination gamma-neutron logs in cased holes. Detectors fall into three categories: ionization chambers, Geiger–Müller or proportional counters, and scintillation counters; the last are the most efficient in use at the present time. The principles underlying the detector types are illustrated and examples of radioactivity logs used to aid in completing gas wells are given.—*V. S. N.*

176–309. Per'kov, N. A., and Korshikov, V. N. Interpretatsiya diagramm radioaktivnogo karottazha skvazhin [The interpretation of diagrams from radioactive logging of drill holes]: Moscow, Gosudarstvenno Nauchnotekhnich. Izdatel'stvo neftyanoy i gorno-toplivnoy literatury, 58 p., 1956.

This instruction book, published by the Scientific Research Institute of Geophysical Methods of Exploration (NIIGR) for scientific personnel engaged in petroleum research, covers the methods and procedures of radioactive well logging. It gives the background in atomic physics necessary for the understanding and effective use of different radioactive logging methods, discusses details of the instruments and of the construction of the probes to be lowered into the holes, the effect of the mud and of the condition of the walls, and finally treats in detail interpretation of the curves obtained by different radioactive methods.—*S. T. V.*

176–310. Campbell, John L. P., and Wilson, John C. Density logging in the Gulf Coast area: Jour. Petroleum Technology, v. 10, no. 7, p. 24–25, 1958.

Rock density is determined by means of a radioactivity logging device using cobalt-60 as a source of gamma radiation, producing a record termed the Densilog. Because the detector of the device is mounted directly above the source and is shielded from it, the gamma radiation which reaches the detector is mainly what has been scattered in the rock surrounding the instrument in the borehole. Measurement of rock density by means of gamma radiation depends basically upon the absorption of radiation as an exponential function of density, but gamma-ray scattering and absorption is so complex that calibration of instrument response versus density was first done by test hole experiments and later modified by comparison with density of drill core. A comparison with laboratory measurements sets the accuracy of the log at approximately 0.03 g per cm^{-3}.

In logging, the tool is held against the borehole wall by a bow spring in order to obtain a maximum contribution from the gamma rays scattered in the formation. In shales and in unconsolidated sands, the borehole may wash to such extent that the tool is not held in contact with the wall, and Densilog does not give a reliable estimate of formation density.

Porosity may be derived from the density log. If the grain or rock matrix density D_G is assumed to be constant, D_B is the bulk density of the rock measured by the Densilog, and D_F is the density of the fluid filling the pore space, the porosity ϕ is given by the relation $\phi=\frac{D_G-D_B}{D_G-D_F}$. Porosity scales and charts are constructed for sandstones by assuming a constant grain density of 2.65, and similar scales and charts are based upon a grain density of 2.71 for limestone and 2.85 for dolomite.—*G. E. M.*

176–311. Widmyer, R. H., and Wood, G. M. Evaluation of porosity determination from neutron logs: Jour. Petroleum Technology, v. 10, no. 5, p. 57–60, 1958.

In neutron logging for the determination of porosity the sources at present are of the radium-beryllium or polonium-beryllium type, and several types of counters detect or measure gamma rays, thermal neutrons, epithermal neutrons, fast neutrons, or a combination of these. The effect of different neutron logging systems and of a number of drill-hole and formation variables on the quantitative determination of porosity was investigated in shallow test holes containing limestone and sandstone blocks about 3 feet in diameter with center holes of 6, 7½, and 9 inches for logging surveys. Calibration, instrument zero, statistical and time constant checks were made before and after survey operations.

The response of different systems to borehole conditions varied considerably. A semiquantitative evaluation expressed as the average maximum percent error for a given borehole condition showed the largest error to be due to borehole diameter, followed in decreasing order by sonde position, salinity, and statistical variation. The difference in composition between a limestone and clean sand has very little effect on the response of most systems, so that the porosity correlation established in limestone sections is usually applicable to clean quartz sands. Instrument response curves obtained from laboratory test facilities should not be used for direct porosity determinations from field logs until the applicability in a given location has been demonstrated.—*G. E. M.*

Plewa, S. Methods of geophysical interpretation and mine surveys including neutron-gamma logging in prospecting for coal. See Geophys. Abs. 176–118.

SEISMIC EXPLORATION

176–312. Lyakhovitskiy, F. M. Primeneniye plastovykh skorostey dlya postroyeniya geologicheskikh razrezov [The utilization of layer velocities for the construction of geologic profiles] : Akad. Nauk SSSR Izv. ser. geofiz., no. 8, p. 1055–1059, 1957.

A method of constructing geologic profiles from the known layer velocities that does not require knowledge of the average velocities, used successfully in 1955 for the interpretation of seismic surveys in the Bashkir A.S.S.R., is described and illustrated for the case of a four-layer medium. The depths to each interface are determined successively from values of origin time and boundary velocity known for each layer. Solution of the multilayer case can be simplified by averaging strata already computed into one and thus reducing the number of layers to be considered. If boundary velocities are not equal to layer velocities the latter must be determined by the refraction correlation method or from well velocity or reflection data.

Disadvantages of the method are the facts that errors in evaluation of any preceding layer are carried over into calculations of succeeding layers, and that layer velocities cannot always be determined with sufficient accuracy. The method is most useful in shallow prospecting, such as for engineering purposes.—*S. T. V., D. B. V.*

176–313. Coloma Pérez, Antonio. Cuestiones analíticas relativas a la prospección sísmica [Analytical questions relative to seismic prospecting] : Rev. Geofísica, v. 16, no. 63–64, p. 270–339, 1957.

The compound seismic wave is analyzed for the sole purpose of establishing the difference between "normal time" and "extrapolated time." For the first, the "normal reflection time" is worked out on the basis of the compound refracted wave; it is concluded that it is possible to include the reflection method with the refraction method at least from the point of view of this study. Two different and original solutions are given for the three-layer problem, the first as a function of vertical depths relative to the ground and the first surface, the second as a function of the normal depths of both surfaces with respect to the ground.

After considering the errors committed in assuming the seismic plane to be vertical, the analysis is extended to the case of an inclined surface, making use of the fact that the compound wave is tangent to the reflected wave.

The parameters of the surface are determined on the basis of Gutenberg's formula and the equations of reflection, also giving the expression for use with the Heiland abacus.

General formulas are given to convert from refraction to reflection, and applied to derivation of Caleya's formula and Durbaum's generalization. This transition is accomplished on the basis of the two expressions derived in this paper for the complex wave for three layers, and Ewing's well-known formulas. Finally, several methods of determining the parameters of the first reflecting horizon are explained.—*D. B. V.*

176–314. Petkov, I. N. O seysmicheskom issledovanii s pomoshch'yu odnostoronnego kombinirovannogo godografa [On seismic investigation with the unilateral combined traveltime curve] Bolgar. Akad. Nauk Doklady, v. 11, no. 1, p. 21–24, 1958.

A method is presented for determining the effective velocities from numerous "equivalent" points on combined traveltime curves. The formula $V=kV/\sqrt{k^2+V^{*2}}$ is derived (in which V = effective velocity, V^* = apparent velocity, and k is determined from the angular coefficients of the straight lines q which are obtained by transformation of individual parts of the combined traveltime curve).—*D. B. V.*

176–315. Adachi, Ryuzo. On the singular point of time-distance curve [in Japanese with English abstract]: Butsuri-Tankō, v. 11, no. 1, p. 4–5, 1958.

The properties of the singular point of the time-distance curve in seismic prospecting are discussed and the following result noted: a time-distance curve has neither a loop nor a salient point and the return point must be that point at which two branches of the curve have a common tangent, provided that the corresponding separation curve has no singular point.—*I. S. N.*

176–316. Baranov, Vladimir [I.], and Kunetz, Geza. Calcul des sismogrammes synthétiques avec des réflexions multiples [Calculation of synthetic seismograms with multiple reflections]: Acad. Sci. Paris Comptes Rendus, v. 247, no. 21, p. 1887–1889, 1958.

A method is described for calculating a complete theoretical "synthetic" seismogram, which is affected by all multiple reflections and therefore more closely approximates the real seismogram, for the case of a horizontally stratified ground. In interpretation of seismic surveys by this method, comparison is made between the curves of the synthetic and real seismograms rather than between the continuous velocity log and real curve which are of different nature, and therefore a less direct comparison.—*D. B. V.*

176–317. Murusidze, G. Ya. O primenenii nagonyayushchikh godografov v seysmorazvedke [Application of the overtaking traveltime curves of reflected waves in seismic prospecting]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 14, p. 91–102, 1955.

The experience of the institute of physics and geophysics during its seismic expedition of 1950 indicated that the overtaking traveltime curves of reflected waves from the same layer, constructed in the same direction from two sources, as is done in the case of refracted waves, can effectively be used even in such cases where it is difficult to obtain a complete system of correlated traveltime curves. Murusidze discusses in his paper a method which makes determination of mean effective seismic velocities possible when the overtaking traveltime curves are used. (See also Geophys. Abs. 168–292.)—*A. J. S.*

176–318. Adachi, Ryuzo. A solution of separation surface on the seismic reflection method (General case in three dimensional space) [in Japanese with English abstract]: Butsuri-Tankō, v. 11, no. 2, p. 75–78, 1958.

A mathematical presentation of the solution for the form of the reflection surface, when the time-distance surface and the velocity of the wave in the first layer are given in three-dimensional space.—*V. S. N.*

176–319. Adachi, Ryuzo. A method of analysis of seismic refraction exploration [in Japanese with English abstract]: Butsuri-Tankō, v. 10, no. 4, p. 184–190, 1957.

Mathematical formulas are given and solutions for a two-dimensional underground structure are calculated from the time-distance curve in the theoretical case of double layers.—*V. S. N.*

176–320. Brauch, W[olfgang]. On reflected refraction waves: Geophys. Prosp., v. 6, no. 4, p. 365–381, 1958.

As an introduction the various ray paths of a refraction wave, which is reflected at a fault, are discussed for the case of an arbitrary angle between the refracting horizon and the fault. Simple geometric considerations lead to the conclusion that the best chances for recording these pulses are encountered, if the angle between the refracting horizon and the fault is either 90° or the critical angle of refraction. In both cases identical travel times of the pulses are to be expected.

The case of a fault perpendicular to the refracting horizon is considered in detail for dipping beds. Formulas for the shot point travel time curve and the time contour map are derived. Computed time contour maps show considerable differences between the direction of strike of the contour lines and the strike of the fault, as well as between the recorded apparent velocity and the true velocity of the refracting horizon. Finally, alignment charts and computing procedures are given by which the position of the fault and the velocity of the refracting horizon can be obtained from the recorded shot point traveltimes or the time contour map.—*Author's abstract*

176–321. Koefoed, O., Ewijk [Ewyk], J. G. van, and Bakker, W. T. Seismic model experiments concerning reflected refractions; Geophys. Prosp. v. 6, no. 4, p. 382–393, 1958.

Seismic model experiments are described in which long strips of plexiglass were used as models. One end of the strip was sawn off at an oblique angle and, at the opposite end, the strip was excited by means of a barium titanate transducer. The experiments showed that, if the width of the strip was sufficiently small, an anomalous reflection against the oblique end occurred which travelled in the longitudinal direction of the strip. This anomalous reflection did not occur when the width of the strip was large. These results are explained on the basis of Fresnel's theory. It is inferred that, in the subsurface, refracted waves may be reflected against fault planes without the law of reflection being satisfied, provided that the refracted wave is propagated in a sufficiently thin high velocity layer.—*Authors' abstract*

176–322. Troyanskiy, V. T. K voprosu o vozmozhnosti issledovaniy intrusivov seysmicheskami metodami razvedki [On the possibility of the investigation of intrusive rocks by seismic methods of exploration]: Razvedka i okhrana nedr, no. 2, p. 32–41, 1957.

The purpose of this study is to show certain possibilities of investigating the shape of buried intrusive rocks or of other bodies, if these have one or several refracting boundaries. The study is a development of the method suggested by Gardner (see Geophys. Abs. 136–10826). When head waves pass through an intrusive body, waves of different types are excited as, for instance, the diffracted waves P_{120} and P_{1201} as well as the waves refracted on the boundary of

the intrusive body, P_{1210} and P_{12101}. The P_{120} wave can always be recorded, whereas the P_{1201} wave rarely appears because its appearance is kinematically conditioned by the ratios of the velocities in adjoining media. The wave P_{120} and its traveltime curve give most of the information on the shape of the intrusive body. A graphoanalytical method is developed and illustrated by a practical example. The method cannot be considered a general one but can be very useful in particular cases.—*S. T. V.*

176–323. Anstey, N. A. A note on the seismic pulse recorded from a mine explosion: Geophys. Prosp., no. 6, v. 4, p. 433–437, 1958.

A seismogram is reproduced that shows clearly the shape of the pulse from a mine explosion. It was recorded fortuitously at the end of a poor record in the course of a normal reflection survey, against a background of wind noise only. Although this was not a controlled experiment, it does show that under practical field conditions—a stratified earth, an oblique path, a weathered layer—the pulse form does not become hopelessly complicated but retains considerable similarity to the simple theoretical form. Therefore theoretical studies confined to a homogeneous earth hold real promise of giving concrete help to the exploration seismologist in years to come, and it may be that many improvements of interpretation technique can be made on the basis of present knowledge of pulse shape.—*D. B. V.*

176–324. McDonal, F[rank] J., Angona, F. A., Mills, R[obert] L., Singbush, R. L., Van Nostrand, R[obert] G., and White, J. E. Attenuation of shear and compressional waves in Pierre shale: Geophys. Prosp., v. 6, no. 4, p. 404–407, 1958.

A very condensed version of the paper published in Geophysics, v. 23, no. 3, p. 421–439, 1958 (see Geophys. Abs. 174–337).—*D. B. V.*

176–325. Tazime, Kyoji, and Okada, Hiroshi. Observation of the velocity of S-waves near the surface of the earth [in Japanese with English abstract]: Butsuri-Tankō, v. 11, no. 2, p. 65–70, 1958.

The surprisingly low phase velocities of S-waves observed near the surface of the earth were attributed to various phase velocities of Love-waves of the zeroth order. In the upper and lower layers, S-wave velocities were estimated at 0.24 and 0.68×10^2 m per sec respectively and the *P*-wave velocities at higher than 3.1×10^2 m per sec.—*V. S. N.*

176–326. Omote, Syun'itiro, Komaki, Shauzow, and Nakajima, Naoyoshi. Seismic wave types in a sand layer near a small explosion: Tokyo Univ. Earthquake Research Inst. Bull., v. 36, pt. 3, p. 311–327, 1958.

Observations of small explosions, on the outskirts of a sand dune area on the Japan Sea shore under conditions such that one uniform layer was underlain by a uniform half space, showed four types of wave groups. The first is the body wave *P* propagating through the substratum. The second consists of the *P*-wave and a surface wave following it, propagating together through the surface layer. The third and fourth are the surface waves corresponding respectively to a kind of hydrodynamic wave (M_{12}) and to an ordinary Rayleigh wave. Phases which seemed to be characteristic of an *S*-wave also appeared; they are regarded as *S*-waves propagated through the surface layer and through the substratum respectively.

Observations on a simpler ground which had the structure of an ideal half space gave simpler records in which only two kinds of wave groups appeared, the *P*-wave and a surface wave; the latter however was not the ordinary Rayleigh wave, because the medium was saturated with sea water.—*D. B. V.*

176–327. Gaither, V. U. Index of wells shot for velocity (seventh supplement): Geophysics, v. 23, no. 5, p. 982–1023, 1958.

Information is tabulated on 2,382 well velocity surveys not reported in previous indexes. Corrections and (or) additional information on 85 previously listed surveys are also tabulated.—*D. B. V.*

176–328. Petkevych, G. I. Do pytannya pro vydīlennya seysmīchnykh granyts' prī seysmokarotazhnykh doslīdyhennyakh [On determination of seismic boundaries in well velocity surveys (in Ukrainian with Russian and English summaries)]: Akad. Nauk Ukrayin. RSR Dopovīdī, no. 10, p. 1104–1109, 1958.

Methods are proposed to facilitate the distinction of seismic boundaries in well velocity surveys. Reflected and refracted waves are recorded in the well and at the surface, the amplitude of direct and reflected waves are observed to determine the effective reflection coefficients, and the data are treated by means of the graphs $\Delta t = f(H)$ and $v_{int} = f(H)$. Used in the Pre-Carpathian depression, the proposed procedure made it possible to establish detailed sections in a number of places which could be correlated stratigraphically from their seismic interfaces.—*D. B. V.*

176–329. Kokesh, F[rank] P., and Blizard, R[obert] B. Geometrical factors in sonic logging: Geophysics, v. 24, no. 1, p. 64–76, 1959.

The purpose of the sonic log is to measure formation velocity, but various geometrical factors can cause apparent velocity readings substantially different from the true velocity at the depth of measurement. An understanding of these factors enables one to derive greater value from the log. Bed thickness, hole size, caves, alteration of the formation adjacent to the bore, spacing of the transducer, and whether the tool is centered in the bore, are among the factors influencing the log. Centering the tool can increase the signal strength, but in large holes and slow formations the first arrival may come through the mud. The transmitter-receiver spacing which is needed to avoid this is given for various hole sizes and formation velocities. The effect of caves is shown with theoretical and actual curves. There is some evidence that action of the mud or stress concentration around the bore can alter the velocity of the formation; the effect on the indicated velocity is shown as a function of transducer spacing and of degree and depth of velocity alteration.—*Authors' abstract*

176–330. Dobrin, Milton B. Seismic prospectings: Canadian Oil and Gas Industries, v. 12, no. 1, p. 52–54, 1959.

This is a review of technological progress in seismic exploration for oil from 1949 to 1959. Dobrin discusses new methods developed to replace shothole explosions as sources of seismic energy, such as the "thumper," a machine which drops a 3-ton weight on the earth several times a minute to produce signals for the geophone, and the continuous mechanical oscillator still in the experimental stage; development of multiple channel magnetic tapes for seismic recording; introduction of various types of record sections, that is, playback equipment

with accessories for time correction, making possible presentation of seismic data in continuous cross sections many miles long; development of the acoustic velocity logger; and the revival of refraction surveying as a result of improvement in recording equipment.—*V. S. N.*

176-331. Seriff, A. J. The response of seismometers in series and parallel connections: Geophysics, v. 24, no. 1, p. 49–63, 1959.

Two similar seismometers connected in series with a load exhibit two independent or "normal" modes of motion. In the first mode the two coils move so that the voltages generated are almost equal and in phase, producing a large current in the circuit and considerable damping of the motion. This is the mode normally considered in designing the external damping circuit for series seismometers. In the second mode the coils move nearly 180° out of phase, produce a relatively small current in the circuit, and consequently, experience very little damping in addition to their open circuit damping. Strong initial excitation of this mode can produce a sustained oscillation damaging to later parts of the seismic record.

The usual mathematical description of this system, i.e., two harmonic oscillators coupled through their damping terms, readily yields approximate expressions for the size and damping of the load current in the case of nearly identical seismometers with little internal damping. For example, two such seismometers connected to a load producing large damping for the first mode will exhibit a damping of only $(\omega_1-\omega_2)^2/4\omega f$ in the second mode. Here ω_1 and ω_2 are the angular frequencies of the two separate seismometers, ω is the average angular frequency, and f is the fraction of critical damping for the first mode.

Two seismometers connected in parallel can have considerable electromagnetic damping in both modes of oscillation.

For η seismometers in series, there are $\eta-1$ modes which may be poorly damped. The frequencies of these modes are distributed so that one lies between each adjacent pair of the original uncoupled frequencies. The damping in each mode is of the order of $\eta(\omega_k-\omega_{k+1})^2/8\omega f$.

The steady-state characteristics can be readily examined using the seismometer equivalent circuits. The result is strongly dependent on the mode of excitation. For example, if two similar seismometers are connected in series but only one is excited, the frequency characteristics shows both a maximum near the root mean square of the two seismometer frequencies and a minimum at the frequency of the seismometer not excited.—*Author's abstract*

176-332. Kovalev, O. I. Nizkochastotnyy razvedochnyy seysmopriyemik [A low-frequency exploratory seismograph]: Akad. Nauk SSSR Izv. ser. geofiz., no. 7, p. 913–916, 1958.

In recent years low-frequency seismographs have become very popular in surveys of the earth's crust by deep seismic profiling. Seismographs of such type were developed by several Russian geophysicists, but mainly for station use. Kovalev has constructed the first low-frequency seismograph of light weight and sturdy construction convenient for fieldwork along the lines recommended by Jones and Dennison (see (Geophys. Abs. 162–94). A description of this instrument (Mark NS–1), with its characteristic curves as well as numerous seismograms taken in the field, are given in the article. Its natural frequency was found to be 5 hours. This is a very sensitive instrument, making it possible to use smaller charges of explosives, while at the same time obtaining clearer

records than with other instruments. Eight NS–1 instruments tested during a 2-month survey in the Donets Basin maintained their high precision and sensitivity in spite of very great traverses from station to station over very poor dirt roads (total length over 3,000 km).—*S. T. V.*

176–333. Toba, Takefumi. Seismic apparatus for prospecting in the drifts [in Japanese with English abstract]: Butsuri-Tankō, v. 11, no. 2, p. 71–74, 1958.

A seismometer, amplifier, and galvanometer were designed for use in a mine drift to record the high-frequency elastic waves generated by dynamite explosions in the mine. The design of the instruments and results of tests are discussed. Preliminary results indicate that it is possible to detect small anomalies in rock structure by this method.—*V. S. N.*

176–334. Martin, Jack, and Hall, Thomas O. Ammonium nitrate: economy blasting agent for oil exploration: Geophysics, v. 24, no. 1, p. 155–163, 1959.

Major savings for operators of seismic parties have been achieved by the use of prilled ammonium nitrate as a substitute for gelatin dynamite in areas where shot holes are dry. Pound for pound, the prills appear to have the same energy yield as 60 percent gelatin dynamite, and some improvement of records has been noted where prills are used. Safety problems are fewer with ammonium nitrate than with dynamite, and the development of efficient field handling techniques prevents the loss of production.—*Authors' abstract*

176–335. Blaik, M[aurice], Northrop, J., and Clay, C. S. Some seismic profiles onshore and offshore Long Island, New York: Jour. Geophys. Research, v. 64, no. 2, p. 231–239, 1959.

Seismic velocity determinations in shallow layers (less than 2,000 ft deep) have been made recently at an experimental location on the Atlantic coast. Two reversed refraction profiles were obtained offshore. An unreversed refraction profile was completed on the beach. Reflection profiles were obtained both on the barrier beach and in the adjoining lagoon. Speed layering indicated by seismic reflection and refraction is compared with bore-hole velocity measurements. Significant thin high-speed and low-speed layers are shown by the borehole velocity data but not by the seismic profile data. The calculations from reflection and refraction shooting show reasonable agreement with the results of the borehole velocity survey for thick layering.—*Authors' abstract*

Ewing, John, and Ewing, Maurice. Seismic-refraction measurements in the Atlantic Ocean basins, in the Mediterranean Sea, on the Mid-Atlantic Ridge, and in the Norwegian Sea. See Geophys. Abs. 176–234.

176–336. Harris, Herbert I. Deep seismic results mean new exploration in Israel: World Oil, v. 148, no. 2, p. 106, 109–110, 1959.

Deep seismic mapping, conducted along the coastal plain of Israel since 1957, is making possible a complete revaluation of the oil possibilities of this coastal plain area previously condemned by dry holes. The most important contribution of the seismic results was proof that the structural pattern of folds and faults in the Cenomanian and older rocks is masked by a veneer of post-Cenomanian sediments. The mapping has already exposed two closed

structures and although oil has not been found in rocks older than Lower Cretaceous, suitable source rocks and reservoirs have been shown to be present in the Jurassic. Test wells drilled on the basis of good reflection data should have a chance to encounter producing horizons in these strata. Seismic crews have now moved into the eastern Negev region for mapping deep structures there.—*V. S. N.*

176–337. Breyer, Friedrich. Versuche zur geologischen Deutung der reflexionsseismischen Messungen in der Gefalteten Molasse Bayerns [Attempts at the geological interpretation of seismic reflection measurements in the Folded Molasse of Bavaria]: Ver. Schweizer. Petroleum-Geologen und Ingenieure Bull., v. 25, no. 68, p. 29–35, 1958.

The results of seismic reflection surveys in the Folded Molasse of upper Bavaria (see Geophys. Abs. 172–258) are interpreted geologically. The surveys brought out the relationships of the Folded Molasse to the adjoining Helvetic and Flysch zones on the south. The folding in the Molasse is not as simple as it first appears in comparison with these more complex Alpine border zones. A number of southwest trending structures are either demonstrated or suggested; this is the direction of the Loisach structural trend.—*D. B. V.*

Förtsch, O[tto], and Vidal, H. Seismoglaciologic studies on a glacier spot (Brandner glacier in the Rätikon). See Geophys. Abs. 176–175.

176–338. Tvaltvadze, G[uri] K., and Murusidze, G. Ya. Opyt primeneniya korrelyatsionnogo metoda prelomlennykh voln dlya resheniya nekotorykh geologicheskikh zadach [Experience with application of the refraction correlation method to the solution of certain geological problems]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 13, p. 139–147, 1954.

The refraction correlation method gave satisfactory results when tested in rough terrain during engineering-geological exploration in the Georgian S.S.R. in 1951. The *P*-wave velocities were determined as follows: diluvial clay, 400 to 600 m per sec; alluvial deposits, 1,700 to 1,900 m per sec; Sarmatian conglomerates, 3,000 to 3,200 m per sec; Paleocene deposits, 3,600 to 3,800 m per sec. No reflections were obtained during the exploration due to the geological characteristics of the region.—*A. J. S.*

176–339. Ioseliani, M. S., and Murusidze, G. Ya. K voprosu primeneniya seysmicheskikh metodov razvedki dlya resheniya nekotorykh zadach inzhenernoy geologii [On the question of application of seismic methods of prospecting to the solution of some problems in engineering geology]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 16, p. 115–128, 1957.

Certain results of seismic exploration in one of the basins in the Terek valley in the Georgian S.S.R. are discussed. After a geologic description of the area (Jurassic, Quaternary, and alluvial deposits), situated high in the Caucasus, data are presented on seismic investigations by the reflection method and by the refraction correlation method. Five profiles along the river valley have revealed the surface relief of the Liassic clay shale, under sediments 2,200 to 2,500 m thick, which is considered to be the depth of the original bed of the Terek River. Better results were obtained with low frequencies, especially

when industrial and natural background noise interfered. The refraction correlation method was found to be better suited for engineering-hydrological exploration. Waves reflected from the crystalline basement were satisfactorily recorded on low frequencies.—*A. J. S.*

176–340. Prangishvili, G. M. Sostoyaniye seysmicheskoy izuchennosti Kolkhidskoy nizmennosti [The state of seismic knowledge of the Kolkhida depression]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 14, p. 103–112, 1955.

Geophysical exploration of the Kolkhida depression in the Georgian S.S.R. is discussed. Tertiary and earlier strata of the depression are covered with thick recent alluvium which prevents geological evaluation of the underlying mineral and oil deposits. Geophysical exploration of the depression began in 1938 with magnetometric, gravimetric, and seismometric observations in the Supsa-Ompareti district. In 1947–50 magnetic and gravity maps were made of the entire depression, and electrical surveys were made of its west-central part. Since 1950 a combination of seismic and gravimetric methods, accompanied with deep drilling, have been used. The refraction correlation method proved to be effective in determining several refracting layers, in good agreement with the data obtained by the reflection method.—*A. J. S.*

176–341. Gal'perin, E. I., and Kosminskaya, I. P. Osobennosti metodiki glubinnogo seysmicheskogo zondirovaniya na more [Features of the methods of deep seismic profiling at sea]: Akad. Nauk SSSR Izv. ser. geofiz., no. 7, p. 833–847, 1958.

Gal'perin and Kosminskaya describe the application of the method of deep seismic profiling to sea bottom surveys, based on experiences in the central Caspian Sea. Different procedures were employed. Nine different combinations were tried of fixed and movable shot points; continuous, interrupted, or point profiling; and single or multiple recording points. The movable shot point combined with point recording is recommended. Low-frequency shot points gave much better results. A combination of littoral and underwater explosions is also recommended. Profiles can be as long as 200 to 250 km from the shot point to the last hydrophone. The study of the sea bottom can be substantially enriched by observations and recordings of weak local earthquakes at stations on the shore, giving information on layer velocities and on local crustal structure, especially on the location of seismically active layers.—*S. T. V.*

Kosminskaya, I. P., Mikhota, G. G., and Tulina, Yu. V. The structure of the earth's crust in the Pamir-Alay zone according to the results of deep seismic profiling. See Geophys. Abs. 176–236.

176–342. Kailasam, L. N. Seismic exploration for oil in the Cambay and neighbouring areas, Bombay State: Current Sci., v. 27, no. 11, p. 433–435, 1958.

The recent discovery of oil near Cambay is the culmination of detailed geophysical investigations carried out by the Geological Survey of India during 1948–57, resulting in the location of the Lunej structure by seismic reflection.

Reconnaissance magnetic surveys indicated that thickness of the sediments was at a maximum in the Cambay area, of the order of 10,000 to 12,000 ft. Further detailed gravity and magnetic surveys outlined strong regional as well as local anomalies which were further investigated by detailed seismic reflection

surveys. These confirmed and outlined a buried structural high in the Paldi-Lunej area, and a site for test drilling was recommended; oil was struck at a depth of 1,600 m.—*D. B. V.*

176–343. Shinada, Yoshijiro, and Hirasawa, Kiyoshi. Geological interpretation for the result of the seismic exploration in the northeastern part of Chiba Prefecture.—Especially, for the seismic velocity layers distribution at the younger formation [in Japanese with English abstract]: Butsuri-Tankō, v. 11, no. 1, p. 16–25, 1958.

A tentative geologic correlation was made of Pliocene, Miocene, and Neogene sediments from data obtained in a seismic refraction survey at Kujukuri, Chiba Prefecture, Honshu, Japan. The distribution of rock facies along the line of survey was determined by study of spontaneous polarization curves obtained from electric logs of several gas wells in the area. Results of the survey indicated: seismic velocity is closely related to depth; the boundaries of seismic velocity layers agree with and change with the boundaries of the rock facies; change of depth of the velocity layers seems to correspond to sudden change in rock facies; and consequently the differentiation of the velocity layer is not always indicative of geological classification.—*V. S. N.*

176–344. Yamaguchi, T., and Shinogi, M. On the field test of the fault interpretation by the refraction method at Nittetsu Futase coal mine [in Japanese with English abstract]: Butsuri-Tankō, v. 11, no. 1, p. 6–15, 1958.

Fault interpretation by means of a refraction survey was tested at the Nittetsu Futase coal mine, Japan, where the underground fault structures were well known. The results are described with particular emphasis given to a comparison of the refractive wave length and the signal-to-noise ratio between faulted and nonfaulted areas. The report is well illustrated.—*V. S. N.*

Imbert, Bertrand. Determination of the thickness of ice in Adélie Land. See Geophys. Abs. 176–177.

Murauchi, Sadanori; Tateishi, Tetsuo; and Matumoto, Tosimatu. Seismic prospecting of the Antarctic iceberg and fast ice near the Syowa Base [in Japanese with English abstract]. See Geophys. Abs. 176–178.

STRENGTH AND PLASTICITY

176–345. Das, Sisir Chandra. On the general plane problem of plasticity and its geophysical significance: Canadian Jour. Physics, v. 37, no. 1, p. 63–74, 1958.

The strong horizontal displacements shown by fault plane studies made at the Dominion Observatory in Canada disagree markedly with existing geotectonic theories. To account for them mathematically, the plane problem of plasticity is studied, using as a yield condition a general functional relationship between the stresses. The differential equations involved in the problem are nonlinear. For solutions these are replaced by a different set of completely equivalent equations expressing variations along families of curves, known as characteristics, across which certain derivatives may be discontinuous under suitable boundary conditions.

Physically the elastic-plastic (or rigid-plastic) interface taken as a characteristic curve is a fundamentally unknown thing which must be ascertained from symmetry of the problem or by experimentation. Investigations in this direction are being done in connection with the International Geophysical Year program. The various relatively modern methods of linearizing the stress conditions are discussed. Each deals essentially with transformation of coordinates depending on the form of the yield condition. The different solutions cannot be compared with observation because of the generality of the assumptions, but are believed to be of significance particularly in explaining deep focus earthquake mechanism and probable fault movements there. The geometry of the methods discussed can be used to determine the flow (or fracture) pattern if the boundary stresses as well as the particular yield condition are known, and conversely it will help to understand the nature of the stresses and the yield condition if the displacements are ascertained. It is both interesting and useful to proceed with various yield conditions and to find their influence on the solutions.—*D. B. V.*

176-346. Hiersemann, L[othar]. Die rheologischen Eigenschaften der Erdkruste vom Standpunkte der neuen Erkenntnisse über den Herdvorgang bei grossen Erdbeben [The rheological properties of the earth's crust from the standpoint of recent knowledge of the focal process in large earthquakes]: Annali Geofisica, v. 17, no. 2, p. 113–123, 1958.

The study of the focal process of tectonic earthquakes plays an important role in the rheological interpretation of seismic data. It is possible, with known focal mechanism and correct choice of aftershocks belonging to a fault plane, to obtain the deformation features for the deeper regions of the earth's crust from earthquake magnitudes. These deformation features, together with structural models and empirical creep functions, constitute the first approximate possibility of describing the rheological behavior of geologic bodies. They form the foundations for simplified structural theories. Exact structural theories require the introduction of other seismic and geologic data which make the setting up of the problem still too complicated at present. So far, the results of seismic measurements show that over a period of 25 yr the earth's crust down to a depth of 700 km behaves like a solid Kelvin body with elastic after effect.—*Author's German summary, D. B. V.*

176-347. Nishihara, Masao. A method for predicting creep characteristics [in Japanese with English summary]: Doshisha Kogaku Kaishi, v. 6, no. 2, p. 89–95, 1955.

The present paper describes a method for predicting creep-time relations under various constant stresses from a strain-time relation under a certain stress-rate. The procedure is given for a case when a material can be regarded as Maxwell, Kelvin or Burgers Body. In the case considered, a creep-time relation is equivalent to a strain-rate-time relation multiplied by any stress under which the creep characteristic of a material is to be obtained and divided by the stress-rate under which a material is tested. According to the method proposed, a test under constant stress-rate is enough to give the stress-strain relation and creep-time relation of a material.—*Author's abstract*

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176–348. Nishihara, Masao. Stress-strain-time relation of rocks (Rheological properties of rocks II) : Doshisha Kogaku Kaishi, v. 8, no. 3, p. 85–115, 1957.

The time dependence of stress and strain is discussed for Maxwell, Kelvin, Burgers, and Sawaragi mechanical models of rocks. The Sawaragi model, consisting of parallel arrangement of dashpot and "slider" is said to account for "intrinsic hysteresis caused by permanent plastic strain".

The deformations of earth materials are classified under three types (elastic, viscous, and plastic) and examples of each are given. A table of the instantaneous elasticity, viscosity and relaxation time is given for dry shale, wet sandy shale, wet sandstone, and other rocks and materials. A discussion of the occurrence of earthquakes is given, based on this table.—*L. P.*

176–349. Murayama, Sakurō, and Shibata, Tōru. On the rheological characters of clay, Part I: Kyōto Univ. Disaster Prevention Research Inst. Bull., no. 26, 43 p., 1958.

The complicated behavior of clay cannot be represented by a simple mechanical model of a dashpot, spring, and slider. The rheological character of clay is derived rather from the structural viscosity calculated from statistical mechanics using an extension of Eyring's theory. Experimental data of compressional flow of clay are found to agree with the calculated structural viscosity when the flow stress is less than the preconsolidation pressure or the upper yield value. Some important problems are discussed theoretically and experimentally; the relation between clay strength and water content, relation between failure strength and time lapse necessary for failure, and the variation in strength and flow. A stress-controlled compression test is proposed for measuring the yield value of clay.—*L. P.*

176–350. Handin, John, and Hager, Rex V., Jr. Experimental deformation of sedimentary rocks under confining pressure: tests at high temperature: Am. Assoc. Petroleum Geologists Bull., v. 42, no. 12, p. 2892–2934, 1958.

Short-time triaxial compression tests of dry anhydrite, dolomite rock, limestone, sandstone, shale, siltstone, slate, and halite single crystals under pressure-temperature conditions simulating depths down to 30,000 feet reveal the following.

1. Invariably an increase of pressure at constant temperature increases the yield stress, but an increase of temperature at constant pressure reduces it.

2. An increase of pressure at constant temperature always enhances the ultimate strength. However, heating at constant pressure may raise the ultimate strength by increasing the ductility of work-hardening rocks. More commonly heating lowers the ultimate strength by eliminating work-hardening, so that even though a rock is more ductile, it is weaker because its yield stress is reduced.

3. In any event for all materials tested except the halite, the ultimate strength at any simulated depth exceeds the crushing strength at atmospheric conditions. Below about 15,000 feet the strength of halite is less than that at the surface.

4. The effect of heating up to 300°C on the strength and ductility of anhydrite, dolomite, sandstone, and slate is small. However, the strength of

limestone, shale, and siltstone at room temperature exceeds that at 300°C by about 50 percent, and of halite by nearly 7 times.

Work in progress will more realistically simulate the natural environment of deeply buried rocks by introducing an independently controlled fluid pore pressure. It will be possible to assess the effects of confining pressure, pore pressure, and temperature separately and to predict the short-time deformational behavior of most sedimentary rocks for a wide variety of conditions.—*Authors' abstract*

176–351. Higgs, Donald V., and Handin, John. Experimental deformation of dolomite single crystals: Geol. Soc. America Bull., v. 70, no. 3, p. 245–278, 1959.

Jacketed cylindrical specimens of dolomite single crystals were deformed dry under a constant confining pressure of 5,000 bars at a strain rate of 1 percent per min at temperature from 24°C to 500°C. Uniaxial compression and extension experiments were carried out with the load oriented parallel to the optic axis, parallel to a horizontal axis, perpendicular to the cleavage, and parallel to an edge. In the first two orientations, unfavorable for basal translation, crystals loaded at temperatures below 400°C are brittle and fail on shear fractures inclined about 30° to the direction of greatest principal pressure; at 400°C and above they flow in compression and extension, respectively. In the last two orientations, favorable for translation gliding, large permanent deformations are achieved at all temperatures. Petrographic studies reveal details of the mechanism of this translation gliding for the different orientations.

The critical resolved shear stress for basal translation increased from about 900 kg per cm^2 at 24°C to about 1,200 kg per cm^2 at 400°C; this phenomenon is not well understood but may be somehow related to the magnesium ion. The critical resolved shear stress for f twinning decreases from at least 2,000 kg per cm^2 at 24°C to about 500 kg per cm^2 at 500°C. The critical stresses for twinning and translation are equal at 400°C, at which point twin gliding becomes important; at 500°C twin gliding on f $\{0\bar{2}21\}$ is the only operative mechanism, contrary to a well-established rule in metallurgy.—*D. B. V.*

SUBMARINE GEOLOGY

176–352. Moore, David G., and Shumway, George. Sediment thickness and physical properties: Pigeon Point shelf, California: Jour. Geophys. Research, v. 64, no. 3, p. 367–374, 1959.

A 200 sq mi area of the continental shelf off Pigeon Point, California (about 40 miles south of San Francisco), was studied in regard to the thickness and physical properties of unconsolidated sediments. Sediment thicknesses and water depths were determined by a high-power low-frequency echo sounder which acoustically penetrates unconsolidated sediments to record bedrock and other sub-bottom reflectors. Seventeen sediment sampling stations were made in the survey area. Determinations were made of wet density, porosity, compressional sound speed and absorption (at 20 to 30 kc per sec), static shear strength, sensitivity, and grain size distribution.

The Pigeon Point shelf is a gently sloping, featureless plain whose surface sediments are mainly unlithified sands and silts. Over much of the area these sediments are several tens of meters thick, but between the 40 and 50 fathom contours the sediments thin, and in the southern part of the area bedrock is

locally exposed on the sea floor. Bedrock surfaces beneath the sediment blanket form two prominent terraces believed to have been cut by wave action during lowered Pleistocene sea levels.—*Authors' abstract*

176–353. Maldonado-Koerdell, M. Recientes adelantos en geofísica e geología submarinas en las áreas del Océano Pacífico próximas a México [Recent advances in submarine geophysics and geology in the areas of the Pacific Ocean near Mexico]: Ciencia (Mexico), v. 18, no. 7–8, p. 105–113, 1958.

A review of the results of studies of submarine geology and crustal structure off the west coast of Mexico, of crustal structure under Mexico, and of volcanism related to the great submarine fracture zones of that part of the Pacific.—*D. B. V.*

176–354. Creager, Joe S. A canyon-like feature in the Bay of Campeche: Deep-Sea Research, v. 5, no. 2, p. 169–172, 1958.

A previously unknown canyon trending north-south for 85 miles on the eastern side of the Bay of Campeche in the southern Gulf of Mexico is described from soundings made in 1957 during a survey by the Department of Oceanography and Meteorology at Texas A. and M. College. The Campeche Bank escarpment forms the east wall and a possible submarine delta forms the west wall of the canyon, indicating a substantial seaward projection by sedimentation of the continental margins. Thus, the canyon floor may be an erosional feature modified by sedimentation or may reflect the original Gulf bottom.—*V. S. N.*

176–355. Ritchie, G. S. Sounding profiles between Fiji, Christmas and Tahiti Islands: Deep-Sea Research, v. 5, no. 2, p. 162–168, 1958.

Three sounding profiles made from Fiji to Christmas Island, Christmas Island to Tahiti, and Tahiti to Fiji during a voyage of the Royal New Zealand Naval Survey Ship *Lachlan* in 1956, are described. The topography revealed by the profiles is classified, according to Koczy (1954), into "plains", "hill districts", and "volcanic regions". Another topographic type, here called "mountainous district" is added to describe a mass of rugged features rising more than 5,000 ft above the level of the seabed along the profile from Fiji to Christmas Island.—*V. S. N.*

176–356. Besrukov, P. L., Zenkevich, N. L., Kanayev, V. F., and Udintsev, G. B. Podvodnyye gory i vulkany Kuril'skoy ostrovnoy gryady [Submarine mountains and volcanoes of the Kurile island ridge]: Akad. Nauk SSSR Lab. Vulkanologii Trudy, no. 13, p. 71–88, 1958.

Data gathered by the Russian oceanographic institute are compiled for 47 submarine volcanoes or mountains. Of these, 44 are situated on the crest or on the northwest flank of the Kurile ridge, and 3 on the bottom of the Kurile trough in the Sea of Okhotsk. Many of them are flat topped, usually mantled with sands and pebbles; this could be due to wave erosion, with subsequent subsidence where present depth is beyond the sphere of wave activity. The slopes of most submarine volcanoes correspond to those of the terrestrial cones in the Kuriles, without their summits.—*D. B. V.*

VOLCANOLOGY

176–357. Dauvillier, Aléxandre. Le volcanisme lunaire et terrestre, l'origine des continents, des océans et des atmosphères, l'énergie géothermique [Lunar and terrestrial volcanism, origin of the continents, oceans and atmospheres, geothermal energy]: Paris, Albin Michel, 300 p., 1958.

This book is one of a series "Sciences of Today". Stating that "to understand volcanism it is necessary to go back to cosmology," Dauvillier begins with a chapter on the evolution of the universe and origin of the solar system, in particular the earth-moon couple, then discusses their geochemical nature and the structure of the lithosphere. Geothermal energy and the chemical and physical evolution of the earth-moon system are also treated as background for the discussion of volcanism itself and its relationship to orogenesis. Finally, the relationship of volcanism to geomagnetism, life, and paleoclimatology are described briefly.—*D. B. V.*

176–358. Levchenko, S. V. Vulkanizm i magmaticheskiye gornye porody [Volcanism and magmatic rocks]: Moscow, Akad. Nauk SSSR, 104 p., 1958.

One of a popular science series, this little book has six chapters, devoted respectively to the earth's crust, contemporary volcanoes, the depths of the earth, volcanic rocks, "geologic monuments," and principles of volcanism.—*D. B. V.*

176–359. Gorshkov, G. S. Nekotorye voprosy teorii vulkanologii [Some questions of the theory of volcanology]: Akad Nauk SSSR Izv. ser. geol., no. 11, p. 21–27, 1958.

From the screening of transverse seismic waves received at the Kamchatka volcanological station, the active magma chamber of Klyuchevskaya volcano has been located at a depth of approximately 60 km, about at the boundary between crust and mantle. The shape of the shadow zone shows that the magma chamber must be a convex lens or a triaxial ellipsoid elongated in an east-west and flattened in a north-south direction. Its length and thickness are of the order of 25 or 35 km and its volume approximately 10,000 to 20,000 km^3. The true shape is probably more complicated, with offshoots and apophyses. The seismic evidence also rules out the possibility of a higher peripheral magma chamber, for there are no anomalies in waves traveling under the Klyuchevskaya group from local shallow foci (3 to 10 km) or from deeper foci (30 km) in Kamchatka and the Kuriles.

The velocity of converted waves through the magma is estimated as 1.6 to 1.8 kmps, close to the velocity of longitudinal waves in water or friable rocks. From this value and an assumed density of 3.4 g per cm^3 for the material in the chamber, its compression modulus K is calculated to be 1×10^{11} dynes per cm^2 or 1×10^5 bars, and the reciprocal compressibility β to be 10×10^{-6} bar^{-1}, between the values for a typical solid and typical liquid.

Location of magma chambers at the boundary between crust and mantle is far from accidental; it is just there that conditions are especially favorable for melting upon change of thermodynamic conditions, such as release of pressure on increase of temperature accompanying large tectonic breaks. The relationship of contemporary volcanism to zones of Alpine orogeny is a logical result,

but magma can reach the surface anywhere that there are deep fractures, as shown by the presence of recent volcanoes in platform and shield areas. The deep location of magma chambers also can explain the astonishing uniformity in composition of magmas over broad areas, and the differences in composition between oceanic, geosynclinal, and platform areas. Simultaneous eruptions of several volcanoes in one or more areas are due to deeper-seated, broadly regional or even planetary causes that are not yet entirely clear; that these are probably related to tectonic movements is suggested by the fact that intermediate earthquakes (60 to 100 km) frequently precede such simultaneous outbreaks. The formation of new volcanoes such as Parícutin or the awakening of dormant ones are also related to magma chamber processes, and are associated with intermediate earthquakes. Deep location of the magma chamber also narrows down possible explanations of certain volcanological problems; for instance, calderas cannot be due to collapse of magma chamber roofs, but probably to collapse of the walls of volcanic conduits weakened by explosions.—*D. B. V.*

176–360. Markhinin, E. K. O kolichestve yuvenil'noy vody, uchastvuyushchey v vulkanicheskikh vzryvakh [On the amount of juvenile water involved in volcanic explosions]: Akad. Nauk SSSR Doklady, v. 119, no. 3, p. 537–539, 1958.

Developing his previous paper (see Geophys. Abs. 174–355), Markhinin has derived a formula $E=10^8\times v\times x(2x^{0.3}-1)$ ergs, where E is energy, v is the volume of juvenile pyroclastic material, and x is the amount of juvenile gases formed in a volcanic explosion. A table for the values of v (from 10^9 cm^3 to 10^{16} cm^3) and for x (from 0.1 to 1.0 percent) is given. The formula makes it possible to determine the energy of a volcanic explosion, if the amount of juvenile pyroclastic material and the amount of volatiles are known. On the other hand, the amount of juvenile water involved in the explosion can be evaluated when the explosion energy is calculated by some other method. The amount of juvenile water in magma that is found to be sufficient to produce a volcanic explosion with formation of juvenile ash is 0.1 to 1.0 percent by weight.—*A. J. S.*

Lotze, Franz. Actuo-geological characteristics of the year 1957. See Geophys. Abs. 176–28.

176–361. Eaton, J[erry] P., and Fraser, George D. Hawaiian Volcano Observatory Summary 10: U.S. Geol. Survey Hawaiian Volcano Observatory Summary, no. 10, 9 p., 1958.

This report summarizes volcanic conditions on the island of Hawaii and lists the data for local and distant earthquakes recorded by seismographs on the islands of Hawaii and Maui for April, May, and June of 1958. Most of the 1,670 local earthquakes recorded originated in or near Kilauea caldera, were small, and had shallow foci. At Whitney station, gentle northerly tilting of the earth's surface during April replaced the gentle southerly tilting normal for that month; during May normal weak westerly tilting was recorded; and during June gentle easterly tilting replaced the gentle northerly tilting normal for that month.—*V. S. N.*

176–362. Gakkel', Ya. Ya. Priznaki sovremennogo podvodnogo vulkanizma na khrebte Lomonosova [Signs of contemporary underwater volcanism on Lomonosov's Ridge] : Priroda, no. 4, p. 87–90, 1958.

Available data indicate a seismically active zone along and near Lomonosov's Ridge in the Arctic Ocean. A submarine earthquake observed on November 21, 1957, by drifting station SP–3, was followed by a rupture of the ice pack (about 3 m thick), accompanied by a strong odor of hydrogen sulfide and sulfur dioxide, suggesting an underwater eruption. Drill cores obtained from the bottom of the Arctic in 1948–54 contained volcanic glass. The upper 5 cm of a core at lat 89°12′ N. (corresponding to 5,000 yr) consisted largely of volcanic glass which was not devitrified. Basaltic hornblende was abundantly distributed around the Ridge; at lat 88°23′ N. it represented 10.5 percent of the heavy fraction of the upper layer. The site of the suspected underwater volcano and the points on the sea floor where volcanic glass was discovered lie along the meridian which stretches through Shokal'skiy Strait to the Lower Taymyr River south, and to Ellsmere Island in the opposite direction, suggesting a deep and long fault passing close to the North Pole.—*A. J. S.*

176–363. Mooser, F., Meyer-Abich, H[elmuth], and McBirney, A[lexander] R. Catalogue of the active volcanoes of the world including solfatara fields: Part 6, Central America: Naples, Italy, Internat. volcanolog. Assoc., 146 p., 1958.

This volume gives name and location, form and structure, activity, petrography, and bibliography for the 55 volcanoes and solfatara fields of Central America including 13 in Mexico, 11 in Guatemala (1 is shared with Mexico), 12 in El Salvador, 12 in Nicaragua, and 7 in Costa Rica. Of these, 42 volcanoes have had recorded eruptions, 9 are in a solfataric or fumarolic stage, and 4 are solfatara or fumarole fields not belonging to a well-formed volcano.—*V. S. N.*

176–364. Maldonado-Koerdell, M. El Volcan Bárcena en la Isla San Benedicto, Archipelago de las Revillagigedo (Mexico) [Bárcena Volcano on San Benedicto Island, Archipelago of the Revillagigedos, Mexico] : Ciencia (Mexico), v. 18, no. 7–8, p. 114–123, 1958.

Bárcena Volcano was born at San Benedicto Island (Archipelago of the Revillagigedos), Mexico, on August 1, 1952, and its pumice cone reached a height of 1,200 ft above sea level in 12 days. Part of its activity was of the glowing-cloud type. After formation of a plug in the crater, a lava delta was extruded from a lateral fissure on the southeast slope. Except for a few fumarolic emissions all activity had ceased, and strong erosion had set in, by the end of 1953. Bárcena and other half-destroyed volcanoes on San Benedicto Island are considered to be parasitic craters on an older volcano, Mount Villalobos, on its northern tip.—*D. B. V.*

176–365. Servicio Geológico Nacional de Nicaragua. Observaciones sobre la actividad del volcan Cerro Negro de León [Observations on the activity of the volcano Cerro Negro de León] : Nicaragua Servicio Geol. Nac. Bol., no. 2, p. 9, 1958.

Cerro Negro volcano, 23 km north-northwest of the city of León in Nicaragua, began to erupt on September 4, 1957. A party which reached the vicinity on September 7 observed that activity was moderately explosive, with projection of practically solid lapilli and bombs either within the principal crater or in a

limited radius around it. A dark cloud of ash rose about 2,000 m above the cone. Moderately viscous acid lava flowed down the northeast slopes from the principal crater, and a second flow, fed from four adventitious craters, flowed toward the village of Malpaisillo 8 km away. Activity began to diminish on September 18 and ceased a few days later.—*D. B. V.*

176–366. Richard, J. J., and Neumann van Padang, M. Catalogue of the active volcanoes of the world including solfatara fields: Part 4, Africa and the Red Sea: Naples, Italy, Internat. volcanolog. Assoc., 118 p., 1957.

This volume gives name and location, form and structure, activity, petrography, and bibliography for the active volcanoes and solfatara fields of Africa subdivided into the following groups: volcanoes and solfatara fields of Ethiopia and the Red Sea; those of the African Lakes, East Africa; those of the Belgian Congo; and the volcano of Cameroon. Forty active areas are known, of which 17 are volcanoes known to have erupted in historic time, 19 are volcanoes in the solfataric or fumarolic stage, and 4 are fumarole fields not belonging to a well-formed volcano.—*V. S. N.*

176–367. Gèze, B[ernard]. The active volcanoes of Tibesti: Annex to the active volcanoes of Africa and the Red Sea: Naples, Italy, Internat. volcanolog. Assoc., 6 p., [no date].

Discusses the location, form and structure, volcanic activity, and petrography of Tousside and Tarso Voon volcanoes in the Northern Territory of Chad, French Equatorial Africa. A short bibliography is given for each volcano.—*V. S. N.*

176–368. Ducrot, Marcel. Le volcan de la Réunion (période 1952–1957) [The volcano of Réunion (period 1952–57)]: Madagascar Bur. Géol. Travaux, no. 88, 95 p., 1958.

Observations and photographs of activity of the volcano on Réunion Island in the Indian Ocean during the period 1952–57 are compiled. Eruptions began on May 30, 1952; March 14 and June 16, 1953; July 6, 1955; March 9 and December 30, 1956; and September 2 and October 21, 1957. Most of the eruptions lasted only a few weeks or 2 months. After the March 9, 1956, outbreak, activity was observed in the central crater on visits on April 1, September 9, and October 15. On the night of November 23–24, a fissure opened in the central crater and emitted about 200,000 m^3 of lava in 8 hr, or allowing for cavities, about 20,000 m^3 per hr. The second phase of the eruption of June–July 1956, although less abrupt, erupted about 26,250 m^3 of material per hour.—*D. B. V.*

176–369. Piyp, B. I. [editor]. Molodoy vulkanizm SSSR [Young volcanism of the USSR]: Akad. Nauk SSSR Lab. Vulkanologii Trudy, no. 13, 255 p., 1958.

The papers in this symposium on young volcanism in the U.S.S.R. were presented at a conference celebrating the twentieth anniversary of the Kamchatka volcanological station in 1955. Questions of contemporary volcanism in the Kamchatka-Kurile area and Cenozoic volcanism of Trans-Carpathia, Primor' (Maritime Territory), and northeastern U.S.S.R. were treated. Papers of geophysical interest are abstracted separately (see Geophys. Abs. 176–170, 356, 370, 373).—*D. B. V.*

176–370. Piyp, B. I. Osobennosti izverzheniya Klyuchevskoy Sopki [Features of the eruptions of Klyuchevskaya Peak]: Akad. Nauk SSSR Lab. Vulkanologii Trudy, no. 13, p. 99–119, 1958.

This paper is a compilation of information on the activity of Klyuchevskaya Peak, the most active volcano of Kamchatka. Paroxysmal eruptions occur on an average of once every 26 yr, with interparoxysmal eruptions at intervals of a few years. The character of its terminal and lateral (subterminal and eccentric) eruptions, lava flows, fumarolic activity, and volcanic earthquakes are described briefly.—*D. B. V.*

176–371. Pasechnik, I. P. Seysmicheskiye i vozdushnyye volny, voznikshiye pri izverzhenii vulkana Bezymyannyy 30 Marta 1956 g. [Seismic and atmospheric waves, originating during the eruption of Bezymyannyy volcano on March 30, 1956]: Akrad. Nauk SSSR Izv. ser. geofiz., no. 9, p. 1121–1126, 1958.

Bezymyannyy volcano on Kamchatka is only 14 km from the volcanological observatory on the flank of Klyuchevskaya Sopka. It showed no signs of activity until the year 1955. On March 30, 1956, an eruption of exceptional violence occurred. The atmospheric wave produced by this eruption was recorded by microbarographs at seismic stations in the U.S.S.R. at distances from 2,250 km to 46,480 km away. This wave traveled more than once around the earth with a velocity of 295 to 333 m per sec. The energy of this wave, computed from the records of different seismic stations by the method suggested by Whipple, was found to be 10^{23} ergs.

Seismic waves were also produced by this eruption. The focus of the earthquake was at or very near the surface; with an average magnitude $M=5$, its energy, calculated from the Gutenberg-Richter formula $\log E=11.8+1.5\,M$, was 10^{19} ergs.—*S. T. V.*

176–372. Gorshkov, G. S. Neobychaynoye izverzheniye na Kamchatke [An unusual eruption in Kamchatka]: Priroda, no. 1, p. 61–68, 1958.

An unusually violent eruption of Bezymyannyy volcano, one of the Klyuchevskaya group in Kamchatka, is described from the data of three field expeditions during the eruption period, which lasted from October 1955 to the late fall of 1956. The volcano had been inactive for several hundred years, and therefore was little known. The eruption was preceded by volcanic earthquakes beginning on September 29, 1955, with a few a day, increasing to dozens and even hundreds a day after October 9.

The first eruptive cloud appeared on October 22, followed by an ashfall. The eruption continued with gradually decreasing intensity until March 30, 1956, when a mighty explosion blew out the top of the volcano, lowering it by 150 to 180 m. An immense agglomerate lava stream was formed in the Sukhaya Khapitsa valley, with thousands of secondary fumaroles, resembling the Katmai lava stream in Alaska. The explosive energy was determined to be approximately 4×10^{23} ergs, the heat energy of the eruption about 3.6×10^{25} ergs, explosion velocity about 500 to 600 m per sec, and initial pressure 3,000 atm. It is interesting to note that although barographs around the world registered a distinct pressure wave from the explosion, no sound was perceived either close to or at a distance from the volcano.—*A. J. S.*

176–373. Gorshkov, G. S. Deystvuyushchiye vulkany Kuril'skoy ostrovoy dugi [Active volcanoes of the Kurile island arc]: Akad. Nauk SSSR Lab. Vulkanologii Trudy, no. 13, p. 5–70, 1958.

The 39 active volcanoes of the Kurile Islands are described individually. Besides these, which either have erupted or have shown fumarolic activity in historic times, seven others show signs of fairly recent activity. In all, 51 or 52 have been active during the past 10,000 or 12,000 yr. Roughly 60 percent are of the Somma-Vesuvius type, 13 percent are calderas, and 27 percent are solitary peaks. Eruptions have been of various types, predominantly vulcanian or strombolian, but never hawaiian. (See also Geophys. Abs. 173–365).—*D. B. V.*

Shima, Michiyasu. On the thermoelasticity in the semi-infinite elastic solid. See Geophys. Abs. 176–83.

Yokoyama, Izumi, and Tajima, Hirokazu. Gravity survey on the Kuttyaro caldera by means of a Worden gravimeter. See Geophys. Abs. 176–198.

176–374. Nakamura, Hisayoshi; Maéda, Kenjirō; and Suzuki, Takashi. On the hot springs in the southern and central parts of the Kii Peninsula [in Japanese with English summary]: Japan Geol. Survey Bull., v. 9, no. 5, p. 57–70, 1958.

Hot springs of the Kii Peninsula, southern Honshu, Japan, are divided into three types on the basis of chemical content: low Cl' and high HCO_3', low Cl' and HCO_3', and high Cl' and HCO_3'. Thermal waters with low Cl' content are believed to represent a deep volcanic hot spring, while those with high Cl' content are believed to be juvenile water formed at moderate depth and related to igneous activity of Tertiary quartz-porphyry.—*V. S. N.*

176–375. Nakamura, Hisayoshi. On regional properties of hot springs in Japan. 1. Hot springs distributed in younger volcanic areas [in Japanese with English abstract]: Jour. Geography (Tokyo), v. 67, no. 3 (709), p. 114–126, 1958.

In any study of the characteristics of hot springs in young volcanic areas, the following phenomena are important: volcanic gases are higher in HCl than fumarolic gases; hot springs in fumarolic areas or in the center of thermal activity in altered rock areas are of two types—the saline water type high in Cl' and the ground water type low in Cl'. It is probable that the Hcl in volcanic gases is dissolved in deep vadose water and also fixed as halide salts in the wall rocks en route to the surface from a volatile source. Hot springs in younger volcanic areas are influenced by shallow volcanic or fumarolic action in addition to the diffusing flow of volcanic or fumarolic gases through the mother rock and the ascending distance of the thermal water to the surface.—*V. S. N.*

176–376. Nakamura, Hisayoshi, and Maéda, Kenjirō. Thermal saline waters in Japan [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 9, no. 6, p. 41–50, 1958.

Thermal saline waters in Japan are classified in three groups on the basis of the Cl^{-1}/Br^{-1} ratio. The first group, with a ratio of 0.34, is emitted at the seashore; the second group with a ratio >0.34 is distributed throughout the Tertiary oil fields; and the third group with a ratio from 0.1 to 0.25 is associated

with Tertiary volcanic or hypabyssal rocks and granite areas. The saline waters of the third group are believed to be concentrated magmatic water formed at moderate depth and related to Tertiary volcanic activity, because of the similarity in ratio between this group and waters from hot springs in the younger volcanic areas.—*V. S. N.*

Watanabe, Kazue. Contribution to the thermodynamic analysis on the heat source of Obama hot springs in the vicinity of Unzen volcano district. See Geophys. Abs. 176–212.

Gregg, D. R. Reports of a submarine eruption off New Zealand in 1877. See Geophys. Abs. 176–43.

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