Geophysical Abstracts 169 April–June 1957

GEOLOGICAL SURVEY BULLETIN 1066-B

Geophysical Abstracts 169 April–June 1957

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

GEOLOGICAL SURVEY BULLETIN 1066–B

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

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1957

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 25 cents (single copy). Subscription price: $1 a year; 35 cents additional for foreign mailing. The printing of this publication has been approved by the Director of the Bureau of the Budget, March 5, 1956.

CONTENTS

GEOPHYSICAL ABSTRACTS 169, MAY-JUNE 1957

By Mary C. Rabbitt, 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) or of other papers presented orally at meetings unless summaries of substantial length are published. Abstracts of papers in Japanese and Chinese are based on abstracts or summaries in a western language accompanying the paper.

LIST OF JOURNALS

Full titles and abbreviations of journals cited for the first time in this issue (with the sponsoring organization and its address where these do not form part of the title) are given below. This list supplements the List of Journals published in Geophysical Abstracts 160 (January-March 1955, Bulletin 1033–A) and the supplements published in Geophysical Abstracts 161–168.

Akad. Nauk Azerbaydzhan. SSR Doklady—Akademiya Nauk Azerbaydzhanskoy SSR Doklady. Baku.

Akad. Nauk Kirgiz. SSR Inst. Geol. Trudy—Akademiya Nauk Kirgizskoy SSR Trudy Instituta Geologii. Frunze.

Akad. Nauk Kirgiz. SSR Izv.—Izvestiya Akademii Nauk Kirgizskoy SSR. Frunze.

Akad. Nauk SSSR Lab. ayerometodov Trudy—Akademiya Nauk SSSR Trudy Laboratorii ayerometodov. Moskva.

Akad. Nauk Tadzhik. SSR Doklady—Doklady Akademii Nauk Tadzhikskoy SSR. Stalinabad.

Akad. Nauk Tadzhik SSR Izv. otdel. yestestven. nauk—Akademiya Nauk Tadzhikskoy SSR Izvestiya otdeleniya yestesvennykh nauk. Stalinabad.

Alberta Soc. Petroleum Geologists Jour.—Journal of the Alberta Society of Petroleum Geologists. Calgary.

Bayerische Akad. Wiss. Sitzungsber., math.-naturw. Kl.—Sitzungsberichte der mathematisch-naturwissenschaftliche Klasse der Bayerischen Akademie der Wissenschaften. Munich.

Československý casopis pro fysiku—Ceskoslovenska akademie ved. Ustav technicke fysiky (Institute of Applied Physics, Czechoslovak Academy of Sciences). Praha.

Czechoslovakia Ústředni. ústav. geol. Věstník—Věstník Ústředního ústavu geologického. Nakladatelství Československé Akademie Ved. Praha.

Elisha Mitchell Sci. Soc. Jour.—Journal of the Elisha Mitchell Scientific Society. University of North Carolina Press, Chapel Hill.

Gold Coast Geol. Survey Bull.—Gold Coast Geological Survey Bulletin. Accra, Gold Coast.

Hesse Landesamt für Bodenforschung zu Wiesbaden Notizbl.—Notizblatt des Hessischen Landesamtes für Bodenforschung zu Wiesbaden. Wiesbaden.

Indian Minerals—Indian Minerals. Geological Survey of India. Delhi.

Japanese Jour. Geology and Geography—Japanese Journal of Geology and Geography. Science Council of Japan. Tokyo.

Kentucky Geol. Survey Special Pub.—Kentucky Geological Survey Special Publication. Lexington.

K. Nederland. Geol.-Mijnb. Genootschap Verh., geol. ser.—Verhandelingen van het Koninklijk Nederlandsch Geologisch-Mijnbouwkundig Genootschap, Geologische Serie. 's Gravenhage.

K. Nederlands Meteorol. Inst. Med. en Verh.—Koninklijk Nederlandsch Meteorologisch Instituut Mededelingen en Verhandelingen. 's Gravenhage.

Kumamoto Jour. Sci.—Kumamoto Journal of Science. Faculty of Science, Kumamoto University, Kumamoto, Japan.

Lab. Nac. Engenharia Civil [Portugal] Rept.—Laboratório Nacional de Engenharia Civil Reports. Ministério das Obras Públicas, Lisbon.

Leningrad Univ. Uchenyye Zapiski—Uchennye Zapiski Leningradskogo Ordena Lenina Gosudarstvennogo Universiteta. Leningrad.

Moskov. Geol.-Razved. Inst. im. Ordzhonikidze Trudy—Trudy moskovskogo geologo-razvedochnogo instituta im. Ordzhonikidze (Transactions of the Moscow geological prospecting institute of Ordzhonikidze). Moskva-Leningrad.

Neues Jahrb. Mineralogie Monatsh.—Neues Jahrbuch für Mineralogie Monatshefte. Stuttgart.

Norges Georg. Oppmåling, Geod. pub.—Norges Geografiske Oppmåling, Geodetiske arbeider (geodetic publication). Oslo.

NR Makedonija Geol. Zavod Trudovi—Geološkiot Zavod na Narodna Republika Makedonija Trudovi. Skopje.

Observatoire Ksara (Lebanon), Annales séismol.—Annales séismologiques de L'Observatoire de Ksara. Lebanon.

Ohio Geol. Survey Rept. Inv.—State of Ohio Department of Natural Resources Division of Geological Survey Report of Investigations. Columbus.

Petermanns geog. Mitt.—Petermanns geographische Mitteilungen Gotha, Germany.

Razvedka i okhrana nedr—Razvedka i okhrana nedr. Organ Ministerstva geologii i okhrany nedr SSSR Gosgeoltekhizdat. Moskva.

Razvedochnaya i promyslovaya geofizica—Razvedochnaya i promyslovaya geofizica. Ministerstvo neftyanoy promyshlennosti SSSR. Glavnoye upravleniye geofizicheskoy i geokhimicheskoy razvedki (Ministerium of the Pe-

troleum Industry of the U. S. S. R. central board of administration of geophysical and geochemical exploration). Moskva.

Smithsonian Contr. Astrophysics—Smithsonian Contributions to Astrophysics. Smithsonian Institution, Washington, D. C.

Soc. savantes Paris—°Cong. Comptes rendus, sec. sci.—Comptes rendus des Congrés des sociétés savantes de Paris et des départements, section des sciences. Paris.

Sovetskaya Geologiya—Sovetskaya Geologiya. Ministerstvo Geologii i Okhrany Nedr. Moskva.

Stromboli—Stromboli. Associazione internazionale dei vulcanologi. Messina, Sicily.

Tennessee Acad. Sci. Jour.—Journal of the Tennessee Academy of Science. Nashville.

Tōhoku Kozan—Tōhoku Kozan (Journal of the Tōhoku Mining Society). Tōhoku University, Sendai.

Versuchsanstalt für Wasserbau u. Erdbau [Zürich] Mitt.—Mitteilungen der Versuchsanstalt für Wasserbau und Erdbau an der Eidgenössischen Technischen Hochschule in Zürich. Zürich, Switzerland.

Vses. nauchno-issled. geol. inst. Materialy—Materialy Vsesoyuznogo nauchno-issledovatel'skogo geologicheskogo instituta. Moskva.

Vses. neft. nauchno-issled. geol.-razved. inst. Trudy, Geol. Sbornik—Trudy vsesoyuznogo neftyanogo nauchno-issledovatel'skogo geologorazvedochnogo instituta, Geologicheskiy Sbornik. Leningrad.

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 was given in Geophysical Abstracts 148 (January-March 1952, Bulletin 991–A). Titles of papers in Japanese and Chinese are given in translation only.

ABSTRACTORS

Abstracts in this issue have been prepared by Beryl T. Everett, R. G. Henderson, A. H. Lachenbruch, D. R. Mabey, Virginia S. Neuschel, and L. C. Pakiser, as well as by the principal aufhors. The notation "Author's abstract" followed by the initials of an abstractor indicates a translation of the author's abstract.

AGE DETERMINATIONS

169–1. Schumacher, E. Ein unterer Grenzwert für das Alter des Universums [A lower limit for the age of the universe]: Experientia, v. 13, fasc. 3, p. 104–105, 1957.

By using the half life of 5.0×10^{10} yrs for Rb^{87} obtained by Aldrich and others (see Geophys. Abs. 167–231), the strontium age of the Forest City chondrite is calculated to be 4.5 ± 0.4 billion years. This age confirms earlier determinations

on this meteorite (see Geophys. Abs. 167–5, 165–15), and establishes a lower limit for the age of the universe.—*D. B. V.*

169–2. Fireman, E. L., and Schwarzer, D. **Measurement of Li^6, He^3, and H^3 in meteorites and its relation to cosmic radiation**: Geochim. et Cosmochim. Acta, v. 11, no. 4, p. 252–262, 1957.

The He^3 contents of 6 iron and 5 stone meteorites, measured by neutron activation, range from 0.13 to 9×10^{-6} cm^3 per gram; the Li^6 contents of the stone meteorites, similarly measured, range from 1.1 to 6.2×10^{16} atoms per gram, whereas iron meteorites have less than 10^{14} Li^6 atoms per gram. No uniform relationship exists between Li^6 and He^3 contents, indicating that the He^3 contents in both stone and iron meteorites are due to spallation caused by high-energy cosmic rays rather than slow neutrons and that the average slow-neutron flux has been less than 1 neutron per cm^2 per sec. The H^3 contents of 3 iron meteorites at the time of their fall are $2.7\pm0.3\times10^6$ atoms per gram for the Norfolk, $5.9\pm1.2\times10^5$ for the Para de Minas, and less than 1.2×10^4 for the Charcas. The H^3 and He^3 content of the Norfolk indicate a cosmic-ray age of at least 0.9×10^9 yrs; if iron meteorites resulted from the breakup of a larger mass, the breakup must have occurred at least 0.9×10^9 yrs ago. Terrestrial iron contains small amounts of tritium but negligible He^3. The tritium content of iron meteorites compared with that produced in iron by high-energy proton bombardment gives the average flux of cosmic rays bombarding a meteorite in extraterrestrial space. The flux determined from the Norfolk meteorite equals the 1954 cosmic-ray flux which does not contain the low energy cut-off; the flux determined from the Para de Minas is lower by a factor of 3–6, indicating that this 112-kg meteorite was shielded from cosmic radiation by material ablated during its passage through the atmosphere, or it was irradiated by a smaller cosmic ray flux than the Norfolk.—*D. B. V.*

169–3. Houtermans, F. [G.] **Radioaktivität und Alter der Erde [Radioactivity and age of the earth]**: Naturw., Jahrg. 44, Heft 6, p. 157–163, 1957.

A view of methods and problems of dating the earth. The age of the crust, calculated on the basis of a model of the development of the isotope ratios in terrestrial lead, is $4.5\pm0.3\times10^9$ yrs. Lead determinations on stony meteorites agree with this figure. Iron meteorites contain too little uranium and thorium to permit use of the lead method; their helium content indicates an age as high as 7×10^9 yrs, but some of the helium may be produced by cosmic ray reactions. Four published lead 207/206 ages, six A^{40}/K^{40}, and one Rb^{87}/Sr^{87} determination on meteorites are cited.—*D. B. V.*

Voitkevich, G. V. Radiogeology and its significance for the knowledge of the history of the earth. See Geophys. Abs. 169–251.

169–4. Haxel, O. Geologische und archäologische Datierungen mit C^{14} [Geological and archeological dating with C^{14}]: Naturw., Jahrg. 44, Heft 5, p. 163–169, 1957.

A review of carbon–14 dating, including discussion of the origin and occurrence of carbon–14, the principles, techniques, sources of error, and limitations of the method, and some results.—*D. B. V.*

169–5. Barendsen, G. W. Radiocarbon dating with liquid CO_2 as diluent in a scintillation solution: Rev. Sci. Instruments, v. 28, no 6, p. 430–432, 1957.

Carbon dioxide obtained by combustion of the sample can be used for radiocarbon dating, without any further chemical conversion, as a diluent in a scintillation solution. As much as 80 percent by weight CO_2 can be dissolved in toluene+5 g per l diphenyloxazole (PPO); the presence of CO_2 in the scintillator, however, interferes with the light emission, so that the percentage of CO_2 that can be used effectively is limited to 30 percent.—*M. C. R.*

169–6. Antevs, Ernst. Geological tests of the varve and radiocarbon chronologies: Jour. Geology, v. 65, no. 2, p. 129–148, 1957.

Estimates of time since the Valders glacial maximum at Milwaukee, based on geologic field data, are as follows: post-Nipissing age, 3,500 years; post-North Bay drainage or post-Pembroke age, 14,500 years; and post-Valders age, 18,000 or 19,000 years. These estimates support varve chronology and indicate that C^{14} dates for the Nipissing Great Lakes are of the right magnitude but that most older dates become progressively too young so that the C^{14} date for the Two Creeks forest bed is several thousand years too young. Possibly contamination of the original radiocarbon becomes increasingly effective as the original radiocarbon is reduced by natural decay. Several C^{14} determinations in one bed do not necessarily certify the age because of agreement, because an organic layer such as the Two Creeks forest bed can be expected to have undergone about equal extra changes and several analyses check one another but not the actual age of the sample.

All C^{14} dates should be checked for general reasonableness and weighed against geologic knowledge. The C^{14} chronology and its correlation with Europe have unreasonable geologic and climatic implications, whereas the varve chronology synchronizes the major temperature ages in North America and Europe. (See also Geophys. Abs. 163–147.)—*V. S. N.*

169–7. Leighton, Morris M. Radiocarbon dates of Mankato drift in Minnesota: A discussion; Wright, H. E., Jr. A reply: Science, v. 125, no. 3256, p. 1037–1039, 1957 .

Leighton agrees with Wright and Rubin's dating (Geophys. Abs. 167–14), on the basis of C^{14} ages, of the Mankato as pre-Two Creeks but believes that Mankato should be retained as a Wisconsin substage younger than Cary and would continue to follow the Wisconsin classification suggested in his recent paper (Jour. Geology, v. 65, no. 1 1957): Farmdale, Iowan, Tazewell, Cary, Mankato, Valders. Wright reports that a recent C^{14} date from glacial Lake Aitkin indicates that his Superior-lobe Valders would be better dated as "late Mankato" and thus the red clay till of northeastern Minnesota must reflect a pre-Two Creeks readvance of the Superior lobe. He is willing to retain the term Mankato as Leighton suggests in hopes that the correlation of the Mankato drift of the Des Moines lobe with the Port Huron of Lake Michigan and Huron lobes will be more strongly confirmed in the future.—*V. S. N.*

169–8. Karlstrom, Thor N. V. The problem of the Cochrane in late Pleistocene chronology: U. S. Geol. Survey Bull., no. 1021–J, 27 p., 1956.

Carbon-14 dating of samples from the Cochrane area in northern Ontario, Canada, indicate the area may have been under a continuous ice cover from

before 36,000 until some time before 4,500 B. C.; this conforms with the radiocarbon dates of the intervening substage events of the Wisconsin glaciation. The results also indicate that the Cochrane preceded rather than followed the Altithermal climatic period and suggest that the Cochrane be considered a Wisconsin event of substage rank. Geoclimatic data give a record of glaciation and eustatic sea level low between 7,000 and 4,500 B. C. which would seem to correlate with the Cochrane as a post-Mankato, pre-Altithermal period.

The correlation of the Cochrane with the Fennoscandian in North American varve chronology seems to be untenable as many radiocarbon dates independently support the European Fennoscandian varve date of 8,800–8,100 B. C., the correlation of the Mankato with the Fennoscandian substage of European chronology, and the correlation of the Cochrane with post-Fennoscandian climatic events.—*V. S. N.*

169–9. Rigg, George B., and Gould, Howard R. Age of Glacier Peak eruption and chronology of postglacial peat deposits in Washington and surrounding areas: Am. Jour. Sci., v. 255, no. 5, p. 341–363, 1957.

A layer of volcanic ash in 200 or more postglacial peat bogs of Washington and in alluvium and bogs of Idaho, Montana, southern Alberta, and British Columbia, has been traced to a short, single eruption of Glacier Peak in the Cascade Range of north-central Washington. A carbon-14 date of 6,700 yrs for peat immediately underlying the ash at two places serves as a prime reference for an absolute chronology of postglacial events in a wide area of the Pacific northwest.

Carbon-14 analysis of peat on glacial outwash at the bottom of two bogs and in bottom sediments of Lake Washington date the withdrawal of the Vashon ice sheet from west-central Washington at more than 13,650 yrs ago. The Vashon recession is, however, dated only as pre-Mankato because of the large time lapse between ice retreat and peat formation.—*V. S. N.*

169–10. Straka, H. Zwei C^{14}-Bestimmungen zum Alter der Eifelmaare [Two C^{14} determinations of the age of the Eifelmaar]: Naturwiss. Rundschau, Jahrg. 10, Heft 3, p. 109–110, 1957.

Two carbon-14 determinations made at Gröningen on a mud from a borehole in volcanic deposits at the Eifelmaar yield ages of 10,770±240 yrs (see Geophys. Abs. 164–16) and 10,550±100 yrs, respectively, confirming earlier pollen analysis dating of 10,000 to 11,000 yrs.—*D. B. V.*

169–11. Brannon, H. R., Jr., Simons, L. H., Perry, D., Daughtry, A. C., and McFarlan, E., Jr. Humble Oil Company radiocarbon dates II: Science, v. 125, no. 3254, p. 919–923, 1957.

Carbon-14 ages are given for 59 samples, most of which were collected from deposits that mark different stages in the development of southern Louisiana and the adjacent continental shelf between the time of the beginning of the last major glacial advance and the present. Three units of time, which correspond to portions of the cycle of sea-level change brought about by the growth of the Late Wisconsin ice masses and their subsequent deterioration, are recognized in this region. Ages are given for samples from deposits laid down during the periods of standing sea level and of rising sea level. Samples selected to establish the age of the basal deposits were too old for the C^{14} method.—*M. C. R.*

169–12. Volchok, Herbert L., and Kulp, J. Laurence. The ionium method of age determination: Geochim. et Cosmochim. Acta, v. 11, no. 4, p. 219–246, 1957.

The ionium method of age determination (based on the decay of ionium to equilibrium with its parent), potentially applicable to deep-sea sediments less than about 300,000 years old, has been studied to define its validity and limitations. The sediment column must be undisturbed chronologically and homogeneous with regard to chemisorption potential. Several cores from the Atlantic and Pacific Oceans and Caribbean Sea were studied by total radium and gas-phase radon measurements with a low-level ionization chamber, total α-emission by scintillation counting, and absolute surface area determination by gas adsorption. Complete age analyses were carried out on a red clay core from the Pacific and globigerina ooze core from the Caribbean. The accuracy of dating was found to depend on accuracy of radium determination and frequency of samples along the core. Rates of sedimentation can be calculated with fair precision. For the red clay the rate was fairly constant (0.15 ± 0.05 cm per 1,000 yrs) from 200,000–300,000 to 30,000–40,000 years ago, for the globigerina ooze similarly constant (0.60 ± 0.20 cm per 1,000 yrs) in the same period; at the close of Wisconsin time the sedimentation rates of both cores increased by factors of 2 to 4. Comparison of ionium ages with carbon-14 ages for several samples in one core show satisfactory agreement.—*D. B. V.*

169–13. Starik, I. Ye. Rol' vtorichnykh protsessov pri opredelenii vozrasta porod radioaktivnymi metodami [The effect of secondary processes in the age determination of rocks by radioactive methods]: Geokhimiya, no. 5, p. 18–29, 1956.

The main sources of errors and discrepancies in radioactive determinations of the age of minerals are leakage of the primary radioactive components by emanation into the surrounding material and leaching of the secondary products of disintegration. Study of these two processes in uraninite and monazite shows that the migrating properties of the different radioelements can be distributed in a series in which Ra>Ac>U>Pb>Th. The error from leaching of the secondary products of distintegration will be least when the Pb^{207}/Pb^{206} or Pb^{208}/Th^{232} ratios are used, because these ratios are of different isotopes of the same element or of elements situated very near each other in the series. The lead method is considered to be the most reliable method of geologic age determination.—*S. T. V.*

169–14. Kulp, J. Laurence, and Eckelmann, Walter R. Discordant U–Pb ages and mineral type: Am. Mineralogist, v. 42, no. 3–4, p. 154–164, 1957.

The discordant ages obtained from the isotopic ratios in different minerals (pitchblende, uraninite, monazite, zircon, samarskite, euxenite, microlite, thorite, yttrotantalite, columbite-tantalite, biotite-xenotime, sphene, and thucolite) are considered in terms of the mineral type. Each mineral structure seems to show a consistent but characteristic discordance except monazite, which exhibits a dual behavior. All minerals can give concordant ages if adequately preserved. The 207/206 age is the best first approximation of the true age for all of these minerals and will almost always be minimal. If several samples of 2 or 3 mineral types from a given locality can be analyzed, it is possible to assign an age within fairly narrow limits. On this basis, despite discordance, the following ages are very likely: Romteland, Norway, $920\pm20\times10^6$ yrs; Huron

Claim, Manitoba, $2{,}600\pm100\times10^6$ yrs; Black Hills, South Dakota, $1620\pm20\times10^6$ yrs; and Wilberforce, Ontario, $1{,}060\pm20\times10^6$ yrs. The particular mechanism of removal of radiogenic lead in nature still must be determined and related quantitatively to mineral structure.

New isotopic ages (206/238, 207/235, 207/206, and 208/232) published in this paper include uraninite, thorite, and euxenite from Romteland, Norway; uraninite from Huron Claim, Manitoba; yttrotantalite from Swaziland, Africa; and euxenite from Kalstad, Norway.—*D. B. V.*

160–15. Russell, R. D., and Ahrens, L[ouis] H. Additional irregularities among discordant lead-uranium ages: Geochim. et Cosmochim. Acta, v. 11, no. 4, p. 213–218, 1957.

The 206/238 and 207/235 ratios are linearly related in 12 samples of pitchblende from the west ore body of the Ace Gold Mine at Goldfields, Saskatchewan. Wetherill's explanation (see Geophys. Abs. 167–28) that such linearity is due to chemical removal of lead leads to an apparent relationship between the time of chemical removal of lead and the age of the mineral. A preferential deficiency (9 percent) of Pb^{207} over Pb^{206} in specimens participating in the linear relationships suggests physical rather than chemical control of lead escape. One possible process involves recoil of atoms following α-particle emission. A convergent age of $1{,}800\times10^6$ yrs is found for the west ore body of the Ace Mine.—*D. B. V.*

169–16. Zykov, S. I., and Stupnikova, N. I. Opredeleniye vozrasta pegmatitovoy zhily Koyta-Tundra po tsirtolitu, ortitu i uraninitu [The determination of the geologic age of a pegmatite vein in Koyta-Tundra using cyrtolite, orthite, and uraninite methods]: Geokhimiya, no. 8, p. 35–38, 1956.

The age of a pegmatite vein in northern Karelia. Uranium, thorium, and lead content of cyrtolite, orthite, and uraninite from the vein were determined by radiometric and colorimetric methods. The possible effect of secondary processes involving different isotopes of lead were studied by experiments on leaching of isotopes from orthite and cyrtolite by solutions of ammonium acetate and acetic acid. The isotopic composition of lead was determined by a mass-spectrometer and the age calculated from the ratios of Pb^{207}/Th^{206}, Pb^{206}/U^{238}, Pb^{207}/U^{235}, and Pb^{208}/Th^{232}, as $(1820\pm100)\times10^6$ years.—*S. T. V.*

169–17. Hée, Arlette, Coche, André, Jarovoy, Michel, and Kraemer, Robert. Sur l'age absolu de deux granites de la chaîne des Vosges [On the absolute age of two granites from the Vosges range]: Acad. Sci. Paris Comptes Rendus, tome 244, no. 7, p. 922–923, 1957.

The absolute age of two granites from the Champ du Feu massif in France has been determined by the lead-alpha zircon method (see Geophys. Abs. 154–14732). The ages of three samples of the Natzwiller granite were found to be 320, 305, and 295 million years (±20 million), and of two samples of the Andlau granite, 215 and 250 million years (±25 million). Measurements on other granites from the same massif are in progress.—*D. B. V.*

169–18. Hée, Arlette, and Flesch, Louis. Âge absolu apparent des zircons d'Espaly (Haute-Loire) [Apparent absolute age of the zircons from Espaly (Haute Loire)]: Acad. Sci. Paris Comptes Rendus, tome 244, no. 13, p. 1796–1798, 1957.

The uranium and thorium content of the zircons that are abundant in the sands of a stream near Espaly, Haute Loire, France, have been determined by the scintillation spectrometer (1 sample), and by the ionization chamber (2 samples); the average age calculated from these measurements is $140 \pm 20 \times 10^6$ yrs. According to Holmes' time scale, the undoubtedly Miocene basalt with which the zircons are associated is 30×10^6 yrs old, and according to a helium determination by Rayleigh the zircons are only 6.3×10^6 yrs old (probably a minimum age owing to helium escape). The discrepancy is explained by the fact that the zircons are older than the basalt, having been present originally in a granulite that was destroyed by the flows. This granulite may have been even older than 140 million years, as some superficial atoms of radiogenic lead could have been lost during the heating and melting to give a low apparent absolute age. Determinations on remnants of the original rock containing intact zircons should clarify this aspect of the problem.—*D. B. V.*

169–19. Roques, Maurice, and Thiebaut, Jean. Sur l'age âbsolu des migmatites du massif du Saint-Barthélemy, dans les Pyrénées ariègeoises [On the absolute age of the migmatites of the Saint Barthélemy massif, in the Pyrenees of Ariège]: Acad. Sci. Paris Comptes Rendus, tome 244, no. 9, p. 1229–1230, 1957.

The absolute age of the debated migmatites from the Saint Barthélemy massif in the Pyrenees has been determined by the lead-alpha zircon method. Two samples are 235 and 210 million years old ±10 percent; these ages confirm Raguin's dating of the migmatites as Carboniferous.—*D. B. V.*

169–20. Ledent, D. Détermination de l'âge absolu des pechblendes de Kalongwe et Luishya (Katanga-Congo belge) [Determination of the absolute age of the pitchblendes from Kalongwe and Luishya (Katanga, Belgian Congo)]: Soc. Belge Géologie Bull., tome 65, fasc. 2, p. 230–233, 1956.

The ages of 3 pitchblendes from Katanga, Belgian Congo have been determined as follows: 207/206—600, 610, and 605×10^6 yrs; 206/238—660, 670, and 610×10^6 yrs; and 207/235—640, 650, and 615×10^6 yrs. The discrepancy between the lead-lead and lead-uranium ages in the first two, both from Kalongwe, indicates loss of uranium in their recent geologic history; the excellent concordance between the ages in the third, from Luishya, reflects its excellent state of preservation. It is concluded that the periods of mineralization at Luishya and Kalongwe are both about 605 million year and undoubtedly contemporaneous with that of Shinkolobwe; this confirms the geologic evidence.—*D. B. V.*

169–21. Ledent, D., Picciotto, E. [E.], and Poulaert, G. Détermination de l'âge de l'yttocrasite de Mitwaba (Katanga) par la méthode au plomb. I.—Mesures chimiques [Determination of the age of the yttrocrasite from Mitwaba (Katanga) by the lead method. I.—Chemical measments]: Soc. Belge Géologie Bull., tome 65, fasc. 2, p. 233–250, 1956. Eberhardt, P[eter], Geiss, J[ohannes], Gunten, H. R. von, Houtermans, F. G., and Signer, P. Mesure de l'âge de l'yttrocrasite de Mitwaba (Katanga) par la méthode au plomb. II.—Mesures isotopiques [Measurement of the age of the yttrocrasite from Mitwaba (Katanga) by the lead method. II—Isotopic measurements (with discussion)]: Soc. Belge Géologie Bull., tome 65, fasc. 2, p. 251–256, 1956.

The first paper is a detailed description of the analytical procedure used in determining the concentrations of Pb, U, and Th in the yttrocrasite from Mitwaba, Katanga, Belgian Congo. The analysis was made by using organic solvent and colorimetric and polarographic methods on a few milligrams of sample. The results were: Pb=0.90±0.01 percent, U=3.3±0.1 percent, Th=7.3±0.1 percent. In the second paper the isotopic composition is discussed and the age calculated from the different ratios. The 207/206, 206/238, and 207/235 ages are concordant within the limits of experimental error (1,045, 1,130, and 1,100±50×10^6 yrs., respectively), showing that the mineral has not lost Pb^{206} or Pb^{207} or uranium. The low 208/232 age (725±50×10^6 yrs) may represent selective loss of Pb^{208}. The ages are also calculated according to the Pb^{210} (RaD)/Pb^{206}, Pb^{210}/Pb^{207}, and Pb^{212} (ThB)/Pb^{208} ratios as 1,106±50, 1,087±50, and 950±150×10^6 yrs, respectively. It is concluded that the absolute age of the mineral is between 1030 and 1130 million years.—*D. B. V.*

169–22. Deutsch, S[arah], Hirschberg, D., and Picciotto, E. [E.] Étude quantitative des halos pléochroiques.—Application à l'estimation de l'âge des roches granitiques [Quantitative study of pleochroic halos.—Application to the estimation of the age of granitic rocks]: Soc. Belge Géologie Bull., tome 65, fasc. 2, p. 267–281, 1956.

New results of relative age measurements by means of pleochroic halos, on 94 samples from 15 granites of known geologic age, are given together with details of experimental procedure. For each halo the optical density (the mean of several photometric profiles) is plotted as a function of total α-radiation per cm^2 and of specific α-activity per cm^2 per sec. For each age group, the points are distributed about the same straight lines calculated in the preliminary study (see Geophys. Abs. 164–25). The California granites of Cretaceous age fall between the Alpine and Hercynian granites; those from Scotland seem consistently too old, probably because of experimental error; the two granites of Precambrian age give aberrant ages. A check of the sensitivity of the various biotites by means of artificial radiation shows that the last are abnormally sensitive, explaining the anomalous ages. Such artificial irradiation measurements must necessarily accompany all determinations by the pleochroic halo method.—*D. B. V.*

169–23. Stevens, J. R., and Shillibeer, H. A. Loss of argon from minerals and rocks due to crushing: Geol. Assoc. Canada Proc., v. 8, pt. 1, p. 71–76, 1956.

Some discrepancies in ages obtained from mica and feldspar can be related to loss of argon in crushing the feldspar. From study of five thin sections, two of feldspars that had apparently lost argon, it is hypothesized that the loss of argon is related to partial metasomatic replacement of a homogeneous potash feldspar in which argon-40, formed before the alteration, escaped with the carrier. The finer structure of the adjacent microcline is weak and gradually releases argon when crushed.—*M. C. R.*

169–24. Aldrich, L. T., Wetherill, G[eorge] W., and Davis, G. L. Occurrence of 1,350 million-year-old granitic rocks in western United States: Geol. Soc. America Bull., v. 68, no. 5, p. 655–656, 1957.

Potassium-argon and rubidium-strontium ages of micas from 11 granites and pegmatites in Arizona, New Mexico, Colorado, and Wyoming are all about 1,350 million yrs (error <5 percent), indicating a widespread crystallization of granitic rocks at that time.—*B. T. E.*

EARTH CURRENTS

169–25. González-Miranda, Luis de Miguel. Tormentas en corrientes telúricas [Telluric current storms]: Rev. Geofísica, año 15, no. 58, p. 149–165, 1956.

Disturbances recorded by telluric current instruments coincide in time with magnetic storms. Both sudden and gradual commencements are described. In the telluric current storms the amplitude of rapid variations is great but the mean value is almost constant, whereas in magnetic storms, rapid variations of smaller amplitude are superposed on a greatly varying mean value. The paper ends with a review of theories on the origin of magnetic storms, and the hope that earth current observations during the International Geophysical Year will contribute toward the solution of some of the problems of geomagnetism and solar activity.—*D. B. V.*

169–26. Enenshteyn, B. S., and Aronov, L. Ye. Eksperimental' nyye issledovaniya yestestvennogo elektromagnitnogo polya zemli v spektre chastot ot 2 go 300 gts [Experimental investigations of the natural electromagnetic field of the earth within the spectrum from 2 to 300 cycles per second]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 1, p. 62–70, 1957.

Field measurements were made of the intensity and the composition of the spectrum of natural electromagnetic oscillations. It was possible to measure and to record simultaneously five field vectors, two electric and three magnetic. The apparatus could be tuned to any frequency from 2 to 300 cycles per sec. Oscillations of the natural geomagnetic field of an average amplitude of 30–50 microvolts per kilometer of traverse were found. Further investigations may disclose whether these oscillations are local or regional.—*S. T. V.*

169–27. Namba, Munetosi. Earth current at Khailar. Part 13 *of* Some studies on Volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 2, no. 2, p. 134–157, 1955.

A tabulation of observed data for 1942.—*M. C. R.*

EARTHQUAKES AND EARTHQUAKE WAVES

169–28. Gryglewicz, Zofia, and Wojtczak, Bożenna. Aktyw-ność sejsmiczna w 1954 r. [Seismic activity in 1954]: Acta Geophys. Polonica, v. 3, no. 3, p. 131–137, 1955.

A discussion of the earthquakes of intensity greater than VIII (Mercalli-Sieberg scale) or of magnitude 6.5 or more as recorded at stations in Poland.—*M. C. R.*

169–29. Due Rojo, Antonio. Notas sísmicas de 1955 [Seismic notes, 1955]: Rev. Geofísica, año 15, no. 58, p. 189–193, 1956.

A review of world-wide seismic activity during 1955, including brief descriptions of the most severe earthquakes (Greece and Aegean Sea, all year but particularly on April 19 and 21; Long Beach, California, and La Vela, Venezuela in January; Quetta, Pakistan, in February; the Philippine Islands in March and April; western China, and off the coast of Chile in April; Chile and Tokushima, Japan in July; and Costa Rica in September), numerical distribution of magnitudes of 5 and over, depth of shallow (<50 km) earthquakes, and a world map of epicenters.—*D. B. V.*

169–30. Lotze, Franz. Aktuo-geologische Charakteristik des Jahres 1955 [Actuo-geological characteristics of the year 1955]: Neues Jahrb. Geologie u. Paläontologie Monatsh., Jahrg. 1956, Heft 12, p. 545–553, 1957.

The foci of 248 of the 788 earthquakes recorded in central Europe during 1955 were determined; 93 were in Europe including the Mediterranean, 14 in the Atlantic and Arctic, 27 in Asia, 94 on the southwestern, western, and northern Pacific border, and 20 on the eastern Pacific border. At least 39 were of magnitude 6 or more, according to Pasadena. The foci of 34 were more than 50 km deep, and 13 were more than 200 km; most of the latter were along the southwestern, western, and northern Pacific border, but one was in the Hindu Kush and another in Mexico. The Philippine earthquake of March 31 killed 340 persons and injured 2,000; the series of shocks in Greece in April killed 14 and injured 150; 12 were killed and 30 were injured in West Pakistan in February; 39 were killed and 113 were injured in southwestern China on April 14; and on December 9, 25 were killed and 90 were injured in Egypt.

Volcanic activity in 1955 included the eruption of Kilauea at the end of February; the eruption of 500,000 m^3 of lava from Etna in July and August and strong activity in a side crater in October and November; the activity of Merapi, Java, beginning in August and becoming dangerous by October; strong eruptions in the Chilean Andes in August; sudden emission of hot rock fragments and sulfur gas from a fissure of Mexicali in Mexico, in September; and renewal of activity at Asama, Japan, calm the second half of the year, in mid-December.—*D. V. B.*

169–31. MacCarthy, Gerald R. A marked alignment of earthquake epicenters in western North Carolina and its tectonic implications: Elisha Mitchell Sci. Soc. Jour., v. 72, no. 2, p. 274–276, 1956.

A study of recorded earthquakes in western North Carolina reveals eleven whose epicenters fall in a straight line trending in a northeasterly direction across western North Carolina and into Virginia. The line is parallel to and west of the Blue Ridge front and could represent a zone of tectonic movement genetically related to the greater Blue Ridge fault.—*V. S. N.*

169–32. Moneymaker, Berlen C. Earthquakes in Tennessee and nearby sections of neighboring states: Tennessee Acad. Sci Jour., v. 32, no. 2, p. 91–105, 1957.

Brief accounts of all known earthquakes in this area from 1901 through 1925.—*V. S. N.*

169–33. Byerly, Perry. Seismicity of the Western United States: World Conference on Earthquake Engineering Proceedings, p. 1-1—1-9, Berkeley, Calif., June 1956.

A review of the relative seismicity of the western states and description of a few of the most notable earthquakes. Except for California the area is only moderately seismic. On the basis of earthquake history, which covers only about 100 years, California, Nevada, Utah, and Washington are the most seismic states. The aseismicity of Oregon is anomalous. A remarkable fact is that the area has no shocks of intermediate or deep focus.—*B. T. E.*

169–34. Mihailović [Mikhailovik'], J[elenko]. Seizmološka karakteristika na terenot na Jugozapadna i Juzhna Makedonija [Seismicity of southwestern and southern Macedonia]: NR Makedonija Geol. Zavod Trudovi, svazek 5, p. 13–20, 1956.

Macedonia has high seismicity, especially in its southern and southwestern parts. Mihailović discusses briefly the most violent earthquakes in different parts of Macedonia, especially those which have occurred since 1870. Several of these earthquakes had an intensity of XI. The study seems to be based on noninstrumental data.—*S. T. V.*

169–35. Shalem, N[athan]. The tremor of the 13th September, 1954, (and the instrumental research from January 1954–June 1955): Israel Geol. Survey, Water Planning for Israel Ltd., 15 p., 1955.

On September 13, 1954, an earthquake of magnitude 4 occurred near Wadi Sirhan Rift along the frontier between Saudia Arabia and Transjordan and was followed by several others on September 14 and 15. The 1954 earthquakes made it evident that the bulk of the seismic areas of Palestine are on Erythrean lines, NW–SE lines parallel to the Red Sea. Present instrumental records of 1½ years duration from seismographs at Jerusalem and Safad are not sufficient for an analysis of seismicity in Palestine.—*V. S. N.*

169–36. L'observatoire de Ksara (Liban). Le séisme libanais du 16 mars 1956 (nouvelle étude) [The Lebanon earthquake of March 16, 1956 (new study)] Observatoire (Ksara (Lebanon) Annales séismol., année 1956, cahier 1, p. 9–15, 1956–57.

This earthquake had an intensity of 9–10 (Mercalli scale of 12) at the epicenter, which was located at Azour. The depth of focus was calculated as 20 km. Radio disturbance (between 10–20 wave lengths) was reported by a radio amateur as having occurred for 5 minutes preceding the earthquake. On a gravity profile made in 1954 two peculiar anomalies were noted across the epicentral area. The earthquake seems to be associated with the Erythraean orogeny, as are those in Palestine. On the other hand, it was propagated chiefly along the axes of the folds of Lebanese orogeny. The epicenter is located at the junction of the directions.—*B. T. E.*

169–37. Gzovskiy, M. V. Tekonofizicheskoye obosnovaniye geologicheskikh kriteriev seysmichnosti, I. [Tectonophysical basis of the geologic criteria of seismicity. Part I]: Akad. Nauk SSSR Izv. Ser. geofiz. no. 2, p. 141–160, 1957.

Earthquakes are caused by tectonic breaks occurring in the process of deformation of the structural elements of the crust and the mantle. The immediate cause of earthquakes is thus the initiation of new faults or renewed activity of old ones along the seismic seams which ordinarily have strength lower than the surrounding formations. Study of past earthquakes shows that these ruptures and the resulting earthquakes are produced in the regions of greatest tangential stresses. Longitudinal ruptures do not produce great seismic effects.

The regions of great tangential stresses can be traced by past violent earthquakes, or by continuous weak earthquakes (seismic "cracking"), by abrupt changes in the elastic properties of the ground as shown by changes in the seismic velocities, by local magnetic discontinuities, or, finally, by subcrustal movements determined on the surface by inclinometers.

435144—57——2

Determination of the stresses in the deep layers of the earth will make possible the localization of the regions of the highest tangential stresses and increase of these stresses will indicate the approach of seismic shocks.—*S. T. V.*

169–38. Andreyev, S. S. O seysmicheskoy kharakteristike russkoy platformy [Seismic characteristics of the Russian platform]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 12, p. 1484–1487, 1956.

Earthquakes occurring within the Russian Platform are usually considered to have originated in the adjoining seismically active Alpine, Fennoscandian, and Ural regions. The few earthquakes which originated within this region are attributed to rock bursts, cave-in of sink holes, or similar phenomena. From study of 76 earthquakes during the last 150 years, however, it is concluded that there have also been several earthquakes of tectonic origin of maximum intensity of VI to VII. Noninstrumental records indicate the earthquakes had deep foci. The most seismically active zone of the Russian Platform is the Baltic Shield; less active is the Voronezh plateau.—*S. T. V.*

169–39. Kuznetsov, V. P. Ob odnoy osobenosti Shemakhinskikh ochagov zemletryaseniy, vyzyvayushchey nesoglasiya v opredeleniya koordinat epitsentrov [Certain peculiarities of the foci of Shemakha earthquakes, causing discrepancies in the determination of the epicentral coordinates]: Akad. Nauk Azerbaydzhan. SSR Doklady, tom 12, no. 9, p. 611–615, 1956.

The rather numerous earthquakes in the region around Shemakha are characteristically of shallow focal depth. Several have been located at depths within the sedimentary formations. The resulting diffraction of the seismic waves is noticeable even at relatively short epicentral distances and changes the spectrum of the waves reaching different stations. Correlative analysis of individual waves is necessary to find the position of the focus.—*S. T. V.*

169–40. Byus, Ye. I., and Rubinshteyn, M. M. O kharaktere seysmicheskoy aktivnosti yuzhnogo sklona Bol'shogo Kavkaza [The nature of seismic activity of the southern slope of the Greater Caucasus]: Akad. Nauk Gruzinskoy SSR Soobshcheniya, tom 17, no. 9, p. 801–806, 1956.

Analysis of more than 300 earthquakes on the southern slope of the main Caucasian Ridge, indicates all have occurred in one relatively narrow zone extending from Kazbek Mountain to the city of Shemakha. The epicenters migrate back and forth along the longer axis of the zone from one end to the other. The line of these epicenters coincides with the line of long extinct volcanoes of the Kel'sk Plateau.—*S. T. V.*

169–41. Byus, Ye I., and Rubinshteyn, M. M. Novyye dannyye o Tabatskurskom zemletryasenii 7–8 Maya 1940 goda [New data on the Tabatskur earthquake of May 7–8, 1940] Akad. Nauk Gruzinskoy SSR Soobshcheniya. tom 14, no. 2, p. 85–89, 1953.

Tthe earthquakes of May 7–8, 1940, in the Akhalkalaki volcanic upland of the Georgian S.S.R. were followed by more than 750 aftershocks. Epicenters of 62 aftershocks were located on a slightly curved line about 120 km long which corresponds to the almost-continuous ridge of craters of long-extinct volcanoes. Strain was successively released by shocks that migrated back and forth along this line.—*S. T. V.*

169–42. Rozova, E. A., and Korolev, V. G. Seysmichnost' rayona g. Frunze [Seismicity of the region around Frunze]: Akad. Nauk Kirgiz. SSR Izv., vypusk 2, p. 45–60, 1956.

A brief description is given of the 157 earthquakes that occurred within 50 km of the city of Frunze between 1929 and 1954. None exceeded intensity V. A brief description of the geology of the southeastern part of the Kirgiz S.S.R. is included.—*S. T. V.*

169–43. Rozova, E. A. K voprosu o seismychnosti basseyna r. Naryn [On the seismicity of the basin of the Naryn River]: Akad. Nauk Kirgiz. SSR Izv., vypusk 3, p. 17–25, 1956.

Evaluation of the seismicity of the Naryn River valley is important because of the proposed construction of important hydroelectric installations. Numerous feeble earthquakes had been noted before November 2, 1946, when a destructive earthquake of intensity IX occurred. A long and precise seismological study of the region by a sufficiently dense network of seismic stations, as well as detailed geologic investigations by deep seismic sounding, will be necessary before a more or less reliable seismic zoning can be made. A start has been made by the 10 seismic stations equipped with good instruments established since World War II in the Kirgiz S.S.R.—*S. T. V.*

169–44. Rustanovich, D. N. Nekotoryye voprosy izucheniya seysmichnosti Ashkhabadskogo rayona [Certain questions related to the study of seismicity of the Ashkhabad region]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 1, p. 10–20, 1957.

The seismicity of the Ashkhabad region in central Asia has been studied on the basis of the records of the four permanent seismic stations in the region and of the material collected by two seismological expeditions sent to the region by the Academy of Sciences of the U.S.S.R. following the destructive earthquake in 1948. During 5 months of operation of temporary seismic stations in 1949, about 1,500 earthquakes were recorded. Earthquakes in the area are characteristically of very shallow focus. Because of the stratification, the great differences in seismic velocities of the different layers, and the irregular boundary surfaces separating the layers, seismograms are difficult to interpret. Best results were obtained by using the method of isochrones to determine the focus. Two northwest-trending seismogenetic belts, about 40 to 50 miles apart, are indicated by the results.—*S. T. V.*

169–45. Bune, V. I. Sravnitel'no-energeticheska kharakteristika seysmichnosti trekh rayonov Tadzhikistana [Relative energy characteristics of the seismicity of three districts of the Tadzhik SSR]: Akad. Nauk Tadzhik. SSR Doklady, vypusk 19, p. 3–12, 1956.

As suggested by Toperczer, the measure of the seismicity of a region is taken as the ratio $\Sigma E/AT$, where ΣE is the total sum of the energies of all earthquakes that occurred during time T and A is the area of the region. The energy E of an earthquake is computed by the method of Gutenberg and Richter. The data for individual earthquakes were taken from instrumental records and estimated from historical data. The seismicity so computed ranged from 6.6 to 8.0; the highest value was in the Khait district, chiefly because of the violent earthquakes of July 8–10, 1949; and the smallest, in the Stalinabad region.—*S. T. V.*

169–46. Pasechnik, I. P. Kizucheniyu seysmichnosti Khaitskoy epicentral'noy zony [Contribution to the study of the seismic activity of the Khait epicentral zone]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 12, p. 1427–1438, 1956.

A partial report on the work of a special expedition of the Academy of Sciences of the U.S.S.R. to the Garma Oblast', Tadzhik S.S.R., where in 1949 a violent earthquake occurred in the Khait district. Six fully equipped seismic stations were set up at the seismically most active points; during 32 days in 1953, 1,700 different earthquakes were recorded at several of these stations, most of them with S–P intervals of less than 5 seconds. Epicenters of the shocks were located along "seams" between more solid blocks, many of which were known as the epicentral lines of previous earthquakes. This result confirms the opinion that study of weak earthquakes is important because of the possibility of establishing tectonic lines along which strong earthquakes will occur.—*S. T. V.*

169–47. Vasil'yeva L. B. Seysmicheskaya karta rayona Gissarskoy Doliny [The seismic map of Gissar Valley region]: Akad. Nauk Tadzhik. SSR Izv. otdel. yestestven. Nauk, vypusk 14, p. 43–57, 1956.

The Gissar valley in northwestern Tadzhik S.S.R. is a region of high seismicity; since 1907 seven local earthquakes of intensity VIII and IX occurred there. A seismotectonic map of the valley, based on geologic and seismological data, shows all the most violent earthquakes are related to faults parallel to the long axis of the valley. Earthquakes at depths of 25–30 km occur along the southernmost of three such faults; foci on the other two are at depths of 10 km or less. Weaker earthquakes of intensity V to VI, at depths of 4–10 km are related to secondary faults, perpendicular to the first set.—*S. T. V.*

169–48. Gorshkov, G. S. Seysmicheskiye nablyudeniya v pervoy polovine 1951 g. [Seismic observations during the first half of the year 1951]: Akad. Nauk SSSR Lab. vulkanol., Byull. vulkanol. stantsii, no. 23, p. 24–37, 1954.

Data are given for 222 earthquakes including 101 local shocks and 75 near earthquakes at the volcanological station during the first 6 months of 1951. Most of the shocks were along the eastern shore of the Kamchatka Peninsula and near Bering Island. Forty percent of the near earthquakes were deep focus shocks.—*S. T. V.*

169–49. Rozova, E. A. Alaykël'skiye zemletryaseniya 15–20 aprelya 1955 goda [The Alaykël' earthquakes of April 15–20, 1955]: Akad. Nauk Kirgiz. SSR Izv., vypusk 3, p. 103–126, 1956.

The earthquake of April 20, 1955, in central Asia was not strong enough to produce significant destruction but was recorded by the Pasadena Observatory, about 12,000 km away. The first motion was so violent that the transverse waves were not observed. The first earthquake was followed by numerous aftershocks; between April 15 and 20, 48 earthquakes were recorded. The epicenters were determined chiefly by the hyperbola method. They show a gradual displacement toward the southeast from the epicenter of the main shock at lat 41°56′ N and long 71°40′ E. The depth of the focus was 100±20 km.—*S. T. V.*

169–50. Koning, L. P. G. Seismic evidence on orogenic processes: K. Nederland. Geol.-Mijnb. Genootschap Verh., geol. ser., deel 16, p. 202–209, 1956.

Shallow earthquakes take place either in belts of Tertiary or younger orogenies, where they are clearly related to the mountain building processes and are accompanied by intermediate and deep-focus shocks; or they may occur outside these large seismic belts, as the result of specific stress conditions caused by the tendency toward crustal equilibrium, such as the regional tectonic earthquakes of Africa and the local tectonic earthquakes of the Rhine Valley. The frequent coincidence of seismicity and volcanism results from the fact that both are accompanying phenomena of the same continuous process; circumstances in areas of shallow shocks may also be favorable for the development of volcanoes, but either phenomenon may occur independently of the other.—*D. B. V.*

169–51. Hodgson, John H. Nature of faulting in large earthquakes: Geol. Soc. America Bull., v. 68, no. 5, p. 611–644, 1957.

Byerly's method of determining direction of faulting has been applied to a total of 75 earthquakes, 65 of them in the Dominion Observatory fault plane project. Satisfactory agreement between the seismic solutions and observed or inferred displacement has been observed in 5 examples; in 2 others, the strikes are in agreement but not the displacement; and in 3 solutions for a closely allied group of earthquakes in Nevada, the strike direction differed slightly from that observed on the surface although in one it agreed exactly with the geodetic data. Of the 75 earthquakes, all but 8 resulted from strike-slip faulting. Within a given area, the strike directions are apparently random, but the dip directions may have some consistent orientation. The apparent inconsistency can be explained by supposing that planes whose strikes deviate from a favored direction tend to develop very steep dips. The intersection of the two planes obtained in each solution defines a unique line, the null vector, which is perpendicular to the displacement couple. In the southwest Pacific the null vectors are parallel to vertical planes that strike in the direction of the associated geographic features.—*M. C. R.*

169–52. McIntyre, Donald B. and Christie, John M. Nature of the faulting in large earthquakes: Geol. Soc. America Bull., v. 68, no. 5, p. 645–652, 1957.

Analysis of fault-plane solutions by stereographic or equal-area projection can under certain conditions make it possible to determine the orientation of the fault plane. Fault movements giving rise to earthquakes have monoclinic symmetry, and their orientations can be described in terms of three kinematic axes: *A*, the direction of motion in the fault plane, *B*, normal to *A* in the fault plane (and equivalent to the null vector of Hodgson); and *C*, normal to the fault plane *AB*. If a *B* diagram (that is, a plot of the great circles representing the fault plane) is made, the *B* maximum, or concentration of great-circle intersections, must coincide with *B*. By this technique it is shown that in the New Zealand-Fiji arc, the faults are parallel to the physiographic feature.—*M. C. R.*

169–53. Scheidegger, Adrian E. The geometrical representation of fault-plane solutions of earthquakes: Seismol. Soc. American Bull., v. 47, no. 2, p. 89–110, 1957.

The four most used geometrical representations of fault-plane determinations are: nodes on a map of the world; stereographic projection of the focal sphere; extended distances; and central projection of the focal sphere. The first is useful only where there is a concentration of seismograph stations; it has been successfully used only in Japan. The last three are equivalent: in each a sphere is used,

some stereographic projection of this sphere is used, and the tangent to the seismic ray at the focus is substituted for the ray itself. The three methods are illustrated by solutions for the shock of December 30, 1948.—*M. C. R.*

169–54. World Conference on Earthquake Engineering Proceedings, 485 p., Berkeley, Calif., June 1956.

A report of the conference at Berkeley, Calif., in June 1956, in observation of the fiftieth anniversary year of the San Francisco earthquake, and sponsored by the Earthquake Engineering Institute and the Department of Engineering, University Extension, University of California. Papers are grouped as follows: Earthquake ground motions, analysis of structural response, development of aseismic construction, earthquake effects on soils and foundations, and design of earthquake-resistant structures. For geophysical contributions see abstracts 169–33, 55, 56, 57, 60.—*B. T. E.*

169–55. Kanai, Kiyoshi; Takahasi, Ryutaro; and Kawasumi, Hirosi. Seismic characteristics of ground: World Conference on Earthquake Engineering Proceedings, p. 31-1—31-16, Berkeley, Calif., June 1956.

Mathematical and observational studies of earthquake motions indicate that the seismic characteristics vary with the properties of the ground; that in ground with one surface layer, the spectral response is of a resonance type, and the predominant period and amplitude coincide; that if there are two or more surface layers, resonance phenomena are not often observed but the amplitude of the earthquake motion may be comparatively large over a wide range of periods.—*M. C. R.*

169–56. Cloud, W[illiam] K., and Carder, D[ean] S. The strong-motion program of the [U. S.] Coast and Geodetic Survey: World Conference on Earthquake Engineering Proceedings, p. 2–1—2–10, Berkeley, Calif., June 1956.

A brief history of the strong-motion seismological program of the U. S. Coast and Geodetic Survey, including description of the instruments developed and used, and an outline of the future program.—*M. C. R.*

169–57. Hudson, D. E. Response spectrum techniques in engineering seismology: World Conference on Earthquake Engineering Proceedings, p. 4–1—4–12, Berkeley, Calif., June 1956.

Definition, determination, and application of the response spectrum are discussed and an electric analog spectrum analyser described. Response spectrum methods have been found to be useful not only for the determination of structural responses in particular cases of ground motion, but also as a means of investigating the general character of earthquake motion. Instrumentation and techniques are available that will permit the determination of response spectra in a form suitable for many applications in engineering seismology. What is now most needed to further such studies are strong-motion accelerometer records of earthquakes and other ground motions, so that an increased amount of basic data can be prepared in the form of response spectra.—*B. T. E.*

169–58. Steinbrugge, Karl V., and Moran, Donald F. An engineering study of the Eureka, California, earthquake of December 21, 1954: Seismol. Soc. America Bull., v. 47, no. 2, p. 129–153, 1957.

Primarily a description of the effects of the earthquake on man-made structures with a view toward developing additional data for engineering design and earthquake insurance rating. The earthquake was of magnitude 6.6 according to the Berkeley station, and the maximum intensity according to the U. S. Coast and Geodetic Survey was VII. Some slight damage was caused in non-earthquake-resistive structures, none in earthquake-resistive structures. Damage to structures and underground pipe lines was found in areas of poor ground.—*M. C. R.*

169–59. California Department of Public Works Division of Water Resources. Report on physical effects of Arvin earthquake of July 21, 1952: California Div. Water Resources, 16 p., 5 plates, 38 photographs, 1952.

A detailed study of the damage caused by the Arvin earthquake and its aftershocks with a view to learning how to minimize earthquake damage by improving the design and location of structures. Effects on terrain, springs and streams, irrigation reservoirs and canals, pumps and standpipes, power transformers, haystacks, buildings, roads, water wells, pipelines, oil wells, and tunnels are discussed. Structures built across the main trace of the fault were damaged regardless of how well they were built. Elsewhere in the megaseismic area structures well built received only slight damage or none at all, particularly those designed against earthquake forces. (See also Geophys. Abs. 158–150.)—*B. T. E.*

169–60. Takahasi, Ryutaro. The "SMAC" strong motion accelerograph and other latest instruments for measuring earthquakes and building vibrations: World Conference on Earthquake Engineering Proceedings, p. 3-11—3-11, Berkeley, Calif., June, 1956.

The "SMAC" (Strong Motion Acceleration Committee) strong-motion accelerograph is described in detail. It has the ability to record accurately earthquake accelerations as great as 1,000 gals with high recording speed and to record two more aftershocks automatically. The instrument requires a careful inspection only once a year together with the bimonthly attention of a less skilled mechanic. Principally for use in combination with the SMAC accelerograph is the reasonably priced a-c accelerograph in which the vertical component pendulum and integral starter are eliminated. The instrument starts recording in response to an electric signal transmitted from the starter of the SMAC accelerograph installed on a different floor level.

A microtremor recorder capable of being installed in a car, an inexpensive maximum acceleration seismoscope, and a direct-reading instrument for observing building vibrations are also described. Photographs of the instruments are included.—*B. T. E.*

169–61. Borges, J. Ferry. Statistical estimate of seismic loading: Lab. Nac. Engenharia Civil [Portugal]. Rept. no. 87, 10 p., 1956. Reprinted from the Preliminary Publication of the 5th Congress of the International Association for Bridge and Structural Engineering.

In order to estimate seismic loadings, the information referring to the seismicity of an area has to be combined with that referring to the behavior of structures subject to seismic action. Assuming an earthquake to be a group of random pulses, it is possible, in accordance with the theory of vibrations, to calculate the probability of a given structure undergoing displacements greater than a given value. On the other hand, it is assumed that the expected number of earthquakes

of an intensity equal to or greater than a given value is inversely proportional to this intensity. In this paper it is shown that the expected number of times the maximum loading reaches a certain value is equal to an expected number of earthquakes. This expected number is the number of earthquakes whose intensity is greater than that which, on the average, produces the given loading.—*Author's abstract*

169–62. Zeuch, R[ichard]. Die graphische Herdbestimmung von Erdbeben [Graphic determination of depth of focus of earthquakes]: Gerlands Beitr. Geophysik, Band 65, Heft 3, p. 216–226, 1956.

Two nomograms are shown for determining epicentral distance and depth of focus of earthquakes registered at only one station. To determine σ and h two travel time differences are necessary, $(S-P)$ and $(pP-P)$ for one nomogram and $(S-P)$ and $(PP-P)$ for the other. Two curve systems are drawn in an orthogonal σ-h-system with ΔT as parameter, and the point of intersection defined by $\phi_i(h, \Delta T_i)=\phi_k(h, \Delta T_k)$ for the two curves determines σ and h.—*B. T. E.*

169–63. Eaton, Jerry [P.], and Byerly, Perry. Calibration of the short-period Sprengnether seismograph: Seismol. Soc. America Bull., v. 47, no. 2, p. 155–166, 1957.

A procedure is presented for calibrating the short-period Sprengnether seismograph and its application to the Berkeley instruments described. (See also Geophys. Abs. 168–51.)—*M. C. R.*

169–64. Kharin, D. A., and Rulev, B. G. Elektrodinamicheskiy seysmograf dlya zapisi bol'shikh peremeshcheniy [Electrodynamic seismograph for recording large displacements]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 1, p. 113–115, 1957.

A seismograph designed for measurement of large displacements of the ground, such as can be observed near the epicenters of earthquakes or very near the shot point when large amounts of explosives are detonated, consists of an inverted pendulum with electric winding on its axis of rotation; linear displacements of the mass are transformed into angular rotations of the axial armature which is enclosed by a magnet with specially adapted pole shoes and producing electromotive impulses. The observed displacements are recorded by an oscillograph which can measure maximum linear displacements of 10 cm at frequencies ranging from 1.5 to 50 cycles per second.—*S. T. V.*

169–65. Båth, Markus. Erdbebenenergie [Earthquake energy]: Bergakademie, Jahrg. 9, no. 1, p. 17–21, 1957.

A summary and analysis of the attempts that have been made to calculate earthquake energy as a function of magnitude. Ten different formulas are discussed and compared graphically.—*D. B. V.*

169–66. Dibble, R. R. Crustal structure project: The seismic energy and magnitude of the explosions: New Zealand Dept. Sci. Indus. Research Geophys. Mem., no. 5, p. 32–35, 1957.

The seismic energy of the largest explosions for making a seismic refraction profile in Wellington Province was 1×10^{14} ergs, the thermal energy 5×10^{16} ergs, and the seismic efficiency, therefore, about 0.3 percent. The seismic energy can

be calculated from the instrumental earthquake magnitude of 2.0 by using Gutneberg and Richter's 1954 formula $\log_{10}E=11+1.6M$.—*V. S. N.*

169–67. Leet, L. Don. Use and abuse of earth waves: Am. Scientist, v. 45, no. 2, p. 114–124, 1957.

A general review of earth waves produced during earthquakes, an atomic bomb test, and microseismic storms and their use, followed by a discussion on vibrations from blasting.—*B. T. E.*

169–68. Andreyev, S. S. Izucheniye glubinnogo stroyeniya zemnoy kory pri pomoshchi obmennykh voln *PS*, registriruyemykh pri zemletryaseniyakh [Investigations of the deep structure of the crust of the earth, using the converted wave *PS*, recorded during earthquakes]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 1, p. 21–29, 1957.

The arrival of converted shear (*PS*) waves can be seen only on horizontal components. Amplitudes of these waves are greater than waves arriving later, and they show clearly noticeable polarization in the plane of the incident ray. Thus the waves are of the *SV* sub-type. Detailed analysis of these waves can elucidate many features of the crust; the conclusions arrived at by this method are independent of absolute arrival times, of the travel time from the focus, and even of the epicentral distance. *PS* waves can be used not only in seismically active regions but at any point where it is possible to observe remote earthquakes.—*S. T. V.*

169–69. Honda, Hirokichi, Sima, Hiromu, and Nakamura, Kōhei. The *ScS* wave, the mechanism of deep earthquake and the rigidity of the earth's core: Tōhoku Univ. Sci. Repts., 5th ser., v. 7, no 3, p. 169–179, 1956.

Displacements of the initial motions of *P* and *S* waves emitted from a focus have been determined mathematically, and the direction and relative magnitude of these motions in a small sphere around the focus of deep earthquakes (the *D*-sphere) can be shown schematically. The amplitude at the surface can be calculated by considering also the effects of variation of velocity and of reflection at the surface and core. Conversely, from the distribution at the surface, motions in the *D*-sphere can be calculated. Examples are given. A mathematical expression is obtained for an *SV* wave reflected at a plane boundary between solid and liquid when an impulsive *SV* wave emitted from a point source within the solid is incident at the boundary. Investigation of the variation of the ratio of the amplitude of the reflected *S* wave to that of the *S* wave incident vertically at the core boundary indicate the core cannot be solid in the ordinary sense. —*M. C. R.*

169–70. Sassa, Kenzō, and Nishimura, Eiichi. On phenomena forerunning earthquakes: Kyōto Univ. Disaster Prevention Research Inst. Bull. no. 13, p. 1–8, 1956.

A minute but characteristic *S*-type tilting motion of the ground was observed several hours before the occurrence of the Tottori, Tonankai, and Nankai earthquakes. Observed tilts were at an angle of the order of 1.0″ at a distance of 100 km from the epicenter. Tilting toward the direction of the epicenter took place several months preceding the Daishōji-Oki and the Yoshino earthquakes. After the earthquakes tilting continued for some time at right angles to the

previous direction. There was also a reversal of tilting starting 16 days before the Yoshino earthquake. A gradual extension of the ground started nearly 1 year before and was followed by a more rapid extension in the last 3 months. One month after the occurrence, strain changed to contraction and conditions returned to normal within a year.—*B. T. E.*

169–71. Utsu, T[okuji]. On some remarkable phases on seismograms of near earthquakes, Part 2: Quart. Jour. Seismology, v. 21, no. 3, p. 107–111, 1956.

Pn, *Pg*, *Sn*, and *Sg* have been identified on Matsushiro seismograms of very shallow earthquakes. The velocities are 7.49, 5.72, 4.11, and 3.44 kmps, respectively. The velocity of S_g is higher than average, and the wave has some of the characteristics of a crustal surface wave.—*M. C. R.*

169–72. Burke-Gaffney, T. N., and Bullen, K. E. Seismological and related aspects of the 1954 hydrogen bomb explosions: Australian Jour. Physics, v. 10, no. 1, p. 130–136, 1957.

Seismic waves from hydrogen bomb explosions in the Pacific in 1954 were recorded at stations at distances of 33.7° to 140.6°. The origin times (in Greenwich mean time) have been determined as: February 28, 18h 45m 0s, March 26, 18h 30m 0s, April 25, 18h 10m 0s, and May 4, 18h 10m 0s. If these surmised times and the assumed source point are correct, the data show that seismic traveltimes from Bikini in all azimuths should be reduced by 1 to 2 seconds or more from the Jeffreys-Bullen traveltimes. If these origin times are used, there is no discrepancy between velocities of air waves from these blasts and those from the Krakatoa eruption and the fall of the Siberian meteor, as indicated by Yamamoto. —*M. C. R.*

EARTH TIDES AND RELATED PHENOMENA

169–73. Tomaschek, Rudolf. Probleme der Erdgezeitenforschung [Problems of earth tide research]: Deutsche Geod. Komm. Veröffentl., Reihe A, Heft 23, 16 p., 1956.

A review of experimental and mathematical problems of earth tide research. Observations by either of the two customary methods (pendulum observations of variation of the horizontal component of gravity, or gravimeter observations of variation of the vertical component) show a much larger spread of values than can be attributed to instrumental or observational error. It is hoped that comparable measurements at many different points on the earth during the International Geophysical Year will lead to determination of the deformation factors *G* and *D* to two decimal places. The causes of the discrepancies in observed values (effect of ocean tides, of density distribution, of geologic structure, of movements within the core), the geodetic significance of earth tides, seasonal variations in the figure of the earth, and the problem of harmonic analysis are all discussed.—*D. B. V.*

169–74. Ellenberger, H. Über die Arbeiten des Deutschen Geodätischen Forschungsinstitut zur Erdgezeitenforschung [On the work of the Deutsches Geodätisches Forschungsinstitut on earth tide research]: Deutsche Geod. Komm. Veröffentl., Reihe A, Heft 10b, p. 7–16, 1955.

A description of the instruments used at the Deutsches Geodätisches Forschungsinstitut in München for registering the three components of earth tides

in an investigation of the elastic properties of the earth as a whole and of individual segments of the crust.—*D. B. V.*

169–75. Ichinohe, Tokio. Study on change of gravity with time. Pt. 3. On the tidal factor of gravity: Kyōto Univ. Coll. Sci. Mem., Ser. A, v. 28, no. 1, p. 11–38, 1956.

Observations of gravity at half-hourly intervals were made for periods of 1 month at Kyōto, Chikubushima, and Shionomisaki with a Worden gravimeter. The tidal factor, G, was calculated as 1.18, 1.21, and 1.21; the first is adopted because the crustal thickness at Kōyto is nearly 30 km, about the average thickness for the world. Using this value of G and 0.66 for the diminishing factor, as obtained by Nishimura, the Love numbers h and k are calculated as 0.66 and 0.32, from which it is deduced that the maximum tidal upheaval of the ground is 51.5 cm.—*M. C. R.*

169–76. Inglis, David R. Shifting of the earth's axis of rotation: Rev. Modern Physics, v. 29, no. 1, p. 9–19, 1957.

Terrestrial variation of the earth's axis of rotation consists of a somewhat irregular nutation of small amplitude and period of a little more than a year and a slow wandering of the pole. The period of nutation is the same as it would be if the earth were rigid and had the smaller ellipticity to which the actual earth would relax elastically if the rotation were stopped. Damping of the nutation can be explained in terms of an earth model in which the axial and equatorial regions are treated as coupled gyroscopes and viscous slipping of the elastic coupling is permitted. The rate of viscous readjustment inferred from the damping is such that possible asymmetries to be expected from the existence of continents in isostatic equilibrium are sufficient to produce a wandering of the pole. The rate of wandering thus inferred is more rapid than needed to explain the apparent motion of the pole in geologic time and is in keeping with Gold's suggestion that it may have taken place in a series of relatively short spurts from one temporarily stable position to another.—*M. C. R.*

ELASTICITY

169–77. Jaeger, J. C. Elasticity, fracture and flow with engineering and geological applications: 152 p., London, Methuen and Co., Ltd., 1956.

The three chapters include discussion of the analysis of stress and strain, the behavior of materials, the stress-strain relations for elasticity in isotropic and simple anisotropic substances, viscosity, and plasticity, and the equations of motion and equilibrium. The propagation of elastic waves, equations of motion of a viscous fluid, and plastic flow in two dimensions are among the applications described.—*M. C. R.*

169–78. Scholte, J. G. J. On seismic waves in a spherical earth: K. Nederlands Meteorol. Inst. Med. en Verh., no. 65, 55 p., 1956.

A discussion of the propagation of seismic waves in a medium consisting of a solid spherical shell surrounding a liquid sphere both of which are composed of perfectly elastic, homogeneous, and isotropic material. The primary disturbance is assumed to be confined to a space the dimensions of which are negligible in comparison to other linear dimensions. The sphericity of the earth is not

neglected and therefore such phenomena as the diffraction of *P* waves by the core and the behavior of waves in the vicinity of a caustic can be investigated.—*M. C. R.*

169–79. Chakraborty, S. K. Disturbances in different types of elastic media: Geofisica Pura e Appl., v. 35, p. 25–32, 1956.

A mathematical discussion of the generation and propagation of disturbances generated by pressure on the inner surface of a spherical cavity in a dispersive medium and a medium transversely isotropic about a radius vector.—*M. C. R.*

169–80. Skuridin, G. A. K teorii rasseyaniya uprugikh voln na krivolineynoy granitse [On the theory of the dissipation of elastic waves by curved boundaries]: Akad. Nauk SSSR Izv. Ser. geofiz. no. 2, p. 161–183, 1957.

By applying Kirchoff's formula from potential theory, it is shown that when an initially plane longitudinal elastic wave is reflected from a curved boundary two waves are produced; one is longitudinal, the other transverse, and they are characterized by a function of dissipation determined by the curvature of the boundary. Similarly, it is shown that when a plane transverse wave is reflected from a similar curved boundary, two waves are produced, one longitudinal, the other transverse. The functions of the dissipation of the reflected waves are given for various angles of the incident waves; the reflected waves, initially plane, become curved.

Analysis of the formula for the wave front produced when the transverse wave is reflected leads to the conclusion that the appearance of several wave fronts is possible. Graphs are given showing the decrease in the intensity of these waves along their trajectories. The laws of damping can be represented by cylinder functions.—*S. T. V.*

169–81. Synge, J. L. Flux of energy for elastic waves in anisotropic media: Royal Irish Acad. Proc., sec. A, v. 58, no. 2, p. 13–21, 1956.

In an earlier paper it was shown that six systems of plane waves are set up in a slab of elastic anisotropic material, the upper face of which is free and the lower face subjected to travelling waves of stress. In this paper the fluxes of energy for the six systems are investigated for applied stress waves of various speeds. For infinite speeds the planes of the six waves are horizontal, three carrying energy up and three carrying energy down. When the speed is reduced to an appreciable finite value, the planes become oblique, but there are still three upward and three downward energy fluxes. When the speed is reduced sufficiently, a pair of complex roots of the six-degree characteristic equation appear with the result that two energy fluxes, one up and one down, are replaced by two that are horizontal and parallel. Ultimately all the energy fluxes are horizontal and parallel. For Rayleigh waves, the energy fluxes are all horizontal.—*R. G. H.*

169–82. Satō, Yasuo. Definition, classification and representation of surface waves [in Japanese with English abstract]: Zisin, v. 9, no. 1, p. 16–20, 1956.

The definition of surface waves as waves propagated in a medium with a single boundary or several parallel boundaries and with the wave front perpendicular to the boundary surface is amended to include the conditions that all media are

bounded with respect to the z-direction and waves in the semi-infinite part are of "[E]-type." Symbolical representations are given for possible types of surface waves.—*M. C. R.*

169–83. Yamaguchi, Rinzo. Velocity of surface waves propagated upon elastic plates [in Japanese with English abstract]: Zisin, v. 9, no. 1, 8–15, 1956.

If vibrations are propagated on an infinite elastic plate, one side of which is fixed, there is no branch of the dispersion curve that converges to a finite value when the wavelength tends to infinity and the waves cannot exist with a velocity smaller than that of Rayleigh waves. Love-type waves are propagated in a double elastic plate in slipless contact with velocities that depend on the ratio of the thickness of the plates as well as the nature of the boundary.—*M. C. R.*

169–84. Chopra, S. D. The range of existence of Stoneley waves in an internal stratum. 1. Symmetric vibrations: Royal Astron. Soc. Monthly Notices, Geophys. supp., v. 7, no. 5, p. 256–270, 1957.

The frequency equation for Stoneley-type waves with symmetric vibrations propagated along the interfaces between an internal stratum and two adjacent halfspaces, all perfectly elastic, homogeneous and isotropic, is obtained as the vanishing of a determinant of the fourth order. For large values of the frequency, the equation reduces to that of Stoneley waves at the interface between two halfspaces. Discussion of the sign of this determinant for suitable values of the unknown leads to the condition for the existence of such waves both for a low-velocity and a high-velocity internal stratum. The ranges of values which the ratios of the elastic constants of the stratum and either halfspace must have are obtained by numerical computation and the results are presented both in tabular form and graphically.

It is found that: (i) Stoneley waves with symmetric vibrations, when they exist, have their phase velocity lying between the distortional and Rayleigh wave velocities of the lower velocity medium. (ii) If, as is usual, a velocity ratio less than unity is associated with a density ratio less than unity, then such waves cannot exist unless the smaller of the two distortional wave velocities is greater than the higher Rayleigh wave velocity. (iii) As the frequency of these waves or the thickness of the stratum is decreased, there is a cut-off value of either below which Stoneley waves cannot be propagated.—*Author's summary*

169–85. Stoneley, Robert [S.], and Hochstrasser, Urs.' The attenuation of Rayleigh waves with depth in a medium with two surface layers: Royal Astron. Soc. Monthly Notices, Geophys. supp., v. 7, no. 5, p. 278–288, 1957.

The Rayleigh-type motion at any depth in an elastic medium with a double surface-layer has been discussed in earlier papers. The ten boundary conditions at the free surface and the interfaces give ten linear simultaneous equations to determine the amplitudes of the horizontal and vertical displacements at all depths in terms of the amplitude of the horizontal motion, say, at any assigned depth. The vanishing of the ten-row determinant obtained by eliminating these ten constants gives an equation determining the wave velocity c as a function of wave-length $2\pi/k$. This equation has previously been solved numerically for a series of values of k under each of the hypotheses $T_2=T_1$; $T_2=1/2\ T_1$; $T_2=1/3\ T_1$, where T_1, T_2 are respectively the thickness of the upper and lower of the two surface layers. For any pair of values (c,k) any set of nine of the equations can

be solved for the ratios of the constants, and in this way the relative amplitudes of the displacements have been found at various depths for each of the pairs (c,k) obtained in an earlier paper. The numerical work is heavy, and has been effected on the SEAC machine of the National Bureau of Standards.—*Authors' summary*

169–86. Nagamune, T. M_2 waves in a medium with double surface layers: Geophys. Mag., v. 27, no. 3, p. 345–352, 1956.

Dispersion curves of M_2 waves in a medium with double surface layers have been computed for two models. In one, the rigidities of the two layers and the medium below are μ, 4μ, and 8μ; in the second the rigidities are μ, 1.479μ, and 2.107μ. Density is constant and $\lambda=\mu$ in each layer. For the first model there is more than one minimum and maximum group velocity; for the latter there is only one minimum and one mini-max group velocity. For the first model, the ratio of horizontal to vertical motion is greater than unity at very small wavelengths and less than unity at others; for the latter the vertical component is always larger. Motion of a particle at the surface is elliptical, and the sense of motion is gravitational in the first case and retrograde in the second.—*M. C. R.*

169–87. Mason, R. G. A small-scale field investigation of motion near the source: Geophys. Prosp., v. 5, no. 2, p. 121–134, 1957.

In the experiments described, a falling weight was used as the source of energy with a recording system that permitted quantitative measurement and the display of two-dimensional pictures of ground displacement on a cathode ray oscillograph. The first wave at points within 100 feet of the source had the characteristics of the *P* wave and a velocity of 2,170 fps; beyond 100 feet the amplitude became so small that the wave could no longer be identified with certainty. The next arrivals were predominantly vertical motion and were identified as *S* waves. Beyond 140 feet, the first arrival was a refracted wave travelling in the lower medium and identified as an *S* wave. The refracting interface was at about the expected depth of the water table. At 40 feet from the source and beyond, the largest amplitudes were associated with motion having the characteristics of Rayleigh waves.—*M. C. R.*

169–88. Sollogub, V. B., Galushko, P. Ya., Vopilkin, A. A., and Patiokha, A. M. O nekotorykh fakorakh, vliyayushchikh na velichinu skorosti rasprostraneniya uprugikh kolebaniy x gornykh porodakh [Certain factors affecting the velocity of propagation of elastic vibrations through rocks]: Akad. Nauk SSSR Doklady, tom 113, no. 1, p. 82–85, 1957.

The effect of unilateral compression on the velocity of propagation of longitudinal waves in the direction of compression was studied by compressing cubes of sandstone and limestone in steps of 20 kg per cm^2. Elastic waves were produced by the ultrasonic impulses seismoscope described by Riznichenko (see Geophys. Abs. 153–14479). When the pressure increased from 0 to 120 kg per cm^2, the velocity increased from 3,200 to 3,900 m per sec; as pressure increased from 120 to 420 kg per cm^2 velocity increased from 3,900 to 4,100 m per sec. Further increase in pressure resulted in a decrease of velocity. At about 610 kg per cm^2 most of the specimens were destroyed.

When compression was repeated after a release of the pressure some specimens behaved almost as perfectly elastic bodies, but in others the velocity curve

did not coincide with that observed at the first compression, indicating a residual deformation. Apparently the elastic properties of rocks, especially their seismic velocity, are affected by the depth of burial and quite often by geologic history of the rock.—*S. T. V.*

169–89. Laughton, A. S. Sound propagation in compacted ocean sediments: Geophysics, v. 22, no. 2, p. 233–260, 1957.

Experiments were made in the laboratory to measure the variations in velocity of propagation of compressional and transverse waves in ocean sediments under varying conditions of compacting pressure. The apparatus included a pressure pot designed so that measurements of compression and velocity could be carried out simultaneously. Pressure was applied by means of a 35-ton ship jack. The samples used were obtained from cores taken in the northeastern Atlantic basin. The increase in velocity of compressional waves with pressure below 3.0 kmps can be represented approximately by the relation $vp=1.5+0.04p^{1/2}$ (vp in kmps, p in kg per sq cm). The theory is offered that the increase is due principally to establishment of a particle structure that in part supports the stresses during transmission of an elastic wave. The structure is not strong enough to sustain shear stresses at compaction pressures less than 500 kg per sq sm. Uniaxial compaction of the finer grained sediments tends to give rise to transverse isotropy in the velocity measurements and in physical properties. The increases in velocity in the top layer of sediments at sea found in seismic experiments are consistent with laboratory results, but the increase below the top layer cannot be explained by compaction alone.—*M. C. R.*

169–90. Krishnamurthi, M., and Balakrishna, S. Attenuation of sound in rocks: Geophysics, v. 22, no. 2, p. 268–274, 1957.

In the experiments described a pulsed ultrasonic beam is generated and received in a cell containing water and the specimen under investigation is interposed normal to the beam. Total loss in acoustic energy per unit distance traversed is determined. Specimens of four different thicknesses were used and absorption measured at three different frequencies. Results show that attenuation in rocks is generally higher than in amorphous substances and in the range of frequencies used (2 to 6 Mcls) attenuation increases with increasing frequency.—*M. C. R.*

169–91. Kato, Yoshio, and Takagi, Akio. Model seismology (Part 2). Two dimensional model experiment on wave propagation in the earth's model: Tōhoku Univ. Sci. Repts., 5th ser., v. 7, no. 3, p. 180–189, 1956.

The propagation of an ultrasonic pulse in a homogeneous ring-shaped disk with an empty core and with the core filled by material of higher or lower velocity was studied. Model dimensions were chosen to simulate conditions in the earth. With the core empty, phases identified as *P*, *PP*, *PcS*, *S*, *ScS*, *SS*, and *L* were observed; *P* and *S* amplitudes were large to distances of about 100°, beyond which point they decreased suddenly but did not vanish. With a higher velocity core, the same phases were observed and, in addition, at about 140°, a wave identified as *PKP*. In the experiment with the low-velocity core, the amplitude of *P* waves decreased rapidly beyond 100° and the traveltime curve became straight, indicating diffraction, and *PKP* appeared, which became prominent at 165°, the focal point.—*M. C. R.*

169–92. Jobert, Nelly. Sur la période propre des oscillations sphéroïdales de la Terre [On the natural period of spheroidal oscillations of the earth]: Acad. Sci. Paris Comptes Rendus, tome 244, no. 7, p. 921–922, 1957.

The natural period of spheroidal oscillations (second class, mode 2, according to Lamb) is calculated for further models (see Geophys. Abs. 168–59). If the inner radius of the elastic homogeneous mantle is 3,473 km; outer radius, 6,371 km; *S* wave velocity, 6.5 kmps; Poisson's ratio, 0.25; the period is 56.8 min for a hollow core and 71 min for a homogeneous liquid core in which $\sigma=0.5$. By applying the Rayleigh principle and using Bullen's data as before, a period of 66 min is obtained; if the effect of gravitation is taken into account, the period is 60 min, which is close to the 57-min period recorded by Benioff in the earthquake of November 4, 1952.—*D. B. V.*

169–93. Volarovich, M. P., and Balashov, D. B. Izucheniye vliyaniya vsestoronnego davleniya do 1,000 kg/cm^2 na skorost' rasprostraneniya uprugikh voln v obraztsakh ugley [Study of the effect of hydrostatic pressure up to 1,000 kg per cm^2 on the velocity of propagation of elastic waves in specimens of coal]: Akad. Nauk SSSR Geofiz. Inst. Trudy, no. 34 (161), p. 164–178, 1956.

The effect of hydrostatic pressure on the velocity of the propagation of elastic waves in specimens of different coals of cylindrical shape, of a diameter of 3 cm and a height ranging from 5 to 12 cm, has been studied. The specimens were placed in a container filled with nitrogen and subjected to a maximum pressure of 1,000 kg per cm^2. Elastic waves were produced by an impulse method using piezo-electric crystals. Only the velocity of longitudinal waves was measured. Special precautions were taken to prevent the leakage of elastic waves from specimens to the walls of the container. A recording oscillograph was used for measurements of the velocity, which was found to increase by 50 to 60 percent when the pressure was increased from atmospheric to 1,000 kg per cm^2.—*S. T. V.*

ELECTRICAL EXPLORATION

169–94. Semenov, A. S. Elektrorazvedka metodom yestestvennogo elektricheskogo polya [Electrical exploration by the natural potential method]: 212 p., Leningrad, Leningrad Univ. Press. 1955. Reviewed by A. G. Tarkhov in Akad. Nauk SSSR Ser. geofiz., no. 11, p. 1364–1366, 1956.

Includes a discussion of the physical principles of the method, description of field procedures, instruments, electrical properties of rocks and ores and methods of determining them, and applications of the method.—*S. T. V.*

169–95. D'yakonov, B. P. Tsilindr v pole tochechnogo istochnika elektricheskogo toka [The effect of a cylinder on the electric field around a point source]: Akad. Nauk SSSR Izv. Ser. geofiz. no. 1, p. 116–121, 1957.

A discussion of the problem of the effect on the electric field, measured at the earth's surface, of a depression shaped like an infinite cylinder of semicircular cross section. The problem can be reduced to determination of the field pattern produced in a homogeneous medium of given electric conductivity σ, in the vicinity of an infinite circular cylinder of radius a and conductivity σ_2 by a point source fed by current I. The electric potential U of the field at any point outside

the cylinder must be determined. In the case of direct current, the stress E of the field is equal to I—grad. U. U satisfies in all regular points of the space the Laplace equation; it is also regular at infinity and has a singular point in the source. Boundary conditions at the cylindrical surface can be readily established.

The general solution of the Laplace equation can be presented as infinite series, using Bessel's functions with their coefficients determined by the conditions of the problem. This solution can be transformed by an appropriate substitution to modified functions whose values can be found in several known books (that of Ya. N. Spiyelreyn is mentioned).—*S. T. V.*

169–96. Bukhnikashvili, A. V., Kebuladze, V. V., and Chanturishvili, L. S. K voprosu ob ispol'zovanii yestestvennogo elektricheskogo polya dlya izucheniya neodnorodnostey gornykh porod [On the use of the natural electric field in studying the heterogeneities of rocks]: Akad. Nauk Gruzinskoy SSR Soobshcheniya, tom 14, no. 4, p. 205–209, 1953.

Spontaneous potential surveys have been made in a number of areas in the Georgian S. S. R. The individual areas are divided into 15–25 closed polygons and the spontaneous potential measured around the perimeter of each polygon. By dividing the sum of the potential around the polygon by the number of stations a factor related to electrochemical reaction and, therefore, to the probability of finding ore is obtained. Good results have been obtained over sulfide deposits.—*S. T. V., L. C. P.*

169–97. Belluigi, Arnaldo. Berechnung der elektrischen Leitfähigkeit des Bodens bei bekannter Verteilung des Oberfiächenpotentials [Determination of the electrical conductivity of the ground by the known distribution of surface potentials]: Gerlands Beitr. Geophysik, Band 65, Heft 3, p. 171–184, 1956.

After treating the inverse geoelectric problem by the rigorous analytic expression given by Langer, Belluigi obtains the same results by a new method of calculation (algorism) in order to provide for the possibility of application in practical cases. Two examples are given.—*M. C. R.*

169–98. Belluigi, Arnaldo, and Maaz, R. Die Methode Stevenson zur Ermittlung der elektrischen Leitfähigkeit aus der Potentialverteilung auf der Begrenzungsebene eines Halbraumes [The Stevenson method for determining the electrical conductivity from the potential distribution on the boundary plane of semispace]: Gerlands Beitr. Geophysik, Band 65, Heft 4, p. 263–272, 1957.

The Stevenson method is investigated critically and is shown to lead to complicated analytical formulas of the geoelectric problem without to any considerable extent contributing to its solution. The earlier Langer procedure is developed and its advantages indicated. The Stevenson method is only practical to furnish the first member of the exponential series of $\sigma(z)/\sigma(z)$. For the second member a completely different value is obtained compared to the exact one found by the Langer method. The method only gives close results for the immediate vicinity of the surface.—*B. T. E.*

435144—57——3

169–99. Bukhnikashvili, A. V. K voprosu o metodike postanovki elektrorazvedki rudnykh mestorozhdeniy [On the methods of electrical exploration of ore deposits]: Akad. Nauk Gruzinskoy SSR Soobshcheniya, tom 16, no. 10, p. 775–779, 1955.

In electrical exploration for ore deposits it is important to take into account not only the electrical properties of ore bodies but those of the country rock as well, and in particular the effects on the electrical properties of the country rock of hydrothermal alteration.—*S. T. V., L. C. P.*

169–100. Karandeyev, K. B., and Mizyuk, L. Ya. O novoy avtomaticheskoy izmeritel'noy apparature dlya elektrorazvedki metodami postoyannogo toka [New automatic measuring equipment for direct current electrical exploration methods]: Razvedka i okrana nedr, no. 1, p. 36–44, 1956.

Automatic equipment designed and constructed by the "Institute of Machine Design and Automation", of the Ukrainian Academy of Sciences measures and records the voltage E_{MN} and the current I_{AB} in the usual Wenner electrode arrangement. Two sets of instruments make possible measurement of the electromotive force in formations having electrical resistances ranging from fractions of an ohm to a million ohms. Measurements are practically unaffected by telluric or industrial currents. One instrument is a high-speed automatic electron-compensator operating on the principle of static compensation; it is so arranged that the noncompensated part of the measured d-c voltage is converted into a pulse that is amplified and controls through a reversible servo-motor the displacement of the carriage of a slide wire bringing it to the condition of equilibrium. The voltage on the *MN* terminals is recorded every 30 seconds, first with current flowing through the circuit *AB*, then with this current absent, thus giving the data for the evaluation of the disturbances. In the second instrument the measured voltage is amplified by an electron amplifier for direct current. The maximum resistance of this instrument is several tens of megohms. The error in either instrument is within ±2 percent.—*S. T. V.*

169–101. Shapiro, D. A. Sovmestnaya zapis' *KS* and *PS* pri rabote odnopolyusnym potentsial-zondom [Simultaneous recording of the apparent resistivity and the *SP* curves when using single-pole potential probe]: Razvedochnaya i promyslovaya geofizika, vypusk 13, p. 54–56, 1955.

In many oil fields of the Tartar S. S. R. and Bashkiria it is impossible to make measurements of the resistivity curve and the *SP* curve simultaneously because the measuring electrode is affected by intensive galvanic corrosion in carbonate formations of high electric resistivity. This difficulty was overcome by using an additional grounding electrode in the *SP* circuit. No unfavorable effect in the resistivity circuit is noticeable on the *SP* circuit, so the *SP* as well as the apparent resistivity curves can be recorded simultaneously.—*S. T. V.*

169–102. Ivanov, A. G. Priblizhennaya formula dlya rascheta peremennogo magnitnogo polya nad zhiloy [An approximate formula for the evaluation of the alternating magnetic field over a vein]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 211–216, 1957.

The magnetic field H is assumed to change only with the depth (z-coordinate), but not with the coordinates x and y. The vein is assumed to be a plate buried

underground at an angle, α, with the vertical. Starting with the fundamental equations of the theory of electromagnetic field, an expression is given for the normal field without the disturbing body, including the properties of the ground. Then a formula is given for the components of H in the special case when $\alpha=0$, that is, when the vein is vertical, and components of H for several cases of depth of the plate and inclination are shown graphically.—*S. T. V.*

169–103. Ivanov, A. G. Izucheniye fazovoy struktury elektromagnitnykh poley pri elektrorazvedke [Investigation of the phase-structure of electromagnetic fields in electric exploration]: Akad. Nauk SSSR Doklady, tom 110, no. 5, p. 772–775, 1956.

The normal electromagnetic field in a given area, or the field produced by a given source in absence of any disturbing bodies, can be represented as the sum of component waves, the n^{th} one having the form $M(X)=A_n \text{ Sin } (\omega t+\psi_n)$. In the presence of anomalies the disturbed field can be represented as the sum of similarly obtained terms, but with different amplitudes and unknown phase displacements, as compared with the normal field; the corresponding n^{th} wave of the disturbed field will thus have the form $M_a=A_a \text{ Sin } (\omega t+\psi_a)$. The anomaly affecting this term is not the ratio $A_x—A_x$ as is often assumed, but a vectorial difference due to unknown phase displacement. This phase displacement must be considered in determining the anomaly. By knowing the normal field and the anomalies produced in consecutive terms of its development, it is possible to localize the disturbing bodies. An example is given of the location of a long reef buried at the depth of some 50 m. The presence of this reef is clearly visible on the obtained curves of the phase angles.—*S. T. V.*

169–104. Gassmann, Fritz, and Weber, Max. Über geoelektrische Widerstandsmessungen in den Schweizeralpen [On electrical resistivity measurements in the Swiss Alps]: Ver. Schweizer. Petroleum-Geologen u. Ingenieure Bull., v. 23, no. 64, p. 71–77, 1956.

Between Gsteig, Sanetsch Pass and Sitten in the Swiss Alps, 31 resistivity profiles were made totalling 12 km in length, using the Wenner configuration. In the Maggia valley, 22 profiles were made totalling about 8.5 km in length. The two cross sections compiled from these profiles are illustrated. A new instrument is described which measures primary current J and potential difference ΔV, giving direct reading of apparent specific resistivity ρ_a from the equation $\rho_a=2\pi\Delta Va/J$.—*D. B. V.*

169–105. Demidovich, O. A. Opyt primeneniya elektricheskikh metodov pri razvedke presnykn vod v usloviyakh polupustyni [Experiences with the use of electrical methods in exploration for drinking water under semidesert conditions]: Razvedka i okhrana nedr, no. 9, p. 34–43, 1956.

A report on experiences in locating sources of drinking water on the northwestern shore of the Caspian Sea in an area of meager precipitation. Vertical electric profiling was used. Curves were interpreted by comparison with the albums of theoretical curves computed and published in the U. S. S. R. Predictions about the mineral content of the water on the basis of geophysical measurements were confirmed on the whole by drilling in the more favorable areas, where clay content of the ground was negligible.—*S. T. V.*

169–106. Gorelik, A. M., and Nesterenko, I. P. Metod elektricheskogo polya fil'tratsii dlya opredeleniya radiusa depressionnoy voronki pri otkachkakh iz skvazhiny [Electrofiltration potential method in the determination of the radius of the depression hollow during a pumping test from a borehole]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 11, p. 1361–1363, 1956.

When water percolates through a porous medium, an electrical field is produced; the greatest potential gradient is produced in the direction of the flow and the smallest, at right angles to it. When the values measured for various angles around a point are plotted as a polar diagram, the extremities of the vectors form a curve similar to the figure eight. Pumping of water produces a change in the initial electric field because water flows from every point of ground within a certain distance toward the hole. Measuring the potential thus gives the picture of the area feeding the drill hole with water, and makes it possible, in prospecting for water, to make an approximate estimation of the capacity of the borehole as well as to determine the location of the largest source.—*S. T. V.*

169–107. Hackett, James E. Relation between earth resistivity and glacial deposits near Shelbyville, Illinois: Illinois Geol. Survey Circ., no. 223, 19 p., 1956.

Studies made in search for water-yielding deposits in glacial drift near Shelbyville, Ill., demonstrate certain limitations in the use of resistivity methods of ground-water exploration without detailed knowledge of geologic conditions. Geologic factors such as porosity, formation factor, and presence of conductive solids can contribute in large measure to determining apparent resistivities. In the Shelbyville area where the mineral content of the ground water is low, these geologic factors are more important than water quality in producing the observed earth-resistivity effects.—*V. S. N.*

169–108. Lee, Frederick W. Can oil be found by direct methods: Oil and Gas Jour., v. 55, no. 13, p. 109–112, 1957.

Two methods for the direct location of oil and gas, relying on the negative potentials carried by oil or gas-impregnated sands in contact with shales, have been developed. Using Sandexsurvey (sand extension survey) techniques, information is obtained regarding the location and extent of the oil and gas-impregnated portions of a sand penetrated by the well. The Longcolog technique involves only measurements on the surface of the ground.—*D. R. M.*

ELECTRICAL LOGGING

169–109. de Witte, A. J. Saturation and porosity from electric logs in shaly sands: Oil and Gas Jour., v. 55, no. 9, p. 89–93; no. 15, p. 115–121, 1957.

A historical account of advances in the interpretation of formation resistivities is given along with resistivity relations between clean and shaly sands. The parallel development relating to the self-potential in clean and shaly formations is presented and the results obtained are combined into a practical method for computing saturation and porosity from electric logs.—*D. R. M.*

169–110. Chombart, L. G. Reconnaissance et évaluation des formations par diagraphies électriqus et nucléaires [Recognition and evaluation of formations by electrical and radioactivity logs]: Rev. Francais du Pétrole, v. 11, no. 10, p. 1193–1231; no. 11, p. 1353–1390, 1956.

A comprehensive summary of the techniques of interpretation of electrical and radioactivity logs. The first installment concerns general theoretical considerations and conventional resistivity and self-potential techniques; the second installment deals with the directed current resistivity techniques, electrical determination of porosity, and radioactivity logging. Three major conclusions are drawn: the use of the newer resistivity techniques, using directed or focused currents, are unconditionally recommended for any exploration program dealing with heterogeneous or lithologically complex formations; the necessity for coordinated planning of the drilling and formation evaluation phases of a program is emphasized; it is stressed that most accurate interpretations are obtained when all data from all techniques are studied together, whether they be mud logging, core analysis, drill stem testing, or formation logging.—*D. B. V.*

169–111. Martin, M[aurice]. Possibilités actuelles des méthodes de diagraphies électriques et nucléaires. Chapitre 1, Rappel des bases de l'interprétation quantitative des diagrammes électriques [Current possibilities of electric and nuclear logging methods. Chapter 1, Review of quantitative interpretation of electric logs]: Rev. Inst. Français du Pétrole, v. 11, no. 12, p. 1544–1570, 1956.

A review. A list of electrical logging symbols and their definitions is included.—*M. C. R.*

169–112. Miller, C. R., Jr., and Evans, C. B. Logs and cores indicate porosity: World Oil, v. 144, no. 1, p. 115–119, 1957.

Porosities calculated from electric logs obtained under conditions in which the electrodes are in contact with the borehole walls agree favorably with porosities measured on side-wall cores.—*L. C. P.*

169–113. Pirson, S. J. Formation evaluation by log interpretation: World Oil, v. 144, no. 5, p. 159–168, 1957.

A discussion of a new method of determining well productivity based on the determination of relative permeability to various reservoir fluids from electric logs.—*L. C. P.*

169–114. True, H. W. Induction-electrical logging in Oklahoma: Kentucky Geol. Survey Special Pub., no. 9, p. 48–61, 1956.

A discussion of induction logging. Examples are given of induction-electric logs from different wells in Oklahoma.—*V. S. N.*

169–115. Avrov, P. Ya., and Dal'yan, I. B. Opyt prokhodki skvazhin na vodu metodom vrashchatel 'nogo bureniya s primeneniyem promyslovoy geofiziki [Experiences in rotary drilling of wells in prospecting for water, using geophysical well-logging methods]: Razvedka i okhrana nedr, no. 8, p. 47–49, 1956.

In the Aktubinsk region, a semi-desert area of the Kazakh S. S. R. the upper layers of the ground contain very little water and it is often not drinkable be-

cause of the high salt content but layers at greater depths, 300 to 600 m, often contain sufficient good water. In exploration for potable water, drill holes to levels supposedly containing good water are logged by electric and radioactive methods and core specimens are extracted and investigated. The hole is then cased and cleaned of the drill mud. On the basis of the geophysical evidence, the hole is then perforated, beginning from the bottom, by bullets opposite the strata supposedly containing good water.—*S. T. V.*

169–116. Nakabayashi, Kazutaka. Results of electric logging in coal fields of Japan: Mining Geology (Japan), v. 7, no. 23, p. 1–12, 1957.

Electric logging instruments, both standard and micrologging, have been successfully modified for use in coal exploration. Tests in the Ishikari and Saga coal fields of Japan have shown that coal and partings more than two centimeters in thickness can be detected, columnar sections where coal is not recovered can be adjusted, and drillers can be checked when no coal is recovered.—*V. S. N.*

169–117. Boydachenko, V. N., and Tuzov, V. P. Rezul 'taty provedeniya karotazhnykh rabot v Podmoskovnom ugol 'nom basseyne [Results of the well logging in the Moscow region coal basin]: Razvedka i okhrana nedr, no. 2, p. 42–47, 1956.

A special study was made of determining the thickness of the layer over the coal layer by logging alone, without extracting core specimens. In every drill hole curves of apparent resistivity, spontaneous polarization, and induced polarization (or "electrolytic well logging") were obtained. The geoelectric properties of the various materials of the basin were first determined by measurements on numerous drill holes, carefully explored electrically and geologically. By using these data it was possible to interpret every chart obtained from a drill hole showing the values of ρ, *SP*, and *IP* and to construct the corresponding geologic profile. In many places the agreement between the geologic profile established later during the working out of the coal deposit with that found from geophysical well logging was better than with the profile determined by coring.—*S. T. V.*

169–118. Cheremenskiy, G. A. K voprosu opredeleniya mineralizatsii plastovykh vod i kollektorskikh svoystv plastov po dannym karottazha v Zapadno-Sibirskoy nizmennosti [On the problem of determining the mineral content of the formation water and associated properties from well logging data in the Western Siberian lowland]: Vses. nauchno-issled. geol. inst. Materialy, nov. ser., vypusk 8, p. 224–237, 1956.

A review of different methods of determining the mineral content of water contained in the formations penetrated by a drill hole and of the various properties of the formations by using electric well-log data.—*S. T. V.*

169–119. Pigrov, V. M. Nekotoryye zamechaniya po zapisi krivoy *PS* pri pomozhchi stantsii *OKS* [Some observations on the recording of the *SP* curve when using the station *OKS*]: Razvedochnaya i promyslovaya geofiz, vypusk 13, p. 57–61, 1955.

Disturbances caused by magnetization in *SP* logging can be avoided by making structural elements of the hoist of antimganetic steel or, still better, by using a cable with one conductor provided with a sheathing made of antimagnetic steel. It may be necessary to demagnetize the hoist from time to time.—*S. T. V.*

169-120. Pryor, Wayne A. Groundwater geology of White County, Illinois: Illinois Geol. Survey Rept. Inv., no. 196, 50 p. 1956.

In White County the major ground-water supplies from unconsolidated glacial material are supplemented by limited supplies from sandstone bodies of upper Pennsylvanian age. Several thousand electric logs of wells were used to map distribution of the sandstone aquifers and to determine the quality of the water in the aquifers.—*V. S. N.*

ELECTRICAL PROPERTIES

169-121. Noritomi, Kazuo, and Asada, Akie. Studies on the electrical conductivity of a few samples of granite and andesite: Tōhoku Univ. Sci. Repts., 5th ser., v. 7, no. 3, p. 201–207, 1956.

Measurement of the change of electrical conductivity with temperature in samples of granite and andesite show different relationships for temperatures below 500° C, from 500° C to 900° C, from 900° C to 1,100° C, and above 1,100° C. Conductivity seems to depend on that of the silicate minerals present. At temperatures below 800° C, however, it depends on Fe_2O_3 and Al_2O_3 and seems to be a process of semiconduction caused by the element having small activation energy. Marked changes are observed near the melting point of the samples. From the melting point to 1,500° C the conductivity seems to be less dependent on temperature. (See also Geophys. Abs. 163–67 and 164–128)—*B. T. E.*

169-122. Polak, L. S., and Rapoport, M. B. O svyazi mezhdu elektricheskimi i uprugimi svoystvami osadochnykh porod [Correlation between electrical and elastic properties of sedimentary rocks]: Prikladnaya geofiz., vypusk 15, p. 127–134, 1956.

Both electrical conductivity and the elastic properties of rocks are related to porosity. The elastic properties of specimens from drill holes in the Kazakh S. S. R. were determined by measuring the coefficient of elastic rebound. By statistical methods it was then found that the coefficient of the correlation between the electrical resistivity and the acoustic rigidity was equal to or greater than 0.7. Similarly, the coefficient of correlation between the electrical resistivity and the velocity of seismic waves was 0.65. It is believed that these values would be higher if the core specimens could be obtained in better shape. By using these coefficients of correlation it should be possible to determine from electric logs at least approximate values of seismic velocity in different strata in the drill hole.—*S. T. V.*

169-123. Mandel, Peter, Jr., Berg, Joseph W., Jr., and Cook, Kenneth L. Resistivity studies of metalliferous synthetic cores: Geophysics, 22, no. 2, p. 398–411, 1957.

The observed resistivities of synthetic cores comprising disseminated test lead particles, quartz sand grains, and commercial cement (25 percent by volume) and saturated with NaCl solutions are apparently best represented by a relationship similar to that of an electrically parallel circuit. The empirical relationship that best approximated the experimental data is:

$$\frac{I}{\rho_t}=\frac{\alpha}{\rho_{Pb}}+\frac{I}{F_P\rho_w},$$

where ρ_t is the observed resistivity of the core; ρ_{Pb} is the resistivity of the lead; F_P is the formation factor that the core would have if none of the solid materials

were conductive; ρ_w is the resistivity of the saturating conductive fluid; and α is a parameter dependent upon the fractional volume of the fluid (ϕ_w), the fractional volume of lead (ϕ_{Pb}), and other factors. These experiments indicate that α can be approximated as follows:

$$\alpha \approx C10^{100\phi_w}(\phi_{Pb})^K$$

where C and K are "constants" for these particular experimental conditions.

It was found that the observed resistivity varies markedly with changes in either lead content or the fractional volume of saturating conductive fluid. At low values of the fractional volume of lead, the current conduction through the cores is largely electrolytic, and the observed resistivity is strongly influenced by changes in the fractional volume of the saturating fluid. When the fractional volume of the saturating fluid is maintained relatively constant and the lead content is increased, the observed resistivity decreases because some of the current is conducted through the lead particles by electronic conduction.—*Authors' abstract*

169–124. Henkel, John H., and Van Nostrand, Robert G. Experiments in induced polarization: Mining Engineering, v. 9, no. 3, p. 355–359, 1957.

Induced polarization is a transient electrochemical phenomenon in which integrated electrochemical signals are generated by the flow of electrical current. It is a surface phenomenon and is present wherever the mode of electrical conduction changes, for example, from electrolytic to metallic. Clay particles are of prime importance in polarization in the earth because they tend to obstruct the passage of anions.—*L. C. P.*

169–125. Rokityanskiy, I. I. Laboratornoye izucheniye vyzvannoy polyarizatsii osadochnykh porod [Laboratory investigation of induced polarization in sedimentary rocks]: Akad. Nauk SSSR Izv. Ser. geofiz., no 2, p. 217–227, 1957.

Induced polarization was tested as an indicator of the electrical properties of rocks. Induced polarization in rocks consists of two components, one dielectric, the other ionic. Quartz sand, which was boiled several times in hydrochloric and nitric acids and rinsed with distilled water, was studied first. Using standard methods, induced polarization was produced and recorded on an oscillograph. The same measurements were repeated with different electrolytes having monovalent, bivalent, and trivalent cations. The induced polarization decreases approximately with time following an exponential law.—*S. T. V.*

169–126. Fritsch, Volker. Zur Frage der geoelektrischen Blitzgefährdung [On the question of geoelectrical lightning risks]: Geofisica Pura e Appl., v. 35, p. 149–160, 1956.

Results obtained in Austria indicate certain places are more often struck by lightning ("lightning nests") and the phenomenon is related to the electrical properties of the ground.—*M. C. R.*

EXPLORATION SUMMARIES AND STATISTICS

169–127. Itenberg, S. S. Geofizicheskiye metody razvedki [Geophysical methods of prospecting], *in* Vassoyevich, N. B., ed., Sputnik polevogo geologa-neftyanika [The vade-mecum of the oil geologists in the field]: tom 2, p. 374–402, Leningrad, Gostoptekhizdat, 1954.

A discussion of the physical bases and the applications of the gravitational, magnetic, seismic, and electric methods.—*S. T. V.*

169–128. Dakhnov, V. N. Geofizicheskiye metody issledovaniya skvazhin [Geophysical methods of the exploration of drill holes], *in* Vassoyevich, N. B., ed., Sputnik polevogo geologa-neftyanika [The vade-mecum of the oil geologists in the field]: tom 2, p. 350–373, Leningrad, Gostoptekhizdat, 1954.

A brief discussion of electric, thermal, and radioactive methods of the exploration of drill holes. Typical graphs are given.—*S. T. V.*

169–129. Holmer, Ralph C. Geochemistry and geophysics in 1956: Mining Engineering, v. 9, no. 2, p. 208–221, 1957.

Geochemical exploration, supplementing geophysical work, is now established on a worldwide basis. Geophysical exploration in mining has continued to increase, characterized by a diversification of methods. There is a definite trend toward smaller geophysical equipment. Applied geophysical research is being done in nuclear resonance, magneto-telluric, and induced polarization methods.—*L. C. P.*

169–130. Dobrin, Milton B., and Dunlap, Henry F. Geophysical research and progress in exploration: Geophysics, v. 22, no. 2, p. 412–433, 1957.

The second annual review of current developments in exploration geophysics, primarily of research in universities and non-commercial institutions.—*M. C. R.*

169–131. Hourcq, V. Bassins sédimentaires du Cameroun [Sedimentary basins of the Cameroun]: Internat. Geol. Cong., 20th, Mexico 1956, Symposium sobre Yacimientos de Petróleo y Gas, tomo 1, p. 45–68, 1956.

This study is primarily on the stratigraphy of the Douala sedimentary basin in the Cameroun of Africa, but it includes an outline of geological and geophysical surveys in this difficult terrain, much of which is mangrove swamp. A gravity survey of the area north of the Sanaga, consisting of 1,000 measurements, one for every 5 sq km, showed the broad configuration of the basement. Anomalies were investigated further by reconnaissance telluric surveys and electric depth profiling, which fully confirmed the interpretation of the gravity surveys. Seismic reflection surveys over the whole basin gave mediocre and variable results, therefore a core drilling program was instituted in selected areas, supplemented by seismic surveys, which led to the discovery of gas in the upper Cretaceous west of Momono and at Logbaba. As a result of special reflection surveys in the navigable channels of the Wouri estuary and along the coast (645 m of fluvial profiles, 125 m of marine), and drilling at Souellaba, oil and gas indications were found in the Paleocene more than 2,500 m deep. Exploration is still in progress.—*D. B. V.*

169–132. Hourcq, V., and Reyre, D. Les recherches pétrolières dans la zone cotière du Gabon (Afrique Équatoriale Française) [Petroleum exploration in the coastal zone of Gabon (French Equatorial Africa)]: Internat. Geol. Cong., 20th, Mexico 1956, Symposium sobre Yacimientos de Petróleo y Gas, tomo 1, p. 114–141, 1956.

The stratigraphy and structure of Gabon are the principal subjects of the report. Geophysical surveys in Gabon include a telluric survey of the Azingo zone

which was followed by general gravimetric reconnaissance of both the Atlantic and Eastern sedimentary basins. Seismic surveys were begun in 1949 and until 1952 were devoted mainly to study of the detailed structure of the Eastern basin, as were telluric surveys. In 1953 detailed seismic work was begun in the Atlantic basin, where reconnaissance gravity surveys had revealed numerous salt domes. A semidetailed gravity survey (1 station per km^2) was made in the savanna zone between the Ogooué and the equator. By use of seismic methods salt domes were found under the delta and coastal area where gravity anomalies had died out owing to decrease in density contrast between the salt and surrounding sediments.—*D. B. V.*

169–133. Evrard, P[ierre], and Lepersonne, J. État des connaissances concernant l'existence de gisements de pétrole au Congo belge et au Ruanda-Urundi [State of knowledge concerning the existence of petroleum deposits in the Belgian Congo and Ruanda-Urundi]: Internat. Geol. Cong., 20th, Mexico 1956, Symposium sobre Yacimientos de Petróleo y Gas, tomo 1, p. 69–78, 1956.

Intensive geological and geophysical exploration of the Congo basin began in 1951. Seismic surveys of regions accessible by road or by water covered an area of 750,000 km^2, with 113 refraction profiles and reflection surveys in a circuit of about 200 km; regional gravity and magnetic surveys, with stations spaced 5 km apart on the average, were made over the same area. A second exploratory borehole is in progress. Other promising areas in this part of Africa include the Atlantic coastal zone and the northern part of the Western Rift Valley. Gas has already been found under Lake Kivu.—*D. B. V.*

169–134. Link, Walter K. Exploration Brazil 1955: Internat. Geol. Cong., 20th, Mexico 1956. Symposium sobre Yacimientos de Petróleo y Gas, tomo 4, p. 61–63, 1956.

A brief outline of the work of the Exploration Department of Petrobrás during 1955, its first complete year of operation. Six seismograph crews operated, two in the Amazon Basin all year, one in the Maranhão São Luis Basin, two in the Rio Grande do Norte (10 months) and Alagôas (2 months), and one in the Recôncavo Basin of Bahia (all year). Of the four gravimeter crews, one operated in the Amazon, two in the Recôncavo, and one in Alagôas (2 months). The magnetometer crew worked in the Amazon all year. Geological surveying, aerial photography, and exploratory drilling were also part of the program.—*D. B. V.*

169–135. Warman, H. R., Roberts, K. H., Brunstrom, R. G., and Adcock, C. M. Report on oil and gas in the United Kingdom: Internat. Geol. Cong., 20th, Mexico 1956, Symposium sobre Yacimientos de Petróleo y Gas, tomo 5, p. 317–357, 1956.

This paper deals mainly with the petroleum geology of the United Kingdom. In the East Midlands oilfields, from which comes the only significant commercial production, the producing anticlines are buried beneath horizontal Mesozoic rocks. The first field discovered, at Eakring in 1939, was deduced from mining and borehole evidence, later confirmed by a refraction survey. Extensive refraction surveys in 1941–1943 then disclosed the Duke's Wood, Kelham Hills, Caunton, and Nocton anticlines, and in 1953 the Plungar was discovered as a result of reinterpretation of an earlier refraction survey. The Egmanton field was discovered in 1955 by seismic reflection. Seismic work and exploratory drilling are hampered by the presence of mining activities, intensive agriculture,

and relative density of habitation, and development is affected by existing land utilization.—*D. B. V.*

169–136. Brinckmeier, Georg. Eine Scholleneinteilung des nordwestdeutschen Raumes [A distribution of structural elements of the northwest German area]: Erdöl u. Kohle, Jahrg. 10, Heft 3, p. 133–141, 1957.

A description of the structural elements in northwestern Germany, delineated largely on the basis of seismic information. Correspondence of the structural lines with gravity and magnetic maps is generally poor, as those anomalies usually reflect much deeper conditions.—*D. B. V.*

169–137. Kertai, Gy. Oil and natural gas in Hungary: Internat. Geol. Cong., 20th, Mexico 1956, Symposium sobre Yacimientos de Petróleo y Gas, tomo 5, p. 275–315, 1956.

The major part of this paper concerns the geology of the various Hungarian oil fields. Because a large part of Hungary is underlain by Tertiary basins in which surface outcrops give no structural information, most petroleum exploration must be carried on by means of indirect geological and, particularly, geophysical methods. All the basins have been mapped with the torsion balance (subsequent drilling has been most successful in places of gravity maximums disclosed by these surveys). Since 1935 gravimetric surveys have been in progress, and in 1949–50 a gravity map of the country was compiled from torsion balance and gravimeter measurements. Seismic measurements were made sporadically between 1935 and 1944 and a magnetometer survey of the Pannonian Basin was made in the same period. Magnetic mapping of the other basins is now almost complete. Large-scale seismic surveying was begun in 1952; thus far 2,500 km of reflection profiles have been completed, accompanied by exploratory drilling (5 holes 2,500–3,000 m deep in the Great Plain and 3 in Transdanubia). Structures revealed in these profiles are being investigated by detailed seismic surveys. Telluric current surveys were introduced in 1955. Geochemical exploration (soil-gas and bitumen analyses) has thus far shown little success.—*D. B. V.*

169–138. Evans, P., and Metre, W. B. Recent geological work in Upper Assam: Indian Minerals, v. 10, no. 3, p. 191–201, 1956.

Geophysical investigations of the alluvial valley of Upper Assam were first made about 30 years ago, but have been intensified since successful drilling for oil in 1953. Magnetic, gravity, and seismic surveys have been made; the latter were still in progress at the time of writing. Interpretation of the seismic data is complicated because of the stratigraphic and structural complexities; in combination with geologic evidence and drilling, however, the seismic evidence has "so far proved petroleum reserves sufficient to sustain production of about a million tons annually, a quarter of India's present requirement."—*M. C. R.*

169–139. Hourcq, V. Les recherches de pétrole à Madagascar [Petroleum exploration in Madagascar]: Internat. Geol. Cong., 20th, Mexico 1956, Symposium sobre Yacimientos de Petróleo y Gas, tomo 1, p. 151–190, 1956.

Several pages of this report on the stratigraphy and structure of the Morondava basin of Madagascar are devoted to discussion of geophysical exploration. The telluric method, supplemented by electric depth profiling, was generally found to be most suitable for determining the configuration of the basement. Aeromag-

netic and gravity surveys were made of the southern part of the basin, beginning in 1954, along with local electric depth profiling, seismic reflection surveys, and exploratory drilling, to clarify the distribution of the Karroo system (in which all oil and gas indications were found) under its cover. In 1956 these studies were extended northward.—*D. B. V.*

169–140. Riel, W. J. van. Enige aspecten van de exploratie van het Peelgebied [Some aspects of the exploration of the Peel region (with English summary)]: Geologie en Mijnbouw, jaarg. 19, no. 3, p. 53–61, 1957.

Exploration of the Peel coal region in the Netherlands is described as an example of integrated drilling, geological, and geophysical techniques. The field was discovered and delineated by a government drilling campaign in 1918. After a long interruption, geological core and sample studies and a gravity survey, during 1940–45, supplied information on the structure and overburden. Finally during 1952–56 a seismic reflection survey together with electrical logging in a few additional boreholes contributed considerably to a better understanding of the overall geological picture.—*D. B. V.*

169–141. Gavala, Juan, and Taylor, Earle F. Oil exploration by Valdebro in Spain: Internat. Geol. Cong., 20th, Mexico 1956, Symposium sobre Yacimientos de Petróleo y Gas, tomo 5, p. 205–215, 1956.

Since 1952 the Valdebro Commission for Petroliferous Investigations ("Valdebro") has carried on a major part of the intensive search for oil and gas in Spain. Geophysical work has been a part of the Valdebro program almost from the start. Seismic surveys have included those of the Falces anticline in the Ebro Valley, extended to the Tafalla anticline and later to the Puente de la Reina area; in the Duero River basin; in the Cuenca area (profiles across the San Lorenzo, Villanueva, and Cerro Morro anticlines); and at Jerez de la Frontera in the south (to check gravity anomalies and outline drilling sites). Gravity surveys began early in 1954 in the Guadalquivir basin in southern Spain, then moved to Zaragoza in the north central part of the country; final interpretation is not yet available. In the meantime additional gravity reconnaissance operations are under way in the south. Exploratory drilling is under way, with three holes completed and a fourth in progress.—*D. B. V.*

169–142. Green, Cecil H. The status and psychology of geophysical exploration within the petroleum industry: Mines Mag., v. 47, no. 5, p. 27–30, 1957.

A general review of geophysical exploration in the oil industry. It is noted that the present-day cost of finding and producing a barrel of oil in the United States is about $3, or six times the cost 1942. During the past 12 years, nearly three times as many new-field wildcat wells have been successful when located on technical advice than when such advice was lacking.—*L. C. P.*

GEODESY

169–143. Nakamura, Saemon Taro. On the surface figure of the earth, the moon, and other planets: Kumamoto Jour. Sci., ser. A, v. 1, no. 1, p. 50–52, 1952; no. 2, p. 35–37, 1953; v. 2, no. 1, p. 90–91, 1954; no. 2, p. 162–166, 1955; no. 3, p. 289–294, 1955.

Love's harmonic analysis of the continental distribution implies that the present distribution of continents is at least quasi-stable and has physical meaning,

but by Wegener's theory the continents are moving. Any continuous function distributed on a spherical surface can be expressed by a series of spherical harmonics, and if a harmonic series that fits some part of the figure also fits the remaining part, the physical significance may be increased. The harmonic series obtained by using data of the continents between longitudes 0° and 210° E. indicates a large continent in a position nearly coinciding with North America when terms are taken to the 3d and 5th orders. When terms are calculated to the 7th order, the 5th order term is the largest; some agency with a frequency corresponding to this mode (calculated from the Kelvin equation as 23.7×10^{-4} per sec) is indicated. The maximum term computed for Mars is at nearly the same frequency as that for the earth; that for the moon is smaller. It is proposed that some extra-solar agency caused oscillations of the same frequency on each, but that those of the moon have been damped by tidal action. The figure of the moon is calculated to be pear shaped.—*B. T. E., M. C. R.*

169–144. Wolf, Helmut. Das von L. Tanni bestimmte Geoid und die Frage der Elliptizität des Erdäquators [The geoid determined by L. Tanni and the question of the ellipticity of the earth's equator]: Deutsche Geod. Komm. Veröffentl., Reihe A, Heft 12, 29 p., 1956.

A new calculation based on Tanni's geoid furnishes the smallest value yet obtained for the ellipticity of the equator: 85.60 m for the actual geoid, 108.59 for the isostatic co-geoid. By using these values the amount of displacement of the earth's center of gravity from the land to the water hemisphere is calculated to be 16.2 ± 1.3 m as against the theoretical value of 5 m, indicating deficiencies in the observational material. Statistical consideration of geoidal undulations shows that they vary systematically and regionally. After a historical review of the question of ellipticity of the equator and discussion of the concept of overcompensation, it is suggested that introduction of another term in the expansion series could eliminate, by interpolation, the systematic effect of inadequacies in observations and give more plausible mean values of, for example, the average radius of the equator or the average gravity on the equator.—*D. B. V.*

GEOTECTONICS

169–145. Dingemans, Guy. Formation et transformation des continents [Formation and transformation of continents]: 182 p., Paris, Librairie Armand Colin, 1956.

Current theories of the formation and transformation of continents are reviewed. According to the latter, continents were originally one mass. They were divided into separate entities by a process similar to that observed in the sun and stars, which have a plastic constitution, and do not rotate around their polar axis as one mass. The speed of rotation of the viscous masses increases progressively from the poles to the equator. Because the earth's magmatic interior is plastic it must be subjected to the same phenomenon. Viscous masses between two latitudes are greater near the equator, therefore a great solid block floating between the pole and the equator would be more attracted to the masses in the equatorial region. It is then not the continents that have a tendency to drift in relation to the underlying sima but the latter which has the tendency to drag the continents with it, as well as the suboceanic blocks, causing the considerable folding, faulting and displacement that takes place in the lithosphere. The explanation of this theory is followed by detailed illustrated descriptions

of the probable aspect of the earth during geologic period and predictions as to its future appearance.—*B. T. E.*

169–146. Aggarwala, B. D., and Saibel, Edward. A hypothesis of formation of mountains and continents: Am. Geophys. Union Trans., v. 38, no. 2, p. 245–247, 1957.

In an earth model of liquid, spherically homogeneous visco-elastic material cooling radially from the surface inwards, thermal stresses produced by cooling in the crust will cause fracturing or buckling. From Timoshenko's discussion of buckling of a thin spherical shell, it can be inferred that for a shell as much as 32 km thick, the strength of the earth would be sufficient to transmit stresses by buckling. Cooling stresses would be so high that failure stress would be reached almost immediately. Failure, therefore, would presumably be by buckling. The buckling would produce depressions and humps that later would become oceans, continents, and mountains.—*M. C. R.*

169–147. Vyskočil, Vincenc. Příspěvek ke studiu současných tektonických pohybů na Slovensku [A contribution to the study of the present tectonic movements in Slovakia]: Czechoslovakia Ústředni ústav geol. Věstník, ročník 31, čislo 5, p. 224–223, 1956.

Comparison of leveling surveys during 1948–52 with those of 1921–38 indicates relative changes of height that are attributed to tectonic movements; the Carpathian Mountains of western and central Slovakia are being uplifted in relation to the lowland area in the south, probably isostatically.—*M. C. R.*

Koning, L. P. G. Seismic-evidence on orogenic processes. See Geophys. Abs. 169–50.

GLACIERS

169–148. Steinemann, Samuel. Flow and recrystallization of ice. Internat. Geod. Geophys. Union Assoc. Sci. Hydrology Pub. 39, tone 4, p. 449–461, 1954.

Laboratory experiments of tension and compression tests on ice bars at −4.8° C show that the proposed exponential creep law for ice is only a good approximation, the exponent varying from 1.6 to 4 for 0.6 to 16 kg cm^{-2}. At deformations of about 2 percent recrystallization under stress sets in, changing grain sizes, producing a complex intergrowth and a preferred orientation.

Direct observations on recrystallization in thin sections by special method (thin section frozen on a glass plate is compressed between two rubber sheets so that a defined stress is applied and deformation can be derived from surface measurements of the ice specimens; after the deformation a series of photographs are taken to determine grain growth) show that induction period, rate of recrystallization and resulting grain size are connected to creep rate.

Application to field studies are proposed: A non-exponential creep law fits better with measurements on glaciers. Grain growth in glaciers can be explained as primary recrystallization under stress, the appropriate grain shape being an intergrowth. The process is periodical at lower, continuous at higher stresses. Textures are a consequence of this process.—*Author's summary*

169–149. Robin, G. de Q. Some factors affecting the temperature distribution in large ice sheets: Internat. Geod. Geophys. Union Assoc. Sci Hydrology Pub. 39, tone 4, p. 411–420, 1954.

The distribution of temperature throughout an ice sheet has been considered, taking into account the influence of ice movement as well as other items previously considered, such as conduction, the geothermal outflow of heat and heat generated by ice movement. By making certain simplifying assumptions, a quantitative method of estimating the temperature distribution near the centre of an ice sheet has been put forward. It is shown that even a small mean annual accumulation will have considerable effect on the temperature distribution in a large ice sheet. For a moderate rate of accumulation a substantial fraction of the total thickness of ice at the centre of a large ice sheet may be isothermal at the prevailing surface ice temperature. Under these conditions at some distance from the centre, the change in the surface ice temperature with elevation may produce a temperature gradient opposite to normal, that is the temperature falls with increasing depth below the surface, due to the outward movement of the ice. It is suggested that a rise from temperatures below melting point at the base of ice sheets may provide an explanation of the occasional catastrophic advances of certain glaciers.—*Author's abstract*

169–150. Haefeli, Robert. Gletscherschwankung und Gletscherbewegung [Glacier fluctuations and glacier flow]: Versuchsanstalt für Wasserbau u. Erdbau [Zürich] Mitt., no. 40, p. 2–16, 1957.

The Rhône glacier in Switzerland is studied in detail as an example of glacier retreat of the past 100 yrs. Relationships apparent between retreat and advance movements, ablation, changes in size and shape of the glacier, and temperature are discussed in detail, qualitatively and quantitatively, and illustrated by 20 figures and photographs, and 6 tables.—*B. T. E.*

169–151. Robin, G. de Q. Ice thickness measurements in Queen Maud Land Antarctica: Internat. Geod. Geophys. Union Assoc. Sci. Hydrology Pub. 39, tone 4, p. 421–428, 1954.

Seismic reflection measurements along a profile 625 km long in a general southeasterly direction from Maudheim indicate that inland from Maudheim the ice consists of two floating ice shelves separated by an ice hill, a second group of ice hills, an inland ice sheet, and an inland plateau. The ice shelves are several hundred feet thick. The ice hills consist of an ice mass resting on a relatively level base below sea level; their form is apparently determined by the mechanism of ice flow rather than the underlying relief. The topography beneath the inland ice is a rugged alpine and fjord type comparable to that of the west coast of Norway.—*M. C. R.*

GRAVITY

169–152. Graf, Anton. Über die Genauigkeit von Gravimetern bei Grossentfernungsmessungen (über 600 km Profillänge) [On the accuracy of gravimeters for long-distance measurements (over a 600-km profile)]: Bayerische Akad. Wiss. Sitzungsber. math-naturw. Kl., Jahrg. 1956, p. 23–31, 1957.

A gravity survey was made over a 600 km profile from Stuttgart to Harzburg to determine the accuracy of a long-distance survey. A Worden, a North American, and two Askania gravimeters were used, and 23 stations were set up about 15 to 20 km apart. Readings obtained by each gravimeter are shown. Results were reduced by two different methods; the errors obtained were ±0.05 mgal and ±0.08 mgal. Most important is that all the apparatus be calibrated over the

same gauge distance before and after a comparison measurement, and that it be set up at identical places and the same elevation observed. Each apparatus should work with a micrometer and not with an average (mean) value for the gauge constant. With more accuracy in the measurements an error of less than 0.08 mgal for a total anomaly of 334 mgals can be reached.—*B. T. E.*

169–153. Lundberg, Hans. Airborne gravity surveys: Canadian Oil and Gas Industries, v. 10, no. 4, p. 121–122, 1957.

An instrument for making airborne gravity surveys was tested over the Ground Hog mine, Ontario, Canada, and over the Michigan Basin oilfield. In the instrument, two small masses are suspended vertically above each other so that the distance between them varies proportionately to the vertical gradient. The variation is small, but positive or negative portions of the change in vertical gradient can be mapped along the flight lines. Future developments will make it possible to record the changes.—*V. S. N.*

169–154. Yurkova, L. A., and Poloyko, F. Z. Opyt raboty s gravimetrami vysotomerami [Experiences with the use of combined gravimeter-altimeters]: Razvedochnaya i promyslovaya geofizika, vypusk 13 p. 10–16, 1955.

In 1954 a gravimetric survey was made of an area of about 5,100 sq km in the Aktyubinsk Oblast, central Asia. The area is a desert without roads and had not been surveyed topographically. The elevation of a few base stations was first determined by geodetic measurements with an accuracy of ±0.12 m; gravity was measured at these stations using a Nørgaard gravimeter with an accuracy of ±0.3 mgal. The altitude of other stations was determined barometrically using two gravimeter-altimeters of Russian construction, one at the next base station, another at the point of the measurements. Check of the final gravity determinations, and the altitude of different stations, shows that the error is less than ±1.5 mgal.—*S. T. V.*

169–155. Gabriel, V. G. Use of gravity meter as a torsion balance: World Oil, v. 144, no. 5, p. 146–150, 1957.

The torsion balance gradients can be calculated directly from the gravity field measured with the gravity meter.—*L. C. P.*

169–156. Bonini, William E., and Woollard, George P. The observation accuracy of high-range geodetic-type Worden gravimeters: Am. Geophys. Union Trans., v. 38, no. 2, p. 147–155, 1957.

The operation of two high-range geodetic-type Worden gravimeters on a program to establish primary gravimeter stations around the world afforded an opportunity to obtain detailed information on the accuracy of such instruments. During the 6 months of the survey the instrumental drifts were reasonably constant at about 0.05 mgals per hour. Variations in drift were caused by agitation and temperature effects. Closure errors on the world-wide loop were +0.1 and —0.2 mgals; larger closure errors in individual loops are explainable as tares or error resulting from rough landings. The relative accuracy over a five-gal range is ±0.3 mgal, when the survey is carefully controlled. When the instruments are calibrated on an absolute basis against modern pendulum measurements, a similar accuracy of observed gravity is possible anywhere in the world.—*M. C. R.*

169–157. Cook, A[lan] H[ugh]. Comparisons between relative gravity measurements with the Cambridge pendulum apparatus and Worden gravity meters in North America, South Africa, Australia, New Zealand, and Great Britain: Royal Astron. Soc. Monthly Notices, Geophys. supp., v. 7, no. 5, p. 228–255, 1957.

The invar pendulums of the Cambridge pendulum apparatus are ferromagnetic and their periods are affected by the Earth's magnetic field. Before 1952, the pendulums were shielded from the Earth's field by a mu-metal screen; since 1952 Helmholtz coils have been used to annul the Earth's field. To see if there is any discrepancy between results with the two systems, pendulum observations made with the screened system in South Africa, Australia, New Zealand, and Great Britain, and with the Helmholtz coil system in North America, have been compared with gravity meter observations made by Dr. G. P. Woollard and his collaborators. The observations, in these groups—South Africa; Australasia and Great Britain; and North America—have been adjusted by the method of least squares, a calibration factor for the gravity meter being calculated, for each group. There is no significant difference between the factors so calculated and accordingly no detectable difference between the two pendulum systems.

The calculated calibration factors of Dr. Woollard's gravity meters 10e and 41b are 0.1 percent greater than those used in calculating the values published in 1952 and 1953 (Woollard, Harding, Muchenfuss, Bonini, and Black, 1952; Woollard, Bonini, Black, Rose, and Ault, 1953). The pendulum observation between Cambridge and Melbourne has a residual of nearly 1.2 mgal; otherwise the pendulum observations in South Africa and Australasia form a satisfactory basis for gravity surveys there. Two pendulum observations between Ottawa and Washington differ by 2.8 mgal and the differences of gravity between Ottawa, Washington, and Teddington (NPL) may be uncertain by about 1 mgal.—*Author's summary*

169–158. Grant, Fraser. A problem in the analysis of geophysical data: Geophysics, v. 22, no. 2, p. 309–344, 1957.

The problem is to analyze mapped data into components which may be termed "trend" and "residual." The approach used is polynomial fitting by least squares, following the method of DeLury when the data are evenly distributed (or sampled), and of Kendall when they are not. The DeLury method, however, is extended somewhat in scope to include missing values. A number of statistical tests are discussed which should assist in determining the optimum amount of complexity to ascribe to "trend." The attitude taken throughout this paper is unbiased in the sense that positive and negative residuals are held a priori to be equally unlikely. An example is given of the regional correction of a gravity survey designed to explore for sulfides near Val d'Or, Quebec. In conclusion, a brief discussion is given of the advantages of polynomial fitting over smoothing and "gridding" methods from the point of view of labor and costs.—*Author's abstract*

169–159. Kuzivanov, V. A. Ob analiticheskom prodolzhenii gravitatsionnogo potentsiala vo vnutrennyuyu oblast' [On the analytic continuation of gravity potential into the interior domain]: Akad. Nauk SSSR Izv. Ser. goefiz, no. 12, p. 1419–1426, 1956.

435144—57——4

Analytical continuation of the gravity potential into the earth can be made in two different inverse problems of gravimetry, namely, in the determination of the shape of the geoid and in the determination of the depth of disturbing bodies. There are many objections of a mathematical nature against analytical continuation into the earth without certain corrections based on knowledge of near-surface geology. Thus use of the method is not satisfactory when the position of the disturbing bodies sought is unknown.—*S. T. V.*

169–160. Kudryavtsev, Yu. I. Ploskaya obratnaya zadacha geofiziki [The inverse two-dimensional problem of geophysics]: Leningrad Univ. Uchenyye Zapiski, no. 210, p. 83–92, 1956.

Solutions of the inverse problems of geophysics facilitate the interpretation of anomalies of gravitational and magnetic fields. The error of determining the depth to the center of a disturbing mass by integration between infinite limits is inadmissibly high because of the uncertainty in the determination of the normal field. This makes it necessary to find another method free of this drawback. Two formulas of Kazanskiy for determining the depth of disturbing masses are analyzed and the errors inherent in these formulas evaluated; certain simplifications facilitating numerical calculations are introduced. The final errors of the suggested procedure range from 10 to 20 percent of the total depth. Kudryavtsev also discusses the accuracy of formulas for determining the potential field below the surface of the ground from the values of the potential function and its derivatives measured on the surface. The problem is solved only for two-dimensional bodies.—*S. T. V.*

169–161. Gerrard, J. A. F., Strickland, L., and Wade, A. L. Gravity anomaly simulator: Rev. Sci. Instruments, v. 28, no. 6, p. 438–442, 1957.

An instrument that will simulate the anomalous gravity effects of a subsurface body that has a density different from its surroundings is based on the similarity between the equation for the vertical component of gravity at a point on the surface of the earth and Lambert's cosine θ law. It consists of a photocell that can be moved horizontally over cutouts of horizontal sections of the anomaly-producing body; each cutout, of black matte paper, rests on a flashed opal glass beneath which is a single incandescent bulb and reflector. The output of the photocell is applied to a meter through an amplifier circuit, for which a diagram is given.— *M. C. R.*

169–162. Collette, B. J. The physical interpretation of gravity data (Some remarks in connection with J. Hospers' paper "Gravity and crustal shortening in the Alps"): Geologie en Mijnbouw, jaarg. 19, no 3, p. 71–73, 1957.

Collette suggests that Hospers (see Geophys. Abs. 168–200) contradicted himself when he started that lateral compression seems to be the only possible agent that can explain gravity anomalies in the Alps and then that van Bemmelen's theory—which precludes the possibility of lateral compression—is one of two that can account for the observed facts. He uses the Po basin as an example to show that the physical interpretation of anomalies is more accurate than the geometric and "leads to the intelligible study of the stress fields in the earth as developed by Vening Meinesz"; that van Bemmelen's theory can be rejected; and that lateral forces probably gave rise to the Po basin. Rather large negative anomalies can never be accounted for by the presence of light sediments; a depression in which

sediments are deposited must exist before the sediments come in; therefore, the negative anomaly must also exist before and be partially compensated by the filling. Erroneous results are also attributed to the geometric interpretation in van Bemmelen's calculations concerning the present compensation of Cyprus (see Geophys. Abs. 166–193).—*D. B. V.*

169–163. Thyssen-Bornemisza, Stephan [von]. Das zweistufige Gravimeter-Messverfahren [The two-stage gravimeter measurement method]: Erdöl u. Kohle, Jahrg. 10, Heft 2, p. 8–9, 1957.

The vertical gradient of gravity can be determined in the field with an accuracy of ±10 Eötvös by means of determinations at two different levels at the same station, from the formula $W_{zz}=\Delta g/\Delta h+\Delta t/\Delta h$, where Δh is the vertical distance between determinations (as little as 4 m) and Δt is the topographic correction. The effect of topography is negligible beyond a distance of 3 m from the station. In hilly country the curvature value can be determined more rapidly, cheaply, and accurately from such gravimeter measurements; in flat areas the torsion balance gives better results. Variations in density within 3 to 10 m under the station may affect the measurements; therefore the method should be used only where the area underlying the station is of "equal density and homogeneity," the allowable limits to be determined for each case. This "undesirable" sensitivity may be used to distinguish the effect of near-surface disturbances and can be used to correct Bouguer values where the level of reference of the gravimeter is near the earth's surface.—*D. B. V.*

169–164. Kazinskiy, V. A. Ob uchete vliyaniya topograficheskikh mass na podzemnyye gravitatsionnyye izmereniya [Correcting for topographic masses in making gravity measurements underground]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 1, p. 30–38, 1957.

When reducing underground gravimetric readings to a new plane, it is necessary to take into account the disturbances produced by empty volumes resulting from mining activity and other factors as well as the effect of variations of topographic relief. Interpolation polynomials in the form of two parabolas of the second order, and approximate evaluation of integrals by Stirling's formula, can be used to evaluate these effects.—*S. T. V.*

169–165. Whetton, J[ohn] T., Myers, J. O., and Smith, R. Correlation of rock density determinations for gravity survey interpretation: Geophys. Prosp., v. 5, no. 1, p. 20–43, 1957.

Densities of a series of Carboniferous, Permian, and Triassic rocks in Yorkshire were determined on samples from coal mine and quarries, borehole samples, by Nettleton's method, and by measurement of the vertical change of gravity in a mine shaft. The last is the most satisfactory. Nettleton's method is not satisfactory in this area because of the weathering of rocks. Laboratory determinations are less reliable for use in interpreting gravity maps.—*M. C. R.*

169–166. Watermann, H. Gezeitenkorrektionen für gemessene Schwerewerte [Tidal corrections for measured gravity values]: Deutsche Geod. Komm. Veröffentl., Reihe A, Heft 10b, p. 33–35, 1955.

Curves for correction of gravity measurements for the effect of earth tides are prepared by the Deutsches Geodätisches Forschungs Institut in München, based on the records of the Deutsches Hydrographisches Institut in Hamburg

which give hourly values of the Z-component with an accuracy of 0.01 mgal. A portion of one of these curves (for June 1953) is presented, with examples of its use.—*D. B. V.*

169–167. Lagrula, Jean, and Lambert, Alexis. Essai d'interprétation des anomalies gravimétriques de l'Algérie orientale [Preliminary interpretation of the gravimetric anomalies of eastern Algeria]: Acad. Sci. Paris Comptes Rendus, tome 244, no. 11 p. 1526–1527, 1957.

On the gravity map of eastern Algeria which has been isostatically corrected on the basis of the Airy hypothesis, $T=30$ km, a zone of negative anomalies between Boghari and the Chott Melrir coincides with the Neogene sedimentary basin, but cannot be explained entirely by recent sedimentation or regional gradient; active orogenesis probably accounts for part. Another negative zone corresponds to the deeper part of a large Miocene fold marking the southern limit of the gliding nappes of the south Tellian front. The recent "Saharan flexure" following the whole southern border of the Saharan Atlas is, surprisingly, not reflected in the isostatic anomalies. Positive anomalies are attributed to the presence of Paleozoic metamorphic rocks that crop out in a narrow littoral band.—*D. B. V.*

169–168. Jelstrup, G. Observations on the gravimetric calibration base, Hammerfest-Munich with the Cambridge pendulum apparatus: Norges Geog. Oppmåling, Geod. pub. no. 7, 42 p. 1957.

Very detailed description, with tables of data, of the instrument, procedure, and itinerary of a series of gravity observations made along the Hammerfest-Munich gravimetric calibration base, using the Cambridge pendulum apparatus. Absolute values for the different stations, calculated on the basis of the accepted Potsdam value, are: Bad Harzburg (Cook's value) 981,180.40 mgals; Munich (Nümphenburg) 980,744.68 mgals; Copenhagen 981,558.16 mgals; Oslo 981,926.95 mgals; Teddington 981,196.07 mgals; Bodö 982,386.17 mgals; and Hammerfest 982,631.12 mgals.—*D. B. V.*

169–169. Albrecht, O. Über die Schweremessungen in Baden-Württemberg [On the gravity measurements in Baden-Württemberg]: Deutsche Geod. Komm. Veröffentl., Reihe A, Heft 10b, p. 17–18, 1955.

A brief description of the procedure used in a gravity survey begun in 1951 for the purpose of reduction of the Baden-Württemberg principal level network. Using a pre-war astatic gravimeter (Askania no. 20), stations were occupied at each altitude point of the network, and additional stations at prominent breaks in slope in rugged terrain and at appreciable changes of direction of the lines of levels. Spacing of stations ranged from 400 to 1,500 m, and averaged 750 m. By early 1953,, 1,600 stations had been measured over a total distance of about 1,300 km, comprising a third of the proposed program. A map shows the extent of the completed measurements and error of closure in each loop of the network.—*D. B. V.*

169–170. Marussi, Antonio. Gravimetric and magnetometric surveys performed by the Italian Karakorum expedition 1954–5: Bull. géod., no. 41, p. 1–8, 1956.

Geophysical work of the expeditions included gravimetric ties between Rome, Beirut, Karachi, and Rawalpindi, between Karachi and Dehra Dun, and between

Rawalpindi and two base stations in the Karakorum region, Shardu and Gilgit; a gravimetric survey of 270 stations and a magnetic survey of 70 stations along routes in the Karakorum region; and determination of altitudes and deflections of the vertical. A map based on all available data shows the isostatic anomalies according to Pratt-Hayford hypothesis with a depth of compensation of 113.7 km. Anomalies range from zero to intensely negative for the Pamir region, except for a positive area at the eastern edge, and are negative in the Tarim basin. The Indus platform is mostly positive, but the base of the pre-Himalayan hills is bordered by a strip of slightly negative anomalies. In the other Himalayas there is a strip of strongly positive anomalies which decrease toward the axis of the chain.—*M. C. R.*

169–171. Shurbert, G. Lynn, and Worzel, J. Lamar. Gravity observations at sea in USS Diablo: Bull. géod., no. 42, p. 42–60, 1956.

Principal facts, including free-air and simple Bouguer anomalies, are tabulated for observations at sea near Puerto Rico during a cruise of the U. S. S. *Diablo* in 1953.—*M. C. R.*

169–172. Innes, M. J. S. Gravity and isostasy in central Quebec: Am. Geophys. Union Trans., v. 38, no. 2, p. 156–165, 1957.

A belt of intensely negative Bouguer and isostatic anomalies, nearly 140 miles wide, has been partially outlined in northern Quebec by a regional gravity survey. The axis of the belt trends northeast parallel to the Front (the boundary zone between the Grenville and Superior geological provinces). The gravity minimums are believed related to batholiths of massive granite intruded during a late Precambrian orogeny. Retention of such "root" structures for great periods of geologic time indicates that the rate of uplift and erosion has been much slower than usually thought. The position of belts of Proterozoic sedimentary rocks in relation to the gravity minimums suggests that they were also involved in the orogeny. The total evidence is consistent with the concept of a strong crust accompanied by some broad regional compensation, and suggests that igneous intrusion, formation of mountains, and their compensation are simultaneous. Much of the gravity disturbance associated with mountains and attributed to crustal thickening may reasonably be explained by horizontal variations in density within the crust. Stress differences estimated from the gravity anomaly do not seem large enough to maintain the subcrustal flow necessary for isostatic adjustment although there is evidence for crustal uplift along the Grenville Front.—*M. C. R.*

169–173. Ritsema, A. R. Two gravity profiles across Timor island: K. Nederland. Geol.-Mijnb. Genootschap Verh., geol. ser., deel 16, p. 380–384, 1956.

Two Bouguer profiles have been made across the island of Timor, one of the few places in the Indonesian archipelago where the outer (nonvolcanic) arc, the youngest orogenic belt, rises above sea level. The gravity values have been calculated relative to the value at Kupang airport (978.17800 mgals), with an assumed density of 2.1. These preliminary results show only positive values on the island; recalculation using a density of 2.67 yields maximum negative values of only −14 mgal in one narrow strip. The highest positive anomaly (more than +158 mgal) is at Ocussi on the north coast, and is possibly related in part to the occurrence of young volcanic rocks. The smallest anomalies are

over the central depression filled with young sediments. The anomalies increase toward the north, with a steep gravity gradient (6 mgal per km) interrupted by narrow belts of roughly equal values. The absolute minimum must lie south of Kolbano in the Timor Sea. Correspondence of Bouguer anomalies with the geology along the strike is evident. Interpretation will be attempted after completion of further measurements.—*D. B. V.*

169–174. Heiskanen, W. A., and Uotila, U. A. Gravity survey of the state of Ohio: Ohio Geol. Survey Rept. Inv. no. 30, 34 p., 1956.

This survey, conducted with a Worden gravimeter and comprising 2,121 stations, shows that the gravity field in Ohio is quite irregular. The maximum Bouguer anomaly is +23 mgals and the minimum, −78 mgals. The average Bouguer anomaly, −38 mgals, shows that Ohio is in nearly complete isostatic equilibrium. The anomaly −38 mgals corresponds to the average elevation, 340 m, which is close to the mean elevation of the state of Ohio. Isostatic reduction of the gravity anomalies was carried out according to the Airy-Heiskanen system. The average gravity anomaly corresponding to the value T=30 km is −8 mgals. A Bouguer and a free air anomaly map are included.

Because of the unusual gravity field of the Fayette County area, where gravity gradients exceed 4 mgals per mile along several profiles, oil companies are reported to have, as a result of the survey, leased an area of about 100,000 acres for prospecting purposes.—*B. T. E.*

169–175. Vecchia, Orlando. Geophysikalische Strukturlinien und Tiefengeologie in Sizilien und den anleigenden Gebieten [Geophysical features and deep geology of Sicily and surrounding areas]: Geologie, Jahrg. 5, Heft 8, p. 756–786, 1956.

A German translation and review (by H. Wartenburg) of a paper originally published in Italian in the *Rivista da Geofisica Applicata* (see Geophys. Abs. 159–27).—*D. B. V.*

169–176. Nettleton, L. L. Submarine gravity detailing, San Luis Pass Dome, Brazoria County, Texas: Geophysics, v. 22, no. 2, p. 348–358, 1957.

The San Luis Pass shallow salt dome lies about 7 miles off-shore from the Texas coast under about 50 feet of water. A detailed submarine gravity survey was made to determine the outline, thickness and depth of caprock as a guide for test drilling for the evaluation of the dome as a sulphur prospect. There were no drilling contacts on the dome when the work was done. Seventeen test wells were subsequently drilled within the shallow dome outline as estimated from analysis of the gravity results. The caprock found was slightly smaller in area, considerably shallower in depth and of substantially the same thickness as predicted. The caprock material is nearly all gypsum.—*Author's abstract*

169–177. Harris, N., Pallister, J. W., and Brown, J. M. Oil in Uganda: Internat. Geol. Cong., 20th, Mexico 1956, Symposium sobre Yacimientos de Petróleo y Gas, tomo 1, p. 213–219, 1956.

After several unsuccessful wildcat wells had been drilled in Uganda, a detailed gravity survey was made, consisting of about 400 stations mostly spaced at 1,500-ft intervals on traverses 2 miles apart. No anomalies suggestive of local structures were revealed, but a major gravity gradient implied a thickness of as much as 6,000 ft of sediments towards the center of the Semliki region.

Several reconnaissance gravity surveys have also been carried out at various points on the margins of the Western Rift Valley from the West Nile district to the Ruwenzori Mountains, with a view to extending Bullard's work on rift valley tectonics.—*D. B. V.*

169–178. Kneissl, M[ax]. Niveau nnd Massstab des vorläufigen europäischen Gravimeternetzes (Morelli-Martin-Netz 1956) [Level and scale of the provisional European gravimeter network (Morelli-Martin Network, 1956)]: Deutsche Geod. Komm. Veröffentl., Reihe A, Heft 21, 1956.

In the first part, the proposals for standardization of gravimeters made by Martin, Cook, Morelli, and Kneissl are compared. Morelli's line method and Kneissl's surface method correspond completely and yield comparable results. Martin's addition method gives good results and is distinguished by its simplicity; the same is true of Cook's. In contrast to the line and surface methods, Martin disregards determination of level (which Morelli also subsequently waives in referring to the Harzburg gravity value). Morelli's method is recommended, and in the second part of the paper it is applied to checking the level and scale of the provisional European network.—*D. B. V.*

169–179. Watermann, H. Über die Schweremessungen der I. Abt. des Deutschen Geodätischen Forschungsinstituts im Jahre 1952 [On the gravity measurements of the 1st Division of the Deutsches Geodätisches Forschungsinstitut in the year 1952]: Deutsche Geod. Komm. Veröffentl., Reihe A, Heft 10b, p. 19–32, 1955.

A description of the gravity survey along the first-order leveling lines in Bavaria, begun in 1952 by the Deutsches Geodätisches Forschungsinstitut in collaboration with the Bayerisches Landesvermessungsamt. The gravimeter (Askania no. 59, type Gs8) was used for checking and calibration measurements between the pendulum stations of München, Traunstein, Garmisch, Zugspitze, Memmingen and along leveling lines to the Bodensee. Subsequently, measurements were made along two levelling loops in the Oberpfalz, tied to the pendulum stations of Regensberg, Marktredwitz, and Nürnberg. The München-Regensberg line was measured on every trip in order to obtain the most exact possible gravity difference between these main Bavarian pendulum points. These measurements served simultaneously for checking the gravimeter and testing new methods of measurement. Altogether 812 stations were occupied. Details of instrumentation, personnel, procedure, and cost are given, and results presented in profiles.—*D. B. V.*

169–180. Schleusener, A[lfred]. Bemerkungen zur Freiluftschwerekarte von Zentraleuropa [Remarks on the free-air gravity map of Central Europe]: Deutsche Geod. Komm. Veröffentl., Reihe A, Heft 10b, p. 37–49, 1955.

The free-air anomalies have been calculated for central Europe, using the mean elevation and mean gravity value for each 500 km^2. Maps are presented showing the Bouguer anomalies of the Darmstadt block; the free-air and Bouguer isogams for the Neckar-Tauber anomaly and Heidelberg Loch; the free-air anomalies in the region of the Bavarian Molasse and Alps; and the free-air anomalies for all of central Europe. The Bouguer anomalies give information on unknown disturbing bodies and are useful in mining geophysics, whereas the mean free-air anomalies give an approximation of the isostatic condition of a

region without necessitating laborious isostatic reductions or arbitrary assumptions of density at depth.—*D. B. V.*

169–181. Watermann, H. Gravimetermessungen [Gravity measurements]; Bruns, R. Pendelmessungen [Pendulum measurements] *in* Das Deutsche Schweregrundnetz, IV. Pendel- und Gravimetermessungen auf den europäischen Gravimeter-Eichlinien im Jahre 1955 ausgeführt durch das Deutsche Geodätische Forschungsinstitut [The German gravity base network, IV. Pendulum and gravimeter measurements on the European gravimeter calibration line in 1955 by the German Geodetic Research Institute]: Deutsche Geod. Komm. Veröffentl., Reihe B, Heft 23, Teil 4, 32 p., 1956.

A tabulation of results and a description of the instruments and procedures used in the pendulum survey.—*B. T. E.*

169–182. Pohly, Richard A. Use of gravity in locating geological traps: Kentucky Geol. Survey Special Pub., no. 9, p. 62–69, 1956.

A brief description of the gravity method as a geophysical tool for locating oil and gas; specific problems in the Appalachian geosyncline where the method can be of particular value in mapping local structure are mentioned.—*V. S. N.*

HEAT AND HEAT FLOW

169–183. Jaeger, J. C. The temperature in the neighborhood of a cooling intrusive sheet: Am Jour. Sci., v. 255, no. 4, p. 306–318, 1957.

Latent heat of solidification, usually neglected in studies of the cooling of an intrusive sheet in the neighborhood of the contact, can affect values by as much as 100° C. It can be taken into account, approximately, by replacing the specific heat C'_2 by $C_2=C'_2+L/(T_2-T_1)$ in thermal calculations, where L is the latent heat in calories per gram T_2-T_1 is the temperature range of solidification. In a magma in plane contact with country rock the contact temperature is not affected greatly by the width of the range of solidification. Temperatures at various points of typical intrusive sheets are plotted against time for three range of solidification. On the basis the derived formulas and curves, the mechanism of differentiation, calculation of grain size near contacts, and prediction of regions in which inversion temperatures have been exceeded can be considered. The formulas are particularly useful in studying the way the Curie temperature moves through rocks. For sufficiently thick sills and dikes, it is even possible by this means to study secular variation of the earth's magnetic field at the time of intrusion. For example the cooling time of a dolerite sill was determined and because of its short duration it is concluded that the reversed magnetism was probably not due to a reversal of the earth's magnetic field.—*R. G. H.*

169–184. Kozlowski, Mieczyslaw. Temperature distribution in a liquid flowing out through a boring: Acta Geophys. Polonica, v. 3, no. 2, p. 93–98, 1955.

The equation of heat conduction is solved for the case of an infinite boring in which flowing liquid exchanges heat with the surrounding medium according to Newton's law. It is assumed that for a given cross section of the boring the temperature of the liquid depends only on time and the ambient temperature does not change with time. Curves representing the temperature distribution at different times for a steady flow of liquid are shown in a figure.—*M. C. R.*

169–185. Clark, Sydney P., Jr. Heat flow at Grass Valley, California: Am. Geophys. Union Trans., v. 38, no. 2, p. 239–244, 1957.

Geothermal gradients, corrected for the effect of topographic irregularities, are calculated from the measurements of underground temperatures in the mines at Grass Valley, Calif. The gradient is 9.46±0.16° per km for indefinitely persisting topography and 8.56±0.16° C per km if the topography has evolved in the last 10^6 years. The mean thermal conductivity of 14 specimens of granodiorite from Grass Valley is $7.68\pm0.09\times10^{-3}$ cal per cm sec °C; that of 15 specimens of porphyrite is $7.14\pm0.14\times10^{-3}$ cal per cm sec °C. Using the conductivity of the granodiorite, the heat flow is found to be $0.73\pm0.01\times10^{-6}$ cal per cm^2 sec and $0.66\pm0.01\times10^{-6}$ cal per cm^2 sec for the two physiographic histories assumed. No explanation of this low value can be deduced from this isolated determination.

A simplified form of correction for the effect of topographic irregularities on underground temperatures is presented.—*Author's abstract*

169–186. Dubinskiy, A. Ya. Geotermicheskiy rezhim Predkavkaz'ya i sosednikh rayonov Vostochnogo Donbassa [Geothermal conditions of Caucasus foreland and of the adjoining regions of the eastern Donbas]: Sovetskaya Geologiya, no. 46, p. 82–99, 1955.

Results of 155 geothermal measurements at various places in the northwestern Caucasus and the eastern Donbas were collected and studied in relation to the structure of the regions. Measurements were made at depths that ranged from 1,000 to 2,000 and in a few places to 3,000 m. The geothermal gradient ranged from 26 m per 1° C to 60 m per 1° C. At 2,000 m depth the highest temperature was 82° C, and at 2,800 m, 93° C. Both electrical thermometers and mercury maximum thermometers were used, and good agreement was found between the results. Higher heat flow was related to anticlinal structures.—*S. T. V.*

169–187. Boldizsár, T. Measurement of terrestrial heat flow in the coal mining district of Komló: Acta Tech. Acad. Sci. Hungaricae, tomus 15, fasc. 1–2, p. 219–227, 1956.

Temperatures were measured in shafts being sunk in the coal basin of Transdanubia by using mercury thermometers placed in dry boreholes 1.2 m deep 6 to 8 hours after the borings. The maximum temperature was 31.10° C at a depth of 478.00 m. Thermal conductivity ranged from 10.73×10^{-3} cal per cm sec °C at 5.46×10^{-3} cal per cm sec °C. The mean heat flow was computed as 3.1×10^{-6} cal per cm^3 sec.—*M. C. R.*

169–188. Noritomi, Kazuo, and Nabetani, Sachio. On the specific heat of rocks and the velocity of elastic waves within the outer layer of the earth's crust: Tōhoku Univ. Sci. Repts., 5th ser., v. 7, no. 3, p. 190–200, 1956.

Changes in specific heat of granite and andesite were measured for temperatures ranging from room temperature to about 800° C. Specific heat in these rocks is most influenced by the silica content. Anomalous changes in specific heat were observed at a temperature of 573° C, corresponding to the inversion point of quartz, and at 250° C, the transformation point of cristobalite. By using Debye's formula, the elastic wave velocity can be estimated from specific heat. The velocity distribution in the crust shows two low velocity regions that can be correlated with the Conrad and Mohorovičić discontinuities. Therefore, anoma-

lous temperatures at the depths of these discontinuities are probably not due to different materials, but rather to physical changes of the same material. Anomalous changes of velocity would not be expected in the mafic rocks.—*B. T. E.*

169–189. Cook, Frank A. Near surface soil temperature measurements at Resolute Bay, Northwest Territories: Arctic, v. 8, no. 4, p. 237–249, 1955.

Temperatures were measured in a 6-foot overburden of frozen gravel and shattered rock overlying limestone bedrock at Cornwallis Island, Resolute Bay. Data are presented as monthly and yearly averages of measurements recorded at depths of 4, 8, 10, 18, 20, 25, 35, and 60 inches for the period 1950–55. The amplitude of the daily variation was greatest in summer and was apparently related to the intensity of solar radiation and the continuous sunshine rather than air temperature, which is the controlling influence in the spring and fall. During winter there was little variation and any fluctuation tended to be the result of an unusually low minimum temperature rather than the influence of surface maximum air temperature. The effect of rainfall was negligible; snowfall decreased variations due to surface temperature changes. A 1-month lag of maximum yearly temperature was noted at depths of 10, 18, 20, and 25 inches, and a 2-month lag at 35 and 60 inches; the lag of minimum temperatures was 1-month at depths of 20, 25, and 35 inches and 2-months at 60 inches.

The second part of the paper is a preliminary report on a special study in the fall of 1955 on the freeze-back in the active layer.—*B. T. E.*

169–190. Aldrich, Harl P., Jr. Frost penetration below highway and airfield pavements: Highway Research Board Bull. 135, p. 124–149, 1956.

Neumann's solution for the temperature in a semi-infinite, two-phase medium with latent heat at the interface can be adapted to the problem of predicting the depth to which seasonal frost will penetrate the ground. The result, which may be expressed in a form similar to Stefan's less general equation, is referred to as the modified Berggren formula. The formula takes into account latent heat of fusion and the mean value of the volumetric states. The form of the surface temperature is idealized, but it can be shown that this has little effect on the predicted depth of thaw. More refined results, taking account of the thermal properties of the frozen and thawed states individually, can be obtained. However, these are more difficult to apply to practical engineering problems.

The relationship between air temperature, ground or pavement surface properties, and surface temperature is the most important unsolved problem remaining in the prediction of frost penetration.—*A. H. L.*

169–191. Yoshizawa, Yukio, and Sugawara, Akira. On the method of measuring thermal conductivity of rock and thermal conductivities of some rocks [in Japanese with English abstract]: Tōhoku Kozan, v. 2, no. 3, p. 69–72, 1956.

Thermal conductivity was measured by passing a steady heat flow through two plates, one of the sample and the other a standard glass plate of known thermal conductivity, and measuring the temperature differences of the two. Conductivities are given in terms of kcal per m h °C for four sandstones ($0.908(1+0.00046t)$ to $0.960(1+0.00050t)$) and for andesites ($0.893(1+0.00056t)$ to $1.114(1+0.00009t)$).—*M. C. R.*

INTERNAL CONSTITUTION

169–192. Kober, Leopold. Atombau und Geologie [Atomic structure and geology]: K. Nederland. Geol.-Mijnb. Genootschap Verh., geol. ser., deel 16, p. 195–201, 1956.

Geological evolution of the earth is related to the structure and origin of the elements. The elements have been formed in order of increasing complexity as the earth condensed from the gaseous state and contracted. The first 28 elements were formed by the time the density had become 1.0; elements 29 to 36 were formed while the density increased from 1.0 to 1.5 and the radius contracted from 11,244 to 9,823 km. Eighty-six elements were present when the earth became solid and the density was 3.5 and the radius, 7,406 km; 96 were present when life began, and 114 exist now; the density is 5.5. The end of this gravitative evolution will be reached in about 2 billion years, when the density will be 7.5 and the radius (which has been contracting at a rate of about 0.3 mm per year since the earth became solid) is 5,744 km.—*D. B. V.*

169–193. Bullen, K. E. On the constitution of Mars (second paper): Royal Astron. Soc. Monthly Notices, Geophys. supp., v. 7, no. 5, p. 271–278, 1957.

A re-examination of the internal structure of Mars has been made in the light of revised observational data on the radius R. Taking the reduced value $R=3330$ km, and the mass of Mars as 6.442×10^{26}g, the hypotheses (a) that the Earth and Mars have the same overall composition and (b) that Model B gives a satisfactory representation of the Earth's mantle, are examined. It is confirmed that the reduced value of the radius implies the presence of a significant proportion of uncombined iron in the mantle of Mars. The assumptions would also require the interior of Mars to deviate from a hydrostatic state, and if correct lend support to the view of Jeffreys that the material of Mars has finite strength. It is still possible for Mars to have a small iron (and/or nickel) core, the radius of which most probably does not exceed 700–900 km; the smaller the radius of the core, however, the less the deviation from a hydrostatic state.

On hypothesis (a), the reduced radius further implies that the Earth contains uncombined iron outside the inner core. A provisional view was that this uncombined iron was located mainly in the outer core. Further calculation, however, gives rise to the speculation that it is the mantle of the Earth which contains this uncombined iron and not the outer core. A coherent picture can be derived by assuming that Mars and the mantle of the Earth both consist broadly of a mixture of uncombined iron with silicates or FeO, MgO, SiO_2 phases. The Earth's outer core on this view would contain no uncombined iron, the latter having gravitated toward the centre to form the inner core. In this way, the hypothesis (a) can be reconciled with the reduced Mars radius and with a hydrostatic state. The corresponding density distribution (ρg/cm^3) in Mars is given approximately by $\rho=4.68-0.86x^2$, where $x=r/R$, r being the distance from the centre.—*Author's summary*

169–194. Davydov, B. I. Ob uravnenii sostoyaniya tverdykh tel [On the equation of state of solid bodies]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 12, p. 1411–1418, 1956.

The general equation of state of a solid body, establishes the relation between the deformation of the body, the hydrostatically applied pressure, and the surrounding temperature. Starting from general concepts of quantum theory,

Davydov derives the equation of free energy for the main crystalline solid forms. The constants contained in these equations are determined from the experiments made by P. W. Bridgman. Characteristic curves are given for several typical solids, such as NaCl, MgO, Fe_3O_4, Si Ge, Te.—*S. T. V.*

169–195. Nishitake, Teruo. Elastic properties of rocks with relation to the earth's interior: Kyōto Univ. Coll. Sci. Mem., Ser. A, v. 28, no. 1, p. 70–98, 1956.

A pressure coefficient of the velocity of dilatational waves in good agreement with observed values can be calculated from experimental data by determining first the $dV_p/d\rho$ and then converting it to dV_p/dP, as in the determination of the pressure coefficient of the bulk modulus. The effect of such factors as temperature, porosity and viscosity are minimized in this solution.—*M. C. R.*

Honda, Hirokichi, Sima, Hiromu, and Nakamura, Kōhei. The *ScS* wave, the mechanism of deep earthquake and the rigidity of the earth's core. See Geophys. Abs. 169–69.

169–196. Miki, Haruo. On the earth's mantle: Kyōto Univ. Coll. Sci. Mem., Ser. A, v. 27, no. 4, p. 363–403, 1956.

Densities and seismic velocities in the earth can be calculated without assuming that the mantle satisfies the hydrostatic relation $dP=g\rho dr$. Thus the abnormal character of the *C* layer (413–984 km) can be explained by the state of non-hydrostatic equilibrium rather than inhomogeneity. The internal force in the *C* layer acts towards the earth's center and is about twice the force of gravity (effectively "strangling" the layers below). The theory is based on a calculation of the variation of Gruneisen's ratio within the earth by considering the pressure effect only.—*M. C. R.*

169–197. Hurley, Patrick M. Test on the possible chondritic composition of the earth's mantle and its abundance of uranium, thorium, and potassium: Geol. Soc. America Bull., v. 68, no. 3, p. 379–382, 1957.

Measurements of alpha particle emissions from powdered surfaces of chondritic meteorites permit calculation of radium equivalents and by appropriate assumptions to values of heat production. The heat production for the Forest City meteorite is 3.48×10^{-8} cal g^{-1} yr^{-1} or only 0.3 of that used by Urey who concluded that the mantle contains less uranium, thorium, and potassium than the meteorites. The approximate average heat production in the mantle material is calculated to be 2.03 ergs g^{-1} yr^{-1}, and agreement with the value of 2.37 ergs g^{-1} yr^{-1} for chondritic meteorites strongly supports the hypothesis that the earth's mantle was originally similar in composition to chondritic meteorites.—*M. C. R.*

169–198. Officer, C[harles] B. [Jr.], Ewing, J. I., Edwards, R. S., and Johnson, H. R. Geophysical investigations in the Eastern Caribbean: Venezuelan basin, Antilles island arc, and Puerto Rico trench: Geol. Soc. America Bull. v. 68, no. 3, p. 359–378, 1957.

A series of seismic refraction profiles were made in the eastern Caribbean sea to determine the crustal structure in the broad Venezuelan basin, the island arcs of the Lesser and Greater Antilles, and the Puerto Rico trench. In comparison with the Atlantic Ocean, the depth of the major seismic discontinuity beneath the Caribbean region is 13 km, instead of 10, and the velocity below the discontinu-

ity is 7.4 kmps rather than 8.0 kmps; there is a wider range of velocities and lower velocities in the crust in the Caribbean region, and more variability in crustal structure and thickness. The crustal structure in the Puerto Rico trench is similar to that beneath the Atlantic except that the crust is somewhat thicker. The structure is more complex along the island arc than elsewhere and crustal velocities are at shallower depths than in the Caribbean or Atlantic. Consideration of geologic, seismic, and gravity data leads to the conclusion that large bodies of femic magma have been intruded throughout the entire Caribbean and that these bodies were differentiated deep in the mantle, and migrated upward, and that introduction of this material has been the primary cause of the tectonic effects observed in the area; and that the island arcs and deep-sea trenches have been formed by horizontal compression along the border of the altered Caribbean and normal Atlantic basin.—*M. C. R.*

169–199. Press, Frank. Determination of crustal structure from phase velocity of Rayleigh waves, part II: San Francisco Bay region: Seismol. Soc. America Bull., v. 47, no. 2, p. 87–88, 1957.

Evernden's data on the phase velocity of Rayleigh waves have been interpreted as indicating that the crust is 30 km thick in the San Francisco Bay region. In both the coastal region of southern California and the Bay region, the thickness is less than reported for inland regions, an effect of the proximity to the margin of the continent.—*M. C. R.*

169–200. Nanda, J. N. Seismic exploration of the continental shelf off the west coast of India: Jour. Geophys. Research, v. 62, no. 1, p. 113–115, 1957.

Observations were made about 30 miles west of Cochin, using a single ship and a single sono-buoy. Five shots were fired while the ship moved westward from the buoy to a maximum distance of 6 miles. Shot times were calculated from the observed arrival times of direct waves by using a velocity of 0.94 miles per sec, consistent with the average temperature and salinity of the water. The thickness of loose sediments is estimated as 2.8 km and the velocity in the sediments as 1.2 miles per sec.—*M. C. R.*

169–201. Eiby, G. A. Crustal structure project: The Wellington profile: New Zealand Dept. Sci. Indus. Research Geophys. Mem., no. 5, p. 5–31, 1957.

A seismic refraction profile recorded in Wellington Province, North Island, shows that the average depth to the Mohorovičić discontinuity is slightly more than 18 km. The crust is assumed to consist of four layers of 0.6_1, 1.6_6, 7.1_8, and 8.8_1 km thick, in which longitudinal wave velocities are 3.5, 5.5_2, 6.0_7, and 6.2_2 kmps; a velocity of 8.0_2 kmps was recorded below these layers. These results considered with the results of studies of natural earthquakes suggest that New Zealand has a substantial layer in which the velocity is that of the conventional "granitic layer" of continental regions. However, the relationship of this layer to the intermediate layer indicates that New Zealand structure is not continental but consists of a complex of metamorphic material superimposed upon an originally oceanic crust. The term "insular" is proposed for crusts of this general type.—*V. S. N.*

169–202. Eiby, G. A. Crustal structure project: The Pencarrow profile: New Zealand Dept. Sci. Indus. Research Geophys. Mem., no. 5, p. 36–39, 1957.

A profile 6.7 km long was made on the eastern side of Wellington Harbour as a supplementary study to the Wellington seismic profile. Velocity was found to increase smoothly from the surface to a depth of about 1.2 km where it was 5.5 kmps. This velocity is taken as characteristic of the unweathered and unshattered basement greywacke in the Wellington district; lower velocities observed during natural earthquakes should presumably be assigned to more recent sediments.—*V. S. N.*

169–203. Eiby, G. A. Note on the velocity discontinuity at a depth of 2 km in the Wellington region: New Zealand Dept. Sci. Indus. Research Geophys. Mem., no. 5, p. 40, 1957.

Changes in velocity between wet and dry rock were calculated by Satō's formulas (see Geophys. Abs. 162–87) using densities and porosities of greywackes measured at the Dominion Physical Laboratory and reasonable values of Poisson's ratio. The changes are not sufficient to explain the discontinuity as the result of variation in water content.—*M. C. R.*

Nortitomi, Kazuo, and Nabetani, Sachio. On the specific heat of rocks and the velocity of elastic waves within the outer layer of the earth's crust. See Geophys. Abs. 169–188.

ISOTASY

169–204. Sugimura, Arata, and Naruse, Yō. Changes in sea level, seismic upheavals, and coastal terraces in the southern Kantō region, Japan: Japanese Jour. Geology and Geography, v. 24, p. 101–113, 1954; v. 26, no. 3–4, p. 165–176, 1955.

In the southern Kantō region raised beach deposits and coastal terraces may be due to upheaval by crustal movements or to lowering of sea level. Upheaval is attributed principally to the accumulation of movements accompanying earthquakes. Eustatic changes in sea level as the result of glaciation and deglaciation can also be recognized from geologic evidence. A rapid transgression and successive slow regression toward the present have been observed in many regions and can be correlated with Japanese observations. The maximum rise was between 5,000 and 3,000 B. C.; data from Japan indicate it as 4,000 B. C.—*M. C. R.*

ISOTOPE GEOLOGY

169–205. Nicolet, Marcel. Sur l'origine de l'argon atmosphérique [On the origin of atmospheric argon]: Acad. Royale Belgique Bull., Cl. sci., 5e sér., tome 42, no. 4, p. 482–498, 1956.

Most of the radiogenic argon took part in the formation of the atmosphere in the period preceding the time at which differentiation of the mantle and crust was sufficiently accomplished. Argon was one of the first constituents of the terrestrial atmosphere and has acted from the very beginning as a screen for X-rays and ultraviolet radiations at wave lengths less than 800 Å.—*Author's résumé*

169–206. Kuroda, P[aul] K., Edwards, R. R., Robinson, Berol L., Jonte, J. H., and Goolsby, Cleo. Chlorine–36 in pitchblende: Geochim. et Cosmochim. Acta, v. 11, no. 3, p. 194–196, 1957.

The natural occurrence of chlorine–36 in pitchblende has been established. The specific activity of chlorine in Great Bear Lake pitchblende, (4 ± 1) disin-

tegrations per minute per gram of chlorine, corresponds to an "apparent thermal neutron flux" of (0.12±0.03) neutrons $cm^{-2}sec^{-1}$.—*Authors' abstract.*

169–207. Damon, Paul E. Terrestrial helium: Geochim. et Cosmochim. Acta, v. 11, no. 3, p. 200–201, 1957; Mayne, K. I. Terrestrial helium: a reply: p. 201–203.

Damon argues that the tenfold extraterrestrial increment of helium-3 demanded by Mayne's calculations (see Geophys. Abs. 165–239) is based on overestimation of the specific helium productivity of U and Th, of the He production of the crust, and of the rate of loss of He from crust to atmosphere. These should be reduced by factors of 3.5, 1.9, and 1.7, respectively, removing the necessity of a large extraterrestrial source of He^3.

Mayne replies that he suggested a daily infall of 5,000, not 10,000, tons of extraterrestrial dust. He considers Damon's calculation of the rate of leakage of He^4 into the atmosphere as an unjustifiably simple view of degassing of the crust. It is also an oversimplification to assume that all radioactive elements are concentrated in the upper crust; the upward diffusion from the base of the crust is discussed. Recalculations based on very conservative values give a figure of 2,000 tons a day of extraterrestrial material required, in reasonable agreement with the former value.—*D. B. V.*

169–208. Parwel, A., Ryhage, R., and Wickman, Frans E. Natural variations in the relative abundances of the nitrogen isotopes: Geochim. et Cosmochim. Acta, v. 11, no. 3, p. 165–170, 1957.

The relative abundance of nitrogen isotopes was measured in 2 samples of natural sal ammoniac, 2 of caliche, 8 of Wealden coal, 5 of Carboniferous coal, 3 of living trees, and 1 of air. The NH_4Cl samples formed a distinct group about 1 percent heavier than the air sample; the others showed variations of a few parts per thousand from air. The observed range of variation is less than half that of the stable carbon isotopes. The nitrogen of the Wealden coal is heavier than that of the Carboniferous coal, contrary to the results found for carbon isotopes.—*D. B. V.*

169–209. Jensen, M[ead] L[eRoy]. Sulfur isotopes and mineral paragenesis: Econ. Geology, v. 52, no. 3, p. 269–281, 1957.

A study of S^{32}/S^{34} ratios from two or more sulfides in one hand specimen indicates that appreciable variations, sometimes greater than 4 percent, exist. A detailed study of the genesis and the paragenetic relationship of the various sulfides present in the specimens suggests the following: isotopic ratios offer a means for distinguishing between exsolution and replacement; the mechanism of replacement of one sulfide by another is not always a diffusion mechanism of the small metal cations but also includes an exchange of the large sulfur anions; hypogene ore fluids forming vein deposits may vary in isotopic composition; and isotopic reactions during supergene enrichment suggest that supergene and hypogene minerals can be distinguished by isotopic analyses.—*V. S. N.*

169–210. Senftle, F. E., Stieff, Lorin [R.], Cuttitta, Frank, and Kuroda, P[aul] K. Comparison of the isotopic abundance of U^{235} and U^{238} and the radium activity ratios in Colorado Plateau uranium ores: Geochim. et Cosmochim. Acta, v. 11, no. 3, p. 189–193, 1957.

The isotopic abundances of uranium and the radium activity ratios of eleven samples of uranium ore from the Colorado Plateau have been measured. No

significant variation in the isotopic abundance of the uranium was noted; within the experimental error, the average U^{235}/U^{238} ratio is 137.7. There is a significant variation in the Ra^{226}/Ra^{223} activity ratios (0.048–0.143), which indicates a relatively recent alteration of the ore samples. The variations do not, however, explain the lead-uranium and lead-lead age discrepancies.—*Authors' abstract*

169–211. Blix, R., Ubisch, H. v[on], and Wickman, Frans E. A search for variations in the relative abundance of the zinc isotopes in nature: Geochim. et Cosmochim. Acta, v. 11, no. 3, p. 162–164, 1957.

The ratio Zn^{64}/Zn^{66} was studied in 18 samples representing 7 different minerals from 16 different places. No variations could be detected. If they exist they are less than 0.1 percent of the ratio.—*D. B. V.*

MAGNETIC FIELD OF THE EARTH

169–212. Elsasser, Walter M. Earth's magnetism: *in* Whipple, Fred L., ed., New horizons in astronomy, Smithsonian Contr. Astrophysics, v. 1, no. 1, p. 67–71, 1956.

A summary of the magnetic field of the earth and the dynamo theory of its origin.—*M. C. R.*

169–213. Mauersberger, Peter. Das Mittel der Energie des geomagnetischen Hauptfeldes an der Erdoberfläche und seine säkulare Änderung [The mean energy density of the main geomagnetic field at the earth's surface and its secular variation]: Gerlands Beitr. Geophysik, Band 65, Heft 3, p. 207–215, 1956.

An equation is derived giving the mean energy density of the main geomagnetic field as a function of the coefficients of spherical harmonic analysis. Numerical results based on analyses published since 1835 are given. The mean values of the energy density seems to have decreased in the past 100 years, the decrease attributed to a decline in the dipole field. When permeability of the air=1, the mean energy density of the main geomagnetic field is calculated to be 80×10^{-4} erg $\times$ cm^{-3}.—*B. T. E.*

169–214. Mauersberger, Peter. Zur Bestimmung des äusseren Anteils des geomagnetischen Hauptfeldes: [Determination of the external part of the main geomagnetic field]: Gerlands Beitr. Geophysik, Band 65, Heft 3, p. 191–206, 1956.

Spherical harmonic analysis of the earth's main magnetic field by the method of least squares is inadequate to determine whether or not there is an externally produced part of the field. Chakrabarty's analysis using numerical integration (see Geophys. Abs. 168–209) and Neumann's procedure seem preferable and will be discussed in a later paper.—*B. T. E.*

169–215. Mauersberger, Peter. Zur bestimmung des potentiallosen Anteils des geomagnetischen Hauptfeldes [On the determination of the non-potential part of the main geomagnetic field]: Gerlands Beitr. Geophysik, Band 65, Heft 4, p. 295–308, 1957.

A spherical harmonic analysis by the method of least squares is not satisfactory for determining whether there is a non-potential part in the earth's

main field. The possibility that a non-potential part is not present has been previously emphasized; it was deceptively taken as different from zero. On the contrary it seems possible that there is a small non-potential part that under unfavorable circumstances is wiped out in the harmonic analysis.—*B. T. E.*

169–216. Hope, E. R. Linear secular oscillation of the northern magnetic pole: Jour. Geophys. Research, v. 62, no. 1, p. 19–27, 1957.

Modern data seem to support the thesis (van Bemmelen, 1899) that the secular motion of the northern magnetic pole is a nearly linear oscillation. This oscillation is along the axis of a great magnetic anomaly in the arctic. Except for the constraint of the anomaly, the motion would probably be circular or quasi-circular, as suggested by the historical declination-dip curves.—*Author's abstract*

169–217. Die Umschau. Neue erdmagnetische Karten vom Polargebiet [New geomagnetic maps of the polar region]: Umschau, Jahrg. 57, Heft 9, p. 274, 1957.

Maps of magnetic declination and horizontal intensity in the north pole region for 1950, based on results of recent Russian expeditions are reproduced. The map of declination suggests the presence of two magnetic poles, one in northern Canada, the other in the Arctic Sea northeast of the Taimyr peninsula, Siberia; the map of horizontal intensity shows only one pole, in northern Canada, but a zone of very low horizontal intensity stretches toward the geographic pole in the direction of the Taimyr peninsula. These anomalies should be closely related to a region of maximum vertical intensity in northern Siberia. With respect to temporal variations, two zones of maximum disturbance are present, one corresponding to the zone of most abundant auroras (66 to 68° N geomagnetic latitude), the other close to the magnetic pole.—*D. B. V.*

169–218. Fanselau, G[erhard], and Lucke, O. Über die Veränderlichkeit des erdmagnetischen Hauptfelds und seine Theorien [On the variability of the main geomagnetic field and its theories]: Zeitschr. Geophysik, Jahrg. 22, Heft 3/4, p. 121–216, 1956.

A new method is given to explain the variability of the geomagnetic field and its density of energy on the basis of the spherical function development of its potential. The secular variation in position and intensity of the dipole and three simple quadrupoles is given in tables and graphs for 1850 to 1950 in 10-year intervals. Two of the quadrupoles show besides a westward drift of 24° per 100 yrs equally great north and south movements. It is shown that multipoles can be produced by a simple current system whose axis is the axis of the multipole. The skin-effect of zonal currents is studied; the currents probably flow in the top layers of the earth's core.

The extended convection streams, which affect the secular variation of the length of the day, are confined to planes perpendicular to the axis of rotation. They are not connected directly to the secular variation of the geomagnetic field, the origin of which must be confined to a boundary layer of the upper border of the core. If the outer core is considered as highly ionized plasma, the geomagnetic field can be interpreted as an effect of the boundary between the earth's core and mantle. The westward drift is then the westward migration of long hydrodynamic waves. The migration of the poles of the quadrupole is influenced by its direction of rotation.—*B. T. E.*

435144—57——5

169–219. Hope, E. R. Rotation, pulse-disturbance, and drift in the geomagnetic secular variation: Jour. Geophys. Research, v. 62, no. 1, p. 29–42, 1957.

The westward drift of surface geomagnetic patterns, the rate of which is about 30° of longitude per century, has at least one superimposed rotation of a period of about 480 yrs, and possibly another of about 800 yrs. The 480-yr rotation is relatively localized in the northern hemisphere and is demonstrable in declination-dip curves and in the isoporic patterns. Imamiti has reported that the secular variation of declination in Japan has a periodicity of about 800 yrs. A strong pulse disturbance in the relative rotation of the core, and hence in the westward drift, occurred between 1880 and 1920. A widespread disturbance in the isoporic patterns accompanied the disturbance.—*M. C. R.*

169–220. Jaeger, J. C., and Green, R. The use of the cooling-history of thick instrusive sheets for the study of the secular variation of the earth's magnetic field: Geofisica Pura e Appl., v. 35, p. 49–53, 1956.

Numerical results are given which show the way in which the Curie temperature moves inward from the margin during the cooling of a thick intrusive sheet. The time taken to move from the margin to the centre varies as the square of the thickness of the sheet, being about 6,500 years for a sheet 1,000 m thick on reasonable assumptions as to the thermal properties of the material. This implies that the secular variation of the earth's magnetic field over periods of time of 1,000 years or more may be studied by measuring the directions of magnetization at a series of points across the thickness of such a sheet. Some measurements on a Tasmanian sill about 430 m thick of Jurassic or Cretaceous age suggest a change from maximum to minimum inclination in a time of about 200 years. Since the margins of the sill are not available this figure may be considerably in error but the results suggest the general practicability of the method.—*Authors' abstract*

169–221. Slaucitajs, Leonidas. Mediciones geomagnéticas en la region de la Peninsula Antarctica, islas adyacentes y mar de Weddell en 1951–56 [Geomagnetic measurements in the region of the Antarctic Peninsula, adjacent islands, and the Weddell Sea in 1951–56]: Geofisica Pura e Appl., v. 35, p. 40–48, 1956.

Four magnetic surveys in Antarctic regions were made in 1951–56 by the La Plata Observatory. Both QHM and BMZ magnetometers were used. Results of observations of *D*, *H*, and *Z* are tabulated for 30 stations. Several anomalies are indicated, some quite strong. In the southern part of the Weddell Sea, observed values differ significantly from those shown on world magnetic maps. Secular change in declination is small, but in intensity, especially the vertical component, the change is rapid.—*M. C. R.*

169–222. Custódio de Morais, J. Observations of terrestrial magnetism made on the west coast of India by D. João de Castro in 1538–1539: Coimbra Univ. Mus. e Lab. Mineralóg. Geol., Mem. e Notícias, no. 41, p. 1–8, 1956.

This paper was published originally in the Indian Journal of Meteorology and Geophysics, v. 5, special no., 1954 (see Geophys. Abs. 168–215).—*D. B. V.*

169–223. Nakamura, Saemon Taro and Onuki, Akira. Magnetic dip in Kumamoto prefecture: Kumamoto Jour. Sci., ser A, v. 2, no. 2, p. 158–161, 1955.

Anomalies in magnetic dip at 100 stations in Kumamoto prefecture range from −84.5′ at Nisemoto to +229.8′ at Kimpōsan, the summit of the old volcano. Anomalies in the middle eastern part of the area are presumably caused by the volcanic rocks of Mt. Aso and a distribution of the anomalies along the fault line from Ōita to Yatusiro is also observed.—*B. T. E.*

169–224. Serson, P. H., and Hannaford, W. L. W. A statistical analysis of magnetic profiles: Jour. Geophys. Research, v. 62, no. 1, p. 1–18, 1957.

Statistical analysis of aeromagnetic profiles in western Canada and in the Atlantic east of Bermuda, involving calculation of autocorrelation functions, shows that where anomalies are the main source of error in magnetic charts, linear interpolation between observations is likely to produce as accurate a chart as any other method; smoothing does not increase the accuracy and may reduce it. The root-mean-square error of a chart is proportional to the distance between observations if the distance is less than 50 km and increases slowly as the distance between observations increases. Comparison with the autocorrelation functions of simple models indicates that under the deep ocean there are many bodies magnetized to an intensity of at least 0.005 cgs that produce magnetic poles 1 km below the ocean bottom, and that under the continent there are still more strongly magnetized (as much as 0.05 cgs) bodies producing poles either in a layer at 10 to 12 km or scattered from 4 km downward.—*M. C. R.*

169–225. Fanselau, G[erhard]. Einige Neuerungen an den geomagnetischen Feldwaagen [Some recent developments in the geomagnetic field balance]: Geophys. Prosp., v. 5, no. 1, p. 9–19, 1957.

Magnetic balances with torsion ribbons, used at the Niemegk Observatory, have a greater stability at zero position than those resting on knife edges. The range of measurement can be easily enlarged, and no serious damage results when the instrument is not clamped. The torsion ribbon balances can be made insensitive to leveling errors, to some extent. Both horizontal, vertical, and a combined balance have been developed. The instruments are chiefly for observatory use.—*M. C. R.*

MAGNETIC PROPERTIES

169–226. Komarov, A. G. K voprosu ob ostatochnoy namagnichennosti izverzhennykh gornykh porod v svyazi s ikh vozrastom [On the remanent magnetization of eruptive rocks and its relation to their age]: Akad. Nauk SSSR Doklady, tom 110, no. 2, p. 260–263, 1956.

On the basis of study of the magnetic properties and mineralogic and petrographic composition of several thousand specimens of different rocks from various parts of the Urals, it is concluded that the magnetic properties of rocks of different geologic ages are usually different, even when the rocks are petrographically similar; and rocks of the same age are magnetically similar. The absolute intensity of the remanent magnetism, as well as the ratio of remanent magnetism to the inducing magnetic field, increases with the decreasing age of the rock. Differences in the content of ferromagnetic minerals affect magnetic susceptibility but not to any extent the ratio of remanent magnetism to inducing field.—*S. T. V.*

169–227. Kalashnikov, A. G. Magnitnyye svoystva neodnorodno namagnichennykh prizm. I [Magnetic properties of heterogeneously magnetized prisms. I]: Akad Nauk SSSR Izv. Ser. geofiz., no. 12, p. 1369–1383, 1956.

The distribution of remanent magnetization in 13 prisms of different materials, sizes, and magnetic susceptibilities has been experimentally determined. The prisms were made of steel, magnetite, and mixtures of magnetite with different amounts of clay. The distribution of the remanent magnetization was not uniform but varied in different cross sections of the prisms and thus influenced the external magnetic field of the prism. Two conclusions are drawn: in interpreting the results of a magnetic survey, it is imperative to take into account the possible heterogeneity of the magnetization of the geologic formations involved, as such heterogeneity can result in considerable difference in the distribution of the field compared with that resulting from homogeneous magnetization which is ordinarily assumed; and in paleomagnetic investigations, the vector of remanent magnetization measured on the surface of the earth can be very different from the direction of the magnetizing field.—*S. T. V.*

169–228. Kalashnikov, A. G. O namagnichivanii prizm v otkrytoy i zamknytoy tsepyakh [Magnetization of prisms in open and closed circuits]: Akad. Nauk SSSR Doklady, tom 111, no. 6, p. 1231–1233, 1956.

The remanent magnetization in different bodies in technology is produced by magnetization in a closed circuit. In nature many bodies are found, as for example iron ores, that never were magnetized in closed circuits. Investigations of the distribution of remanent magnetization in iron prisms that were initially magnetized in a closed circuit and those that were initially magnetized in an open circuit show that the distribution of the intensity of the remanent magnetic field is in either type of magnetization nearly parabolic, and the maximum is in the middle section.—*S. T. V.*

169–229. Petrova, G. N. Magnitnaya stabil'nost' gornykh porod [Magnetic stability of rocks]: Akad. Nauk SSSR Izv. Ser. goefiz. no. 1, p. 52–61, 1957.

Magnetic stability of a rock is defined as the ratio H_c/H_e, where H_c is the intensity of the coercive field and H_e that of the external field. Experiments show that the thermal magnetization is the most stable, normal magnetization is the least stable, and ideal magnetization is intermediate between the two. Rocks cooled from high temperature, and thus thermally magnetized, should have higher magnetic stability than those normally magnetized to the same values. Normal magnetization in the weak geomagnetic field cannot be stable, so that the magnetic stability of the rocks found in nature is the result of the fact that their remanent magnetism is of thermal origin.—*S. T. V.*

169–230. Runcorn, S. K[eith]. Palaeomagnetic comparisons between Europe and North America: Geol. Assoc. Canada Proc., v. 8, pt. 1, p. 77–85, 1956.

Pole positions derived from directions of remanent magnetization in rocks in Great Britain and in southwestern United States are in rough agreement and indicate the magnetic pole has moved relative to the earth's surface at a mean rate of about 1/3° per million years since Precambrian times. Discrepancies can be explained by a westward displacement of 24° of North America related to Europe in post-Triassic, probably late Mesozoic, time—*M. C. R.*

169–231. Howell, Lynn G., and Martinez, Joseph D. Polar movement as indicated by rock magnetism: Geophysics, v. 22, no. 2, p. 384–397, 1957.

Directions of magnetization of samples of calcareous concretions in the Barnett formation of Mississippian age from nine places in the Llano uplift area of central Texas indicate pole positions in good agreement with those obtained by Belshe for rocks of Carboniferous age in England and by Runcorn for rocks of Pennsylvanian age in Arizona. The agreement is taken as evidence that little if any continental drift has occurred. Samples of Upper Cambrian age indicate the north pole was at lat 0°, long 22° W, in fairly good agreement with results given by Creer for samples in Great Britain and in lesser agreement with Day and Runcorn's results in Arizona. Data from the Sawatch formation (of Cambrian age) in Colorado indicate the rock may have been magnetized near the end of Paleozoic time; the late postdepositional magnetization may be the result of formation and magnetization of hematite in a late dolomitization or remagnetization of the rock in the presence of stresses related to formation of the ancestral Rockies.—*M. C. R.*

169–232. Runcorn, S. K[eith]. Rock magnetism: Nature, v. 179, no. 4565, p. 866, 1957.

Comments on Clegg's account of the discussion on rock magnetism at the British Association meeting (see Geophys. Abs. 167–195) and the lack of mention of his (Runcorn's) and Irving's work on positions of the pole in the geologic past.—*M. C. R.*

169–233. Cox, Allan. Remanent magnetization of lower to middle Eocene basalt flows from Oregon: Nature, v. 179, no. 4561, p. 685–686, 1957.

Fifty-seven oriented samples were collected from eight flows in the Siletz River volcanic series in the Coast Range of northwestern Oregon. The considerable scatter in the observed direction of magnetization was strikingly reduced by heating the specimens to 225° C and cooling them in a magnetic field of zero intensity. By Fisher's statistical methods, a mean direction of N 70° E and 55° down was obtained for the eight flows, and a mean direction of N 67° E and 56° down was obtained for the combined 57 samples. The field indicated by the former is such as would be produced by an axial dipole field with a pole at latitude 37° N and longitude 50° W. This pole is about 30° northeast of the average pole found by Clegg and others (see Geophys. Abs. 166–281) from the Deccan traps and even farther from the Eocene poles computed from European data by Hospers (see Geophys. Abs. 158–52).—*M. C. R.*

169–234. Khramov, A. N. O vozmozhnosti stratigraficheskoy korrelyatsii i raschleneniya osadochnykh tolshch po vektoru ostatochnoy namagnichennosti [On the possibility of stratigraphic correlation and identification of sedimentary series by their remanent magnetization]: Vses. neft. nauchno-issled. geol.-razved. inst. Trudy, Geol. Sbornik 2, vypusk 95, p. 198–208, 1956.

The magnetic state I of any ferromagnetic rock is the sum of two factors, one determined by the exterior magnetic field H, another determined by the remanent magnetism I_r reflecting the previous magnetic history of the mineral. Thus $I=KH+I_r$, where K is the magnetic susceptibility. The magnetic properties of more than 700 specimens extracted from drill holes in sedimentary rocks in western Turkmen S.S.R. were determined with an astatic magnetometer and

indicate that the remanent magnetization of sedimentary rocks was produced at the time of the formation of the sediments by the consistent orientation of ferromagnetic particles which had their own remanent magnetization. This direction of the magnetization as a rule is preserved as long as the rock has not been exposed to the effect of high temperature or intensive deformation. If such metamorphism takes place, it can be discovered by careful examination of the specimen. The main factor determining the orientation of the ferromagnetic particles is the field. This fact makes it possible to draw conclusions on the past direction of the field. The rocks can also be correlated by comparison of the magnetic properties, such as susceptibility and remanent magnetism.—*S. T. V.*

169–235. Minakami, Takeshi, and Sakuma, Shūzō. On magnetization of Mt. Fuji (Huzi) and other volcanoes in Japan: Bull. vulcanolog., Sér. 2, tome 18, p. 77–102, 1956.

Geomagnetic study shows that the active and dormant volcanoes of Japan are magnetized nearly towards the north. Intensity of magnetization depends not only on chemical composition of the lavas but also on structure of the volcano. The intensity of thermoremanent magnetization is commonly several to ten times that of the induced; but in the andesitic volcanoes such as Kusatu-Sirano, the magnetic anomalies near the volcano are influenced more by the present geomagnetic field than by remanent magnetization. The intense magnetization of new lavas, on the other hand (such as Miyake-sima in 1940 or Sakura-sima in 1946), is almost entirely thermoremanent.—*D. B. V.*

MAGNETIC SURVEYS

169–236. Kozulin, Yu. N. Pole vertikal'nogo magnitnogo diploya nad dvukhsloynoy sredoy [The field of the vertical magnetic dipole over a two-layer medium]: Leningrad Univ. Uchenyye Zapiski, no. 210, p. 158–167, 1956.

In this continuation of the paper by P. P. Pavinskiy and Yu. N. Kozulin (see Geophys. Abs. 168–89), mathematical refinements and certain transformations are introduced to simplify the numerical computation of the general solution. Several tables of numerical values of the expressions contained in the general solution are included.—*S. T. V.*

169–237. Roze, T. N. Opredeleniye nekotorykh kharakteristik zalezhi po magnitnym i gravitatsionnym nablyudeniyam [Determination of the characteristics of a deposit from magnetic and gravitational observations]: Vses. nauchno-issled geol. inst. Materialy, nov. ser., vypusk 8, p. 195–207, 1956.

Using Poisson's theorem it is often possible to determine the ratio T/σ where T is the intensity of magnetization of a disturbing body and σ is the excess of its density over that of the surrounding material. This ratio can be a good indicator of the type of rocks in surveyed areas and thus be of interest in geophysical exploration. A new method of determining T/σ using curves of the gravitational anomalies and of the anomalous magnetic field is suggested. The procedure also makes possible determination of the angle of inclination of the vector T with a horizontal plane. Knowledge of the gravitational and magnetic anomalies also makes possible, by using Gauss' theorem for the flux of the field vector, determination of the cross section of a disturbing body if the intensity

of its magnetization is known. The procedure is demonstrated on data of the Kursk magnetic anomaly.—*S. T. V.*

169–238. Roze, T. N. Priblizhennaya otsenka glubiny zaleganiya namagnichennykh tel [Approximate estimation of the depth of magnetized bodies] : Vses. nauchno-issled. geol. inst. Materialy, nov. ser., vypusk 8, p. 208–223, 1956.

The approximate method presented for determining the depth of a buried disturbing body is independent of the shape of the body and presumes only a knowledge of an anomalous vertical magnetic field profile. It is applicable to bodies extended in the horizontal direction to a length at least 5 times the depth of the body. The values of the vertical component for points sufficiently remote from the maximum value decrease proportionally with $1/X^2$, so that the expression $\lim(X^2Z)$ for X approaching infinity becomes constant and equal to $2\mu h$, where h is the depth of the lines of poles equivalent to the magnetic body and extending in the same direction, and μ is the linear density of the magnetization. The value of 2μ can be found from Gauss' formula for the flux of the field vector so that for the two dimensional case $\int_{-\infty}^{\infty} Z dx = 2\pi\mu$

Thus h is equal to $\pi \dfrac{\lim(x^2Z)}{\int_{-\infty}^{\infty} Z dx}$ for large values of X.—*S. T. V.*

169–239. Stupak, N. K., and Tyapkin, K. F. Logarifmicheskaya paletka $T_a = H_a^2 + Z_a^2$ dlya opredeleniya glubiny zaleganiya plasta namagnichennykh porod [Logarithmic master chart $T_a = \sqrt{H_a^2 + Z_a^2}$ for determination of the depth of a layer of magnetized rocks] : Razvedka i okhrana nedr, no. 3, p. 39–41, 1956.

Let T_a be the intensity of the anomalous field, and H_a and Z_a the horizontal and vertical components of this vector. T_a is a function of the magnetization of the body, its dimensions, position, and its depth h. Thus for a finite tabular body it is possible to represent T_a on a double logarithmic scale as a function of log x/h. The family of such curves has been determined for different values of T_a and other parameters, including the depth h, so that h can be readily found.—*S. T. V.*

169–240. Mikov, D. S. Atlas teoreticheskikh krivykh dlya interpretatsii magnitnykh i gravitatsionnykh anomaliy [Album of theoretical curves for the interpretation of magnetic and gravitational anomalies] : 128 sheets, Tomsk, Trudy Tomskogo Politekhnicheskogo Instituta, 1955. From the review in Razvedka i okhrana nedr, no. 5, p. 63, 1956.

An album of theoretically computed curves of the intensity of the gravitational and magnetic fields of a sphere, ellipsoids of revolution, vertical dikes, circular cylinders, vertical, horizontal and oblique laminas at different depths, anticlines and synclines of different ratios of height and radius of curvature, prismatic bodies of square and rectangular cross section and some other geometric forms. Charts are also given for gravitational and magnetic anomalies of several two-dimensional bodies.—*S. T. V.*

169–241. Baranov, V. A new method for interpretation of aeromagnetic maps: pseudo-gravimetric anomalies: Geophysics, v. 22, no. 2, p. 359–383, 1957.

Total magnetic intensity anomalies can be transformed into simpler anomalies and the distortion due to the obliquity of the normal magnetic field eliminated so that the resulting anomalies are vertically over the disturbing bodies. The transformation is based on the known relation between the magnetic potential V and the Newtonian potential U. The relation may be considered as a partial differential equation; the boundary conditions are the measured values of the total field at each point at the datum plane. $T(P)$ is the derivative of a harmonic function V which can thus be determined everywhere above the datum plane. By solving the partial differential equation, the Newtonian potential and its vertical derivatives can be determined, and these quantities can be obtained as functions of the measured magnetic anomaly. The pseudogravimetric anomalies have all the usual properties of a gravimetric anomaly and the interpretation is as simple as that of a Bouguer anomaly map.—*M. C. R.*

169–242. Agocs, W. B., and Hartman, R. R. Airborne magnetometer profile from Olympia, Wash., to Laramie, Wyo.: Mining Engineering, v. 8, no. 12, p. 1210–1215, 1956.

A 1,000-mile magnetic profile from Olympia, Wash., to Laramie, Wyo., reveals numerous correlations between geologic structures and magnetic anomalies. Depths to igneous rocks are also obtained by analysis of the magnetic anomalies.—*L. C. P.*

169–243. Merriam, Daniel F., and Hambleton, William W. Relation of an airborne magnetic profile to the geology along the Kansas-Nebraska border: Kansas Geol. Survey Bull., no. 119, pt. 7, p. 251–266, 1956.

An airborne magnetic profile made along the 40th parallel is shown in relation to the geologic cross section along the Kansas-Nebraska state line. Information for constructing the cross section was largely from electric logs, sample logs, and logs of oil and gas wells. Precambrian to Recent formations are present and major structural provinces shown on the cross section and crossed by the magnetic profile include the Hugoton embayment, Cambridge arch, Salina basin, Nemaha anticline, and Forest City basin.

Thinning of the sedimentary rock sequence toward the east produces a regional magnetic gradient with values higher in eastern than western Kansas. In western Kansas, magnetic data indicate the position and form of the Precambrian basement, but in eastern Kansas they seem to show the general distribution of Precambrian rock types.—*V. S. N.*

169–244. Kutscher, Fritz. Angewandte erdmagnetische Messungen in Hessen. 1. Zusammenstellung der bisherigen speziellen erdmagnetischen Untersuchungen in Hessen [Applied magnetic measurements in Hesse. 1. Summary of specific magnetic investigations in Hesse to the present time]: Hesse Landesamt für Bodenforschung zu Wiesbaden Notizbl., Band 81, Folge 6, Heft 4, p. 350–367, 1956.

A summary of magnetic surveys by various individuals and companies in different areas of volcanic basalt, diabase, gabbro, and botryoidal rock and iron ore deposits in Hesse, Germany. The geologic features of each area are described and the order of magnitude of the anomalies found to be associated with them are given.—*B. T. E.*

169–245. Gay, L. O., and Kosten, M. Some applications of geophysical methods to geological problems in the Gold Coast: Gold Coast Geol. Survey Bull., no. 21, 37 p., 1956.

A discussion of the methods used and the results from a magnetic variometer survey to determine a possible extension of the mineralized zone north of the Nanwa gold mine and from three electrical restivity surveys to locate water supplies in sediments and in areas of gneiss.—*V. S. N.*

169–246. Nakamura, Saemon Taro, and Onuki, Akira. Magnetic anomalies along the Bay of Yatusiro, Kumamoto prefecture: Kumamoto Jour. Sci., ser. A, v. 1, no. 3, p. 59–63, 1954.

The magnetic dip was measured at 21 places along the Bay of Yatusiro. The large dip observed can be explained by a linear double source at a depth of 12.5 km. Earthquakes have occurred on both northern and southern extensions of this line, and a fault is known along the east coast of the bay.—*M. C. R.*

169–247. Nodia, M. Z. Rezul'taty issledovaniya odnoy sverkhintensivnoy ultralokal 'noy magnitnoy anomalii [Results of the exploration of a sharply localized magnetic anomaly of extreme intensity]: Akad. Nauk Gruzinskoy SSR Soobshcheniya, tom 14, no. 4, p. 211–216, 1953.

A vertical intensity magnetic anomaly ranging from −56170 gammas to +13430 gammas was found over a small mound of porphyrite in 1947. The extremely high range of values may be explained by the irregular topography of the area.—*S. T. V., L. C. P.*

169–248. Pegum, D. M. Magnetic investigations in the Kadina-Wallaroo and surrounding areas: South Australia Dept. Mines Min. Rev., no. 101, p. 79–87, 1956.

A ground magnetometer survey was made of anomalies found by an aeromagnetic survey of the northern Yorke Peninsula. The survey indicated that anomalies similar to those around the Wallaroo copper mines area occur at North Kadina and Weetulta but without the same degree of magnetic disturbance. As the relation of the anomalies to the copper deposits is doubtful and as there is a lack of geologic knowledge in the area, it is probable that interpretation of the anomalies must be based on results of drilling.—*V. S. N.*

MICROSEISMS

169–249. Oliver, Jack, and Ewing, Maurice. Microseisms in the 11- to 18-second period range: Seismol. Soc. America Bull., v. 47, no. 2, p. 111–127, 1957.

Storm microseisms in the 11- to 18-second range recorded at Palisades and Bermuda are attributed to ocean swell of identical periods in the vicinity of the sea coast near the seismograph station. Evidence is based on traveltime, correlation with wave-recorder data, and dispersion of the waves from hurricane Dolly [September 1–3, 1954], which remained in deep water when near the Palisades station and passed at a speed greater than the group velocity of ocean swell. Ground-particle motion is longitudinal, with little or no vertical component. With some qualifications, the results agree with the classical surf theory of microseism generation. Certainly, the energy is transferred to the earth within the littoral zone.—*Authors' abstract*

169–250. Geddes, A. E. M. Note on large microseisms recorded at Aberdeen on 1954 December 9: Royal Astron. Soc. Monthly Notices, Geophys. supp., v. 7 no. 5, p. 219–227, 1957.

A deep depression moved rapidly NNE from the Welsh coast across northern England to the Firth of Forth on 1954 December 9. At the same time microseisms of very large amplitude were recorded at Aberdeen, the maximum effect occurring when the centre of low pressure was situated over land. If the disturbances were due to standing waves set up in the sea in accordance with the Longuet-Higgins theory, these waves must have arisen behind the low centre by reflection from the coast. There was no other low centre in the neighbourhood likely to produce the effects. So far as the nature of the microseisms is concerned, the records support the idea that they consist of a mixture of Rayleigh waves and Love waves, and that in the present case they approached Aberdeen from a direction approximately SSW of the station.—*Author's summary*

RADIOACTIVITY

169–251. Voitkevich, G. V. Radiogeologiya i yeye znacheniye v poznanii istorii zemli [Radiogeology and its significance for the knowledge of the history of the earth]: 112 p., Moscow, Gosgeoltekhizdat, 1956.

A textbook on radiogeology, defined as the application of the methods and results of radiochemistry and nuclear physics in solving fundamental problems of geology. Chapter titles: Radioactivity and the atomic nucleus; Atomic transformations in nature; The radioactivity of the earth; Determination of the geologic age by the methods of atomic disintegration; The age of the earth; Absolute chronology of the earth's history; Radioactivity and thermal conditions in the earth; Radioactivity and the dynamics of the earth's crust; Radioactivity and certain questions of cosmogony.—*S. T. V.*

169–252. Neher, H. V. Gamma rays from local radioactive sources: Science, v. 125, no. 3257, p. 1088–1089, 1957.

Measurements of total gamma-ray radiation were made at a series of 11 stations from California to New York City and at stations in Canada, Greenland, and Peru. Results are plotted to show total gamma radiation, local gamma radiation, and man-made contamination. It is evident that man-made contamination is small compared with changes in natural radiation.—*V. S. N.*

169–253. Picciotto, E. [E.] Utilisation des émulsions liquides dans l'étude de la radioactivité des roches [Use of liquid emulsions in the study of the radioactivity of rocks]: Soc. Belge Géologie Bull., tome 65, fasc. 2, p. 257–260, 1956.

A preliminary note on the study of radioactivity of a series of intrusive rocks and lavas by means of the new liquid nuclear emulsions. Several thin sections (35μ) were covered with a layer of the emulsion and kept for 3 months at 4° C. The results are shown in photomicrographs comparing the thin sections and the developed emulsions showing α-tracks. If powdered minerals are incorporated directly in the emulsion, the emission of particles in three dimensions can be studied more effectively than if the powder is between two layers of stripped emulsion, as before. Where the rocks are in radioactive equilibrium, the uranium-thorium ratio can be calculated from the formula $N/10.7 \cdot n' = 1 + 4.14$ U/Th, where N is total α and n' is α from ThC'. For rocks not in equi-

librium (those younger than 10^6 yrs or subjected to recent transformations) the α-energy sprectrum, and with it valuable information on the history of the rock, can be determined from the length of α-tracks around the grains of powder. The results obtained with powdered monazite are shown.—*D. B. V.*

169–254. Polak, L. S., and Rapoport, M. B. O pogloshchenii gammaluchey osadochnymi porodami [The absorption of gamma rays by sedimentary rocks]: Prikladnaya geofiz., vypusk 15, p. 135–139, 1956.

The absorption of gamma rays by different substances is the result of three factors: the photo-electric effect, the Compton effect, and the annihilation due to formation of electron-positron pairs. The values of these coefficients are determined by the energy of the source radiating the gamma rays. These data are given in handbooks for lead as the absorbing medium; they can be computed from the atomic weight, atomic number, and density for any other element. For lighter elements that make up sedimentary rocks, the predominant factor that determines the absorption of gamma rays is the Compton effect, especially when the radioactive cobalt is used. But the Compton effect is proportional to the density of the rock and is independent of its mineralogical composition; therefore, gamma ray absorption in well logging makes it possible to obtain information on the density of the formation penetrated by a drill hole.—*S. T. V.*

169–255. Rogers, John J. W., and Adams, John A. S. Autoradiography of volcanic rocks of Mount Lassen: Science, v. 125, no. 3258, p. 1150, 1957.

An autoradiographic study of rocks from Lassen Volcanic National Park was made using the method of Guilbert and Adams (Nucleonics 13, no. 7, p. 43, 1955). In each thin section, 100 alpha tracks were counted and the mineral from which each emanated was identified. These data and a modal analysis of each section made it possible to calculate for each mineral the ratio: percentage of alpha tracks from mineral percentage of mineral in rocks. It was concluded that the alpha-emitting elements are uniformly distributed among all the constituents of the volcanic rocks because rapid solidification of the lavas prevented concentration of thorium and uranium in any single mineral.—*V. S. N.*

169–256. Morais, Marília Xavier de. Radioactividade de rochas graníticas do Maciço Hespérico [Radioactivity of granitic rocks from the Hesperic Massif]; Coimbra Univ. Mus. e Lab. Mineralog. Geol., Mem. e Notícias, no. 41, p. 26–39, 1956.

The radioactivity of 41 granitic rocks from the Hesperic Massif (Iberian Tableland), Portugal, has been found to range generally between 0.003 and 0.005 percent U_3O_8; the SiO_2 content generally falls between 69 and 74 percent. A maximum of 29 percent U_3O_8 in a specimen from Urgeiriça (Nelas) is explained by its proximity to a vein containing radioactive minerals. Samples collected at different depths along the pegmatite veins at Cabração (Ponte do Lima) show that the radioactivity increases with depth; in these same pegmatites a correlation is noted between SiO_2 content and radioactivity. A granite near the Cabração veins is more radioactive than the veins, but the contrary is true of a granite near pegmatite at Paradela-do-Rio (Montalegre, Vila Real district). Each rock was measured by two sets of apparatus, a portable battery-operated Geiger counter and a more complex laboratory apparatus involving a scaler, watch, and Geiger tube. The slight increase in accuracy with the laboratory

set-up is deemed insufficient to outweight the cheapness and convenience of the field instrument.—*D. B. V.*

169–257. Husmann, Otto. Bestimmungen des Thorium- und Uran-Gehaltes an Gneisen, an anatektischen und magmatischen Gesteinen des mittleren Schwarzwaldes mittels der Koinzidenz-Methode [Determinations of the thorium and uranium content of gneisses, anatectic, and magmatic rocks of the central Black Forest by means of the coincidence method]: Neues Jahrb. Mineralogie Monatsh., Jahrg. 1956, Heft 5, p. 108–120.

By the coincidence method of measuring radioactivity it is possible to distinguish directly between thorium and uranium even in limited masses of rocks of average radioactivity. Measurements of the percentage of K_2O and the grams of thorium per ton, grams of uranium per ton, and ratios of the latter are tabulated for 35 different crystalline rocks in the Black Forest of Germany. These results are further summarized from a petrographic point of view in a table giving the uranium-thorium ratios (maximum, minimum, and average) for each rock type. The following average results are obtained for the three broad groups of gneisses, anatectic rocks, and magmatic rocks, respectively: g U per ton=5.5, 7.3, 15; g Th per ton=10, 13.8, 9.9; and ratios of 1.8, 1.8, 0.7.—*D. B. V.*

169–258. Sarrot-Reynauld, J. Répartition de la radioactivité des sédiments houillers, permiens et triasiques dans le dôme de La Mure (Isère) [Distribution of the radioactivity of the Carboniferous, Permian and Triassic sediments of the La Mure dome (Isère)]: Soc. savantes Paris 81e Cong. Comptes rendus, sec. sci., p. 9–16, 1956.

The radioactivity of about 300 samples from the Coal Measures of the Dauphine coal basin of France ranges from 120 to 323 counts per hour. Schists of overlying Permian sediments from the eastern edge of the La Mure dome show 350 counts per hour, but the Permian sandstones are weaker. Argillaceous Triassic sediments intercalated in gypsum and anhydrite beds of the basal Keuper west of the La Mure dome show 130 counts per hour, those associated with spilites of the late Keuper surrounding the La Mure dome show an average of 200 counts per hour. The distribution of radioactivity is governed by three factors: placer-type accumulation of radioactive minerals in the sediments; adsorption of radioactive elements by colloidal clay particles; and absorption of radioactive elements into the crystal lattice of micaceous minerals. The last is particularly interesting in view of the fact that illite is very common in the sediments.—*D. B. V.*

169–259. Merlin, O. Hieke, Picciotto, E. [E.], and Wilgain, S. Étude photographique de la distribution de la radioactivité dans la granodiorite de l'Adamello [Photographic study of the distribution of radioactivity in the Adamello granodiorite]: Geochim. et Cosmochim. Acta, v. 11, no. 3, p. 171–188, 1957.

Study of Adamello granodiorite from Italy by means of photographic emulsions shows heterogeneous distribution of α-activity similar to that of granitic rocks. More than 95 percent of the activity is concentrated in accessory minerals forming 0.1 percent of the volume of the rock; the most active are 100,000 times more radioactive than the essential minerals. More than 90 percent of the activity of some of the essential minerals is due to microscopic inclusions of accessory minerals. The apparent enrichment of ferromagnesian minerals in uranium and

thorium is due to such inclusions rather than to substitution by uranium and thorium in the crystal lattice. The most highly radioactive inclusions carry more than 10 percent uranium and thorium; exact identification is not possible, but they are believed to be uraninite and torbernite. The "real activity" of the essential minerals (quartz, feldspar, and biotite) is of the order of 3×10^{-5} α per cm^2 per sec, corresponding to 10^{-7} g U per g. Contrary to observations in other granitic rocks, there is no concentration of radioactivity at crystal boundaries; this homogeneity of distribution is very important in age determinations on isolated minerals. The pleochroic haloes in biotite around inclusions larger than 50μ in diameter represent an energy spectrum; they are not formed of concentric rings as in very tiny inclusions but are uniform over the whole radius of the halo.—*D. B. V.*

169–260. Przewlocki, Kazimierz, Buja, Zdzislaw, Jurkiewicz, Leopold, and Poborski, Józef. An attempt of a radioactive characteristic of the Zechstein salt series in Kujawy [central Poland]: Acta Geophys. Polonica, v. 4, no. 1, p. 5–20, 1956.

Measurements of radioactivity were made in the salt dome in the "Solno" mine at Inowrocław in an attempt to distinguish the different salt series by means of their radioactivity. A scanning instrument consisting of three small Geiger-Müller counters was placed in holes of uniform size in the walls of horizontal passages in the mine. It was found possible to distinguish the older salts from the rest but not to establish the boundary between the younger and youngest salts. However, the radioactivity measurements proved useful in prospecting and in underground surveying, especially in areas of secondary discoloration.—*M. C. R.*

169–261. Kubo, Kyōsuke, and Fujiwara, Kiyomaru. Report on the radioactivity of earthy graphite in the Kumano District, Omine Coal Field: Geol. Survey Japan Bull., v. 7, no. 8, p. 33–36, 1956.

Radioactivity of earthy graphite, of Triassic age, measured by a Philips pocket monitor, is 40 counts per minute or 1½ to 2 times the background count. Radioactivity of granite and granite porphyry, closely related with the origin of graphite, is 25–30 counts per minute. The radioactive minerals in the sedimentary rocks of this coal field are probably related to the carbonaceous material.—*V. S. N.*

169–262. Balavadze, B. K. Radioaktivnost' nekotorykh termal'nykh istochnikov Tkvarcheli [The radioactivity of some thermal springs of Tkvarcheli]: Akad. Nauk Gruzinskoy SSR Soobshcheniya, tom 16, no. 10, p. 781–784, 1955.

The radioactivity of springs of the Tkvarcheli region of the Georgian S. S. R., measured with a previously calibrated universal electrometer, ranged from 20.9 to 39.5 emanation units. A chemical analysis of the water is also given.—*S. T. V.*

169–263. Aurand, K., Jacobi, W., and Schraub, A. Untersuchungen über die Folgeprodukte des Radons im Gasteiner Thermalwasser [Investigations on the radon decay products in the Gastein thermal water]: Österreich. Akad. Wiss. Sitzungsber., Abt. 2, Band 165, Heft 1–4, p. 133–148, 1956.

Radioactivity of the thermal waters of Bad Gastein and Bad Hofgastein was measured at different points in their distribution system in order to determine

whether the radon decay products were present in equilibrium quantities. In the large majority of samples, including those taken right at spring mouths, the short-lived decay products are present in less than 20 percent of the equilibrium amount. It is assumed that the same mechanism that causes precipitation and deposition of the decay products in the distribution system, between spring outlets and points of use, is also at work as the waters percolate underground, thus causing the deficiency at the outlet. The variation is so great among the various points measured that the mean value is without significance.—*D. B. V.*

169–264. Okabe, Sigeru. On some relations between the hot spring and radioactivity: Kyōto Univ. Coll. Sci. Mem., Ser. A, v. 28, no. 1, p. 39–71, 1956.

Rapid and violent fluctuations of the radon content of hot spring water were observed at several places in Japan by a method that involved bottling samples of the water and after 3 hours, during which the radon reached equilibrium with its daughter products, measuring the activity of the precipitate formed when sulfuric acid and barium nitrate were added. The variations are believed due to the differences in the amounts of radon contributed to the thermal waters by underground cavities containing radioactive liquids. Observations at several places indicate a correlation between a high radioactive background and the occurrence of hot springs, and between radioactivity and temperature. The source of the radon is presumed to be at a shallow depth and not connected with the original source of the hot spring water.—*M. C. R.*

169–265. Kaku, Koichi. Distribution of radon in central Kyushu; Kumamoto Jour. Sci., ser. A., v. 1, no. 3, p. 86–110; v. 2, no. 1, p. 108–118, 1954.

Measurements of radon content were made at 47 hot springs in central Kyushu by use of an I. M. Fontactoscope. Highest observed values were at Musashi Hot Springs (12 mache). Radon content is greatest in areas underlain by granite rocks and least in areas underlain by volcanic rock. Inferences on the geology of the areas are drawn from the "iso-radon" curves and temperature distribution.—*M. C. R.*

169–266. Iwasaki, I., Katsura, T., Shimojima, H., and Kamada, M[asaakira]. Radioactivity of volcanic gases in Japan: Bull. volcanolog., sér. 2, tome 18, p. 103–123, 1956.

Measurements of the radon and thoron content of the gases from volcanic hot springs and fumaroles in Japan, made with an I. M. Fontactoscope, show that considerable radon and thoron are present in nearly all volcanic gases and that the radioactivity of the thoron is generally stronger than that of the radon in the same gas. The radioactivity of the Japanese gases is never negligible, as in those of Kamchatka, and is often comparable to that of the strongly radioactive mineral springs or to that of the volcanic gases from the island of Vulcano, Italy. The presence of many radioactive elements (Rn, RaA, RaB, RaC, Tn, ThA, ThB) was confirmed, but no actinon was found. Variations in the radioactivity were noted but for the most part the radon content of the most powerful fumaroles is unaffected by changes of season, temperature, precipitation, or atmospheric pressure. From the Tn/Rn ratio in a single gas it is calculated that both elements originated within 10 minutes transportation time from the surface. In the weak, lower-temperature fumaroles accompanied by hot water, there is an excess of Rn and Tn in the gas phase; from this it is concluded that the fumarolic gases are the principal source of the radioactivity of the water. Hot springs far from

volcanic centers do not show any excess of radon in their gas phase; the origin of the radon and thoron in fumarolic gases, therefore, seems to be different from that of non-volcanic radioactive mineral or hot springs.—*D. B. V.*

RADIOACTIVITY LOGGING AND SURVEYING

169–267. Bright, O. T. Introduction to radioactivity logging: Kentucky Geol. Survey Special Pub., no 9, p. 40–47, 1956.

A discussion of the principles and application of the radioactivity log.—*V. S. N.*

169–268. Dakhnov, V. N. Sovremennoye sostoyaniye i perspectivy dal'neyshego razvitiya radiometrii skvazhin [The present state and the anticipated further development of the radiometry of drill holes]: Razvedka i okhrana nedr, no. 6, p. 25–39, 1956.

A discussion of the principles of the different methods of radioactivity logging and their application, including boron, manganese, cobalt, tungsten, and mercury.—*S. T. V.*

169–269. Voskoboynikov, G. M., and Deyev, L. L. Plotnostnoy karottazh ugler-azvedochnykh skvazhin [Density logging of drill holes in exploration for coal]: Razvedka i okhrana nedr, no. 10, p. 38–46, 1956.

A report on experiments in the Ural Mountains to improve geophysical logging methods in exploration for coal. Both radioactivity (gamma-gamma) and electrical logging methods were found to be advantageous. The experiments indicate that gamma-gamma logging makes it possible to separate the coal-bearing layers of the drill holes and improves the reliability of the logging but is subject to erroneous indications caused by the presence in the wells of wide cavities. A system for simultaneous recording of gamma-gamma and electrical logging is recommended.—*S. T. V.*

169–270. Shibata, Isamu. Supplementary report on the radioactivity of coal-measures in some coalfields of Kyūshū: Mining Geology (Japan), v. 7, no. 23, p. 58–60, 1957.

Earlier measurements of the radioactivity of coal and attendant rocks in the Saga coalfield (see Geophys. Abs. 168–261) were made in the mine gallery. To rule out the direct influence of the rhyolite body on instruments, samples were collected and sent to Tokyo for testing. Results showed that, as in the gallery tests, the samples increased in radioactivity with nearness to the rhyolite while samples from parts of the mine where igneous rocks are absent show the normal low counts.

A recent survey of the Akaike coal mine shows that mafic igneous rocks, such as basalt, have no effect on the radioactivity of coal measures. Moreover, the radioactivity of the basalt varies with its surroundings: the count is very low where basalt is intruded into coal seams but is relatively high where intruded into shale.—*V. S. N.*

169–271. Bulashevich, Yu P., and Voskoboynikov, G. M. Gamma-gamma-karottazh na ugol'nykh mestorozhdeniyakh Urala i vozmozhnost' beskernovogo bureniya chasti razvedochnykh skvazhin [Gamma-gamma well logging in coal deposits of the Urals and the possibility of avoiding lithological logging in some of the exploratory drill holes]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 1, p. 109–112, 1957.

From data obtained by lithologic logging of drill holes in many coal deposits of eastern Ural, it was found that the adjacent formations ordinarily are about 1 g per cm^3 more dense than the coal layers. Radioactive logging of drill holes may be used to find coal seams between denser formations, because the intensity of the dissipated gamma-radiation is very sensitive to changes in the density of the strata pierced by the hole. In the arrangement used, the source of gamma-rays was a small amount of radium. The logging was performed by recording the varying intensity of gamma-rays as the source of the rays moved along the hole with a velocity of about 150 m per hour. The length of the probe in the experiments was about 70 cm. The agreement between the indications of the gamma-logging and the lithology is very good.—*S. T. V.*

169–272. Rossi, Dino. Il carotaggio radioattivo di laboratorio nella ricerca del vapore endogeno [Radioactivity logging in the investigation of endogene steam]: Industria Mineraria, anno 8, no. 1, p. 1–7, 1957.

Gives examples of the use of gamma-ray measurements in the logging of geothermal steam borings in Italy. Measurements on well cuttings or drilling mud were found to give an entirely satisfactory picture of the permeability of the formations traversed, without interrupting drilling operations. Direct logging in the borehole was used only when mud circulation was lost. The relatively simple apparatus can be set up in the vicinity of drilling operations, serves several borings at a time, and does not require highly specialized personnel.—*D. B. V.*

169–273. Williams, W. J., and Lorenz, Phillip J. Detecting subsurface faults by radioactive measurements: World Oil, v. 144, no. 5, p. 126–128, 1957.

Radioactive gases that migrate upward from a buried fault may be detected by gamma-ray surveys at the surface.—*L. C. P.*

169–274. Seedsman, K. R., and Harris, J. L. Airborne scintillometer survey of eastern Eyre Peninsula: South Australia Dept. Mines Min. Rev., no. 101, p. 72–78, 1956.

In an airborne scintillometer survey covering 3,370 square miles, 42 major anomalies and 1,300 minor anomalies were located. The major anomalies were ground-checked and found to be caused by the mass effect of widespread low-grade sources of radioactivity in granites and gneisses.—*V. S. N.*

SEISMIC EXPLORATION

169–275. Hale, John D. Petroleum geologist and exploration geophysicist: coordination and seismic velocity: Alberta Soc. Petroleum Geologists Jour., v. 4, no. 11, p. 249–254, 1956.

Changes in seismic velocities are due to changes primarily in the density of subsurface formations as the result of different stratigraphic or structural conditions; a combination of some geologic changes may result in no change in velocity. Therefore for best interpretation the petroleum geologist must "be better able to anticipate velocity gradients and the geophysicists to detect them . . ."—*M. C. R.*

169–276. Burg, K. E. How to make seismic data understood: Oil and Gas Jour., v. 55, no. 13, p. 136–141, 1957.

By using corrected record sections it is possible for the geophysicist to prepare a presentation of seismic data that can be readily related to known geology, presented in a form that is readily reproducible and preserves the original data.—*D. R. M.*

169–277. Slutskovskiy, A. I. Elektrodinamicheskiye seysmografy [Electrodynamic seismographs]: Razvedochnaya i promyslovaya geofizika, vypusk 13, p. 28–35, 1955.

A report on the result of field and laboratory tests of several seismographs of Russian design.—*S. T. V.*

169–278. Waldie, Alan D. New geophone will improve seismic field production: World Oil, v. 144, no. 5, p. 119–122, 1957.

A new geophone for land use is fixed permanently in the geophone cable and requires no special effort in placement, as do ordinary geophones. The geophone is 4 inches long, ¾ inch in diameter, weighs 5 ounces, and operates on the variable reluctance principle.—*L. C. P.*

169–279. Aksenovich, G. I., Gal'perin, E. I., and Zayonchkovskiy, M. A. Osobennosti apparatury dlya glubinnogo seysmicheskogo zondirovaniya i rezul'taty eye oprobovaniya [Special features of the equipment for deep seismic sounding and the results of its use]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 184–189, 1957.

Deep seismic sounding is based on the correlation of refracted seismic waves produced by relatively small amounts of explosives (50–300 kg) recorded at distances of as much as 400 km from the shot point. Low frequencies are used; in recent experiments best results were obtained with frequencies ranging from 8 to 15 cycles per second. The number of geophones is increased in relation to distance; in recent surveys in the region between the rivers Volga and Ural, four mobile seismographic stations were used, each with 60 receiving channels. The geophones are assembled in groups to decrease the effect of microseisms and other disturbing factors. Seismographs used are preferably of the dynamic type with a natural frequency of 9–12 c. Four-step amplifiers are provided with filters operating at low frequencies. The coefficient of total amplification is about 750,000 (measured on voltage). The amplifiers and the recording mechanisms are so adjusted, that a signal of 1 mkv produces on the recording film an amplitude of 20 mm. A wiring diagram of the installation is given.

One of the most successful surveys was performed over the northern slope of the Tian Shan where the explosions were made in the water of the Issyk-Kul' and Balkhash lakes at depths of 17–20 m. With 50 kg of explosives clear seismograms were obtained over a total distance of more than 366 km.—*S. T. V.*

169–280. Mozzhenko, A. N. Seysmokarottazhnyy zond [A probe for seismic logging]: Razvedochnaya i promyslovaya geofizika, vypusk 13, p. 40–42, 1955.

Difficulties in building a probe for seismic logging that uses a three-conductor cable to service two instruments because of the inductive coupling between the two seismographs have been overcome by balancing resistances in each part of the

wiring system. The device can be used to depths of 2,000 or 2,500 m. A wiring diagram is given.—*S. T. V.*

169–281. Palmer, E. M. The Gulf seismic profile printer: Geophysics, v. 22, no. 2, p. 286–308, 1957.

A seismic recording system has been developed in which seismic sections, printed photographically in variable density form, simulate geologic cross-sections. The seismic signals recorded from geophone stations arranged for continuous reflection center-point control are presented in a sequence of vertical tracks. The tracks are adjusted for known corrections and reproduced at a selected horizontal scale. Prints of the variable-density section exhibit all events and their interrelationships for ready recognition and appraisal.

The printer mechanism reduces seismic information to a uniform time basis, with weathering and elevation corrections to datum, and with stepout corrections in which account is taken of changing wave-front velocity with vertical travel-path time.

The original field records comprise variable-density tracks on strips of 70-mm film. In the printer, individual record tracks are successively scanned and transferred to a continuous sheet of film by contact printing. Punched cards supply correction data to mechnisms which displace each record track according to the desired corrections. Normal and special printing functions are automatically performed.—*Author's abstract*

169–282. Wilson, Gilbert M. Magnetic recording—new key to data interpretation: World Oil, v. 144, no. 5, p. 113–118, 1957.

A review of modern magnetic tape recording of seismic data, marine sonic exploration, the nuclear magnetometer, and interval velocity logging.—*L. C. P.*

169–283. Kaufman, S., Parrack, A. L., and Skelton, J. D. Report of SEG Subcommittee on magnetic recorder characteristics: Geophysics, v. 22, no. 2, p. 434–441, 1957.

A summary of information on magnetic recording and playback systems based on the specifications of several manufacturers.—*M. C. R.*

169–284. Badger, A. S. New developments made in direct recording heads: World Oil, v. 144, no. 5, p. 123–125, 1957.

A discussion of low-frequency direct magnetic recording heads using mumetal.—*L. C. P.*

169–285. Anstey, N. A. Modern technique in seismic reflection recording: Geophys. Prosp., v. 5, no. 1, p. 44–68, 1957.

A review of present knowledge on the seismic process and a discussion of its application in determining recording techniques for maximum results.—*M. C. R.*

169–286. Khurges, L. L. Ispol'zovaniye unformera RU–11 dlya pitaniya anodnykh tsepey seysmostantsii [Use of a converter for feeding the anodic circuits of a seismic station]: Razvedochnaya i promyslovaya geofiz., vypusk 13, p. 42–44, 1955.

A motor-generator set may be used to replace high-voltage batteries for portable seismic stations. Fed from a standard storage battery of low voltage, the motor-generator can give voltages ranging up to 200 or more volts and keep

this voltage sufficiently stable, making measurements and the recording convenient.—*S. T. V.*

169–287. Adachi, Ryutaro. Fundamental relations on the seismic prospecting: Kumamoto Jour. Sci., ser. A, v. 2, no. 3, p. 253–258, 1955.

Mathematical demonstration that, for the two-layer case, if the discontinuity is a straight line, the traveltime curve is also a straight line, and vice versa.—*M. C. R.*

169–288. Adachi, Ryutaro. On a proof of fundamental formula concerning refraction method of geophysical prospecting and some remarks: Kumamoto Jour. Sci., ser. A, v. 2, no. 1, p. 18–23, 1954.

A mathematical discussion of the formula for the traveltime of a wave refracted through n dipping layers.—*M. C. R.*

169–289. Danchev, P. S. O zavisimosti nachal'nogo davleniya vzryva ot koeffitsienta zaryazhaniya [On the relation between the initial pressure of the explosion and the coefficient of charging]: Akad. Nauk Kirgiz. SSR, Inst. Geol. Trudy, vypusk 7, p. 105–110, 1956.

Using the formulas of thermochemistry, the author derives the relation between the pressure on the walls of a hole and the value of the charging coefficient of an explosion. From this formula it can be seen that by proper selection of the value of the charging coefficient it is possible to obtain the greater seismic effect on the walls of the hole with smaller crushing effect.—*S. T. V.*

169–290. Horton, C. W. The structure of the noise background of a seismogram II: Geophysics, v. 22, no. 2, p. 261–267, 1957.

Statistical analysis of one-second samples of two seismogram traces leads to the tentative (because of the small amount of data) conclusions that the theory of shot noise presented by S. O. Rice offers a good first approximation to the statistical properties of the noise background of a seismogram trace, and that the noise structure of the seismogram becomes appreciably more complicated as the point of observation approaches the surface.—*M. C. R.*

169–291. Press, Frank. A seismic model study of the phase velocity method of exploration: Geophysics, v. 22, no. 2, p. 275–285, 1957.

Variations in the phase velocity of earthquake-generated surface waves have been used to determine local variations in the thickness of the earth's crust. In model studies, using the two-dimensional techniques described by Oliver, Press, and Ewing (see Geophys. Abs. 157–90), of the effect of changes in thickness, and in lithology, and faults and scarps on the phase velocity of surface waves, measurable variations resulting from all these factors were observed. To apply the methods in field exploration guided waves in the frequency range 1 to 1/10 c would be required.—*M. C. R.*

169–292. Volin, A. P., and Rudakov, A. G. O seysmorazvedochnykh rabotakh na poperechnykh volnakh [Exploratory operations using seismic transverse waves]: Prikladnaya geofiz., vypusk 15, p. 53–82, 1956.

From 1952 to 1954 experiments were carried out by the staff and the students of Leningrad University to develop a seismic method of exploration that would produce and utilize only transverse waves. Such a method results in much

simpler seismograms that are easier to interpret. These seismograms eliminate many errors that are difficult to avoid when transverse and longitudinal waves are produced simultaneously. Transverse waves can be recorded with many types of ordinary seismographs. Certain difficulties were experienced in making equipment which would produce only transverse waves. A mechanical device was tested and gave satisfactory results, but produced only moderately intense waves. Much better results were achieved with a directed explosion.—*S. T. V.*

169–293. Castro, Honorato de. Determinacion de la ley de variación de velocidades sismicas en un pozo petrolero [Determination of the law of variation of seismic velocities in an oil well]: Ciencia (Mexico), v. 16, no. 7–8, p. 162–167, 1956.

From a graphic representation of velocity observations, the straight line which most closely fits the observed values is determined by a least-squares methods. The formula for this line is found to be $v=0.000064998p^2+0.661647812p+2300.709626800$, where v=velocity and p=depth. A table is presented giving the velocities based on this formula for every hundred meters of depth from sea level to 3,000 m.—*D. B. V.*

169–294. Yepinat'yeva, A. M. Opyt registratsii poperechnykh prelomlennykh voln pri seysmicheskoy razvedke [Experiences in recording refracted transverse waves in seismic exploration]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 11, p. 1309–1315, 1956.

Seismic waves were observed on a profile about 28 km long by using instruments tuned to natural frequencies of either 10 or 40 cycles per sec. The structure in the region included layers of argillaceous sands of different degrees of consolidation and different seismic velocities, conditions favorable for producing refracted transverse waves. The waves were observed at a distance of 1,100 m and at greater distances to 29 km or more. At these distances the first refracted waves to arrive had an apparent velocity of 7,000 m per sec. Although the observed waves arrived as transverse waves, it is possible that they were propagated as longitudinal waves only through the thin topmost layer.—*S. T. V.*

169–295. Ryabinkin, L. A., and Znamenskiy, V. V. Novyye dannye o registratsii kratnykh voln pri seysmorazvedke [New data on recording multiple waves in seismic exploration]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 11, p. 1316–1321, 1956.

Compound waves of complex shape, composed of repeatedly-reflected refracted waves and up to five multiple reflections were observed at a distance of about 800 m from a shot point. The reflections were returned from a layer of high rigidity at shallow depth. When analyzing a compound wave, individual components should be removed as soon as they can be reasonably identified. This simplifies the subsequent procedure and the final interpretation of the seismogram.—*S. T. V.*

169–296. Shan'gin, N. V. K voprosu o zatukhanii seymicheskikh voln [On the damping of seismic waves]: Leningrad Univ. Uchenyye Zapiski, no. 210, p. 168–190, 1956.

Elastic vibrations in the ground are produced by using a drop hammer composed of a tripod, a cast iron spherical ram weighing about 50 kg, and a simple hoist; the ram is raised to a height of 3 m and let fall on a short post buried in the ground. Waves measurable at a distance of 150–200 m were produced in

this manner to investigate the upper layers of the ground to a depth of about 25 m. The propagation of seismic waves, first through homogeneous ground and later through stratified ground composed of two or three strata was investigated. The variation of the amplitude A of the wave was assumed to vary according to the relation $A=(c/r)e-Kr/2$, where c is the constant characterizing the decrease of the amplitude due to geometric dissipation of the wave front, K is the constant of damping related to the imperfect elasticity of the ground, and r is distance from the "shot" point.

If the actual thickness of the second layer is less than a certain critical thickness the wave will not be among the first arrivals. This fact is to be taken into account in interpreting the results of seismic surveys.—*S. T. V.*

169–297. Walling, Dean, and Savit, Carl H. Interpretation method for well velocity surveys: Geophys. Prosp., v. 5, no. 1, p. 69–79, 1957.

"Cable" and other extraneous energy in well velocity surveys may be identified and distinguished from "formation" energy by using phase relationships. Conventional instruments are used with at least two different narrow band-pass filters chosen to produce considerable phase lag. Criteria are amplitude (the greatest is normally the formation arrival), velocity (in the Schlumberger cable velocity is of the order of 11,000 fps), and vertical time (consistent only in formation arrivals when shots are taken at two different offsets). An example is given—*M. C. R.*

169–298. Opitz, D. Der Seiteneffekt in der Reflexionsseismik [The lateral effect in seismic reflection surveys]: Gerlands Beitr. Geophysik, Band 65, Heft 3, p. 227–245, 1956.

A description of a method of correcting for reflections not in the plane of the profile.—*M. C. R.*

169–299. Weber, Max. Die Auswertung von seismischen Refraktionsmessungen in einem einachsig inhomogenen Körper mit abgebrochenen potenzreihen [The evaluation of seismic refraction measurements in a uniaxial inhomogeneous body by a power series with a finite number of terms]: Geofisica Pura e Appl., v. 35, p. 14–24, 1956.

The interpretation of seismic traveltime surfaces $\psi(r)$ for refracted waves [see Geophys. Abs. 168–294] is given under the assumption that $\psi(r)$ is a power series with a finite number of terms. Two examples are included.—*M. C. R.*

169–300. Graeser, E., Lode, W., and Pott, G. Representation of depth-contour maps of arbitrarily curved reflection horizons, including refraction of rays, three-dimensional case: Geophys. Prosp., v. 5, no. 2, p. 135–141, 1957.

An exact method is given for constructing depth contour maps of arbitrarily curved horizons from observed normal reflection times. The method takes into account the refraction of rays in space when the overburden consists of layers with different velocities and does not require construction of seismic cross sections—*M. C. R.*

169–301. Skorupa, Jan. Szybki i wygodny sposób obliczania efektywnych prędkości z hodografów refleksyjnych [A rapid and convenient method of evaluating effective velocities from traveltime curves of reflected waves]: Przegląd geol., zeszyt 7, p. 317–318, 1956.

The traveltime of a reflected wave is a hyperbola with the equation $t=(1/v)\sqrt{x^2+z^2}$, where t is the travel time of a wave at a point x, z. By applying this equation to two points corresponding to the times t_o and $t_o+\Delta t$, it is possible to obtain the expression for the velocity V in the form $V=x\sqrt{\Delta t(2t_o1\Delta t}$ or $V=x.f(t_o1\Delta t)$. Values of the function $f(t_o1\Delta t)$ are given in a table, making it possible to obtain the velocity V without difficulty.—*S. T. V.*

169–302. Berzon, I. S. Trassirovaniye vertikal'nykh tranits razdela po dinamicheskii osobennostyam seysmicheskikh prelomlennykh voln [Determination of vertical discontinuities by using dynamic properties of seismic refracted waves]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 11, p. 1294–1308, 1956.

The dynamic characteristics of refracted waves can be used as a possible indication of the position of elastic boundaries in a vertically stratified medium. The method, which is described, can be used for thicknesses as small as 20 m. Where the velocity contrast is great, frequencies of 30–60 cycles per sec can be used; frequencies of 80–130 cycles per sec must be used for small velocity contrasts.—*S. T. V., L. C. P.*

169–303. Bukhnikashvili, A. V., and Prangishvili, G. M. Opyty po registratsii seysmoelektricheskogo effecta [The experiences with the registration of the seismoelectric effect]: Akad. Nauk Gruzinskoy SSR Soobshcheniya, Tom 17, no. 9, p. 789–795, 1956.

Electromotive forces generated when seismic waves propagate through the earth (the seismo-electric effect) travel faster than seismic waves and thus could be observed as forerunners with practical value. Field experiments based on this principle were carried out without convincing results, probably because of the difficulty of eliminating the effect of shaking electrodes.—*S. T. V., L. C. P.*

169–304. Yurchenk, B. I. K metodike seymicheskikh nablyudeniy v burovykh skvazhinakh [The method of seismic observations in drill holes]: Razvedochnaya i promyslovaya geofizika, vypusk 13, p. 35–40, 1955.

The precision of measurements of the seismic velocity in the strata penetrated by a drill hole is limited by the disturbing effect of the hole itself and by the cable carrying the geophone, both acting as wave guides. The main source of the possible errors is the result of dying out of the initial phases of a compound explosion wave. An increase in the accuracy of the measurements was obtained by the use of two seismographs connected by a cable of some 20 m length. The time measurements were made with an error of only ± 0.001–0.003 sec. It was thus possible to determine seismic velocity in the strata with an error of 15–20 m per sec where the average velocity was 2,000–2,400 m per sec. Several horizons, only 20 to 40 m thick, with velocities up to 5,500 m per sec, can be resolved. As many as 4 or 5 explosions should be made at every depth.—*S. T. V.*

169–305. Gal'perin, E. I. Ob azimutal'nykh otkloneniyakh seysmicheskikh luchey [Azimuthal deflections of seismic rays]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 11, p. 1282–1293, 1956.

The planes containing the reflected seismic rays are vertical only in a horizontally stratified medium; in all others the ray is deflected after reflection from a plane boundary. The angle of deflection is called the azimuthal deflection. A method of studying this angle is introduced, which involves use of a special

chart, called the field of azimuthal deflections, composed of curves of equal angle of deflection. Such curves are much more sensitive to changes in the position of the reflecting boundary plane than, for instance, the traveltime curves, and thus give a more precise method of determination.

Master charts of equal angles of deflection for waves reflected and refracted on a plane boundary have been constructed and their use is illustrated by several examples.—*S. T. V.*

169–306. Zietz, Isidore, and Pakiser, L. C. Note on an application of sonar to shallow reflection problem: Geophysics, v. 22, no. 2, 345–347, 1957.

In preliminary tests in Portage County, Ohio, apparent reflections from velocity discontinuities at depths of a few feet to 100 feet or more were recorded using a sonar-type transducer placed directly over the ground. Best records were obtained where a water-filled tank was used as a coupling device; rubber and grease-filled and water-filled shallow pits were also tried.—*M. C. R.*

169–307. Muraour, Pierre. Études de séismicité artificielle sous-marine (méthode de réflexion) dans la baie d'Alger [Underwater seismic exploration (reflection method) in the bay of Algiers]: Soc. géol. France Bull., 6e sér., tome 6, fasc. 6, p. 669–678, 1956.

Describes details of procedure and interpretation of a seismic reflection survey made in the bay of Algiers. About thirty stations were occupied, at depths of water ranging from 10 to 1,500 m. The reflections resulting from charges placed directly on the sea floor and from those exploded somewhat above the bottom are analyzed. The speed of sound in water, actually variable, was assumed to be 1,450 m per sec. Three layers were observed, the upper consisting of recent sediments, the intermediate of Miocene(?) deposits, and the third the metamorphic basement, a continuation of the Bouzaréa massif. The sediments increase in thickness as the basement drops toward the north-northeast.—*D. B. V.*

169–308. Ninagawa, Shinji. Seismic prospecting at Chiba district—Seismic prospecting on Kwantō district (I): Geol. Survey Japan Bull., v. 7, no. 5, p. 205–212, 1956.

A seismic survey near the town of Tako in northern Chiba Prefecture indicates existence of four velocity layers determined: two in Quaternary deposits, one in Pliocene, and one in basement rock. The results also show that positive gravity anomaly in the area is caused by a slight protuberance of the basement rock.—*V. S. N.*

169–309. Kuznetsova, N. P., and Kupalov-Yaropolk, I. K. Voprosy interpretatsii seysmicheskikh dannykh v Uralo-Embenskom neftenosnom rayone [On the interpretation of seismic data in the Ural-Emba oil-bearing region]: Razvedochnaya i promyslovaya geofizika, vypusk 13, p. 16–27, 1955.

Interpretations of the data obtained from seismic surveys surveys for salt domes in the Ural-Emba oil bearing region are difficult because of many unfavorable features of these domes, such as their shape and great depth. Further, the seismic velocity of the overlying strata is very high, sometimes reaching 4,000 m per sec, and the flanks of the domes are very flat, making angles of 8°–10° with the horizontal. Many domes have benches. Routine methods of

interpretation often lead to erroneous results. Often it becomes necessary to follow a seismic survey by a detailed gravimetric survey. Great help can be obtained from precise measurements of the arrival times of different waves. —*S. T. V.*

169–310. Orekhovskiy, F. V., and Bykov, A. A. Opyt primeneniya seysmorazvedki v zimnikh usloviyakh Kuybyshevskogo Povolzh'ya [Experiences in the use of seismic exploration methods under winter conditions in the Kuybyshev region along the Volga River]: Razvedka i okhrana nedr, no. 2, p. 36–42, 1956.

A report on seismic work in the Kuybyshev Oblast' during the winter of 1953–54, and the technical details to be considered in seismic exploration under such conditions.—*S. T. V.*

169–311. Dyachkova, A. Ya., and Sollogub, V. B. Trassirovaniye sbrosov seysmicheskim metodom otrazhennykh voln vo vneshney zone Predkarpatskogo progiba [Tracing faults by the seismic reflection method in the outer zone of the Carpathian arc]: Razvedka i okhrana nedr, no. 8, p. 37–42, 1956.

Because of its excellent reflecting properties, even small dislocations of a layer of anhydrite between the upper and lower Tortonian deposits can be determined by the seismic method. Both reflection and refraction methods were used to trace faults with displacements ranging from 25 to 140 m.—*S. T. V.*

STRENGTH AND PLASTICITY

169–312. Volarovich, M. P., and Parkhomenko, E. I. Issledovaniye razrusheniy pri kruchenii tonkikh obraztsov gornykh porod pri odnostoronnem davlenii [The investigation of the destruction of thin specimens of rocks by twisting combined with unilateral pressure]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 190–199, 1957.

Small cylindrical specimens of granite, diabase, basalt, gabbro, syenite, marble, and dolomite 8 to 16 mm in diameter and 0.5 to 2.5 mm thick were axially compressed and simultaneously twisted around the same axis. The specimens were destroyed as soon as the axial pressure reached 6,000, 15,000, or 20,000 kg per cm^2, according to the height and thickness of the specimen and the material. In some the specimens were deformed indicating a high degree of plasticity of some minerals, whereas, in others the combination of the dimensions and certain minerals led to phenomena similar to rock bursts with an abrupt pulverizaton of the specimens.—*S. T. V.*

169–313. Volarovich, M. P., and Parkhomenko, E. I. Izucheniye yavleniya vnezapnykh vybrosov i drugikh dvizheniy uglya putem szhatiya obraztsov tislindricheskoy formy v stal'nykh tsilindrakh s bokovym otverstiyem [Study of rock burst phenomena and other deformations of coal, by exposing cylindrical specimens to compression in steel cylinders with lateral opening]: Akad. Nauk SSSR Geofiz. Inst. Trudy, no. 34 (161), p. 179–193, 1956.

Experiments were made on artificially produced rock bursts for specimens of different coals subjected to unequal tri-axial compression in cylindrical containers having a small lateral opening. The kinetic energy of the pulverized portion

of the specimen was computed after the rock burst explosion and found to be about 20 percent of the applied potential energy. The results of the experiments thus confirm the theory developed by various authors as to the cause of rock bursts. Using photo-elastic methods the distribution of stresses in transparent models subject to the action of combined forces tending to produce rock bursts was studied. These experiments have shown the existence of local stress concentrations in different points of the models that exceed the average pressure by as much as 5–6 times.—*S. T. V.*

169–314. Volarovich, M. P., and Parkhomenko, E. I. Vosproizvedeniye yavleniy vnezapnykh vybrosov uglya pri szhatii i odnovremennom kruchenii tonkikh obraztsov [Artificial production of rock-burst phenomena by compression and simultaneous torsion of thin specimens]: Akad. Nauk SSSR Geofiz. Inst. Trudy no. 34(161), p. 193–207, 1956.

Experiments on the artificial production of rock bursts (see Geophys. Abs. 169–313) included some on specimens of coal subjected to simultaneous axial pressure and torsion around an axis perpendicular to the direction of the compression. This combination of stresses is a possible cause of mining disasters and of certain tectonic phenomena.—*S. T. V.*

169–315. Riznichenko, Yu. V., Silayeva, O. I., Shamina, O. G., Myachkin, V. I., Glukhov, V. A., and Vinogradov, S. D. Seysmoakusticheskiye metody izucheniya napryazhennogo sostoyaniya gornykh porod na obraztsakh i v massive [Seismoacoustic method of studying stress conditions in rocks, models, and in the solid mass]: Akad. Nauk SSSR Geofiz. Inst. Trudy, no. 34(161), p. 74–163, 1956.

Mechanical properties and the stresses in formations can be studied by seismic and acoustic (or sonic) methods. In the former the velocity of propagation of artificially produced seismic impulses through rocks is measured; in the latter sounds that are produced in rocks in their natural state, when they are exposed to stresses are observed. During earthquakes such sounds have been known to exist in the form of rumbling; in mines they are perceived as cracking and gnashing. The first noise accompanies ruptures (due to tensile stress), the second is related to torsional stress. Extensive experiments and observations in the laboratory, in mines, and in the field, here reported in detail, have been made to study the possibility of predicting collapses and rockbursts in mines. The experimental technique is also applicable in seismology, for possible prediction of approaching earthquakes because underground noise can be observed at the surface, by using geophones lowered into drill holes or to the bottom of the ocean.—*S. T. V.*

169–316. Rivkin, I. D., Zapol'skiy, V. P., and Bogdanov, P. A. Zvukometricheskiy metod nablyudeniya Proyavleniy gornogo davleniya na shakhtakh Krivorozhskogo basseyna. [The sonic method of observation of rock pressure in mines of the Krivoy Rog basin]: 188 p., Moscow, Metallurizdat, 1956.

The sonic method can be used in mines to observe stresses developed in the process of mining the surrounding formations; it can also be used, with slight modifications, to make continuous observation of stresses in the ground, increases in which can often serve as a warning of approaching partial destruction and resulting earthquakes. In a region approaching destruction, most of the forma-

tions begin to produce cracking noises that increase in intensity as the stress increases. Apparatus used is described and the results of several experiments in mines and in the field, mostly in Krivoy Rog Basin of Ukraine, are cited.—*S. T. V.*

VOLCANOLOGY

169–317. Taylor, G. A. Australian National Committee on Geodesy and Geophysics. Report of the sub-committee on vulcanology, 1953. Review of volcanic activity in the territory of Papua-New Guinea, the Solomon and New Hebrides Islands, 1951–53: Bull. volcanolog., sér. 2 tome 18, p. 25–37, 1956.

Volcanic activity during 1951–1953 in New Guinea-Papua and the New Hebrides and the Solomon Islands included eruptions of Mount Lamington (5 months of explosive activity ending in June 1951, succeeded by a characteristically long-continued and slowly declining effusive phase during which a dome was built 1,900 ft above the old crater floor in 1952); Long Island (building of a horseshoe-shaped ridge 100 ft above the crater lake level between May 8, 1953 and January 7, 1954); Mount Bagana (intermittent powerful gas explosions(including glowing clouds, and slow lava movement during 1952 and 1953); Ambrym (unusually prolonged and powerful explosive activity in the first 11 months of 1951 accompanied by abnormal seismic activity, and resumed intermittently after 9 months of quiescence on August 19, 1952); and Yasour, on Tanna Island (continuation of normal mild Strombolian activity). At Mount Langila, gas was emitted in 1952 from an old crater; temperatures as high as 240° C were measured. Gas emission at Manam Island increased in 1953.

Submarine eruptions took place 21 miles ENE of Karkar Island on November 24, 1951; between Baluan and Lou islands in St. Andrew strait from June 1953 to February 1954; south of Vangunu Island in the New Georgia group (after years of intermittent activity an island emerged on November 11, 1952, reached 100 ft by December, disappeared by January 19, 1953); at the site of vanished Karua Island, between Tongoa and Epi islands, on October 3, 1952; at a previously unknown center off the coast of Epi, from February 10 to 17, 1952; and at Matthew Island (a new land mass, west of the island and connected to it by an isthmus of sand, was sighted in October 1953, found to be 465 ft high and 400–500 yds in diameter).—*D. B. V.*

169–318. Minakami, Takeshi. Report on volcanic activities and volcanological studies in Japan for the period from 1951 to 1954: Bull. volcanolog., sér. 2, tome 18, p. 39–76, 1956.

A summary of volcanological studies in Japan during 1951–1954. In that period 7 volcanoes were investigated. The eruption of Myojin reef was the most spectacular and destructive (see Geophys. Abs. 168–315). At Aso, several eruptions took place in the northernmost of the 5 summit craters; of these the eruption of April 27, 1953 was most intense, killing and injuring a number of sightseers in and on the rim of the crater. The amplitude of volcanic tremors associated with this eruption increased for three weeks before the eruptions but decreased for several days immediately preceding; a similar relation was noted in the 1950 activity. At Asama, quiescent since the explosion of September 23, 1950, renewal of activity was presaged early in August 1953 by a swarm of microearthquakes near the summit crater and by variation in amount and composition of its gases. Mild activity took place from December 27, 1953 to March 1954. Geophysical observations at Asama included determination of foci of micro-

earthquakes from data at 5 stations in 1951 and 1952, 6 in 1953; precise levelling; and a gravity survey.

The 1950–1951 eruption of Ōshima (Mihara) ceased in June 1951. Strombolian activity was resumed on October 5, 1953 on a smaller scale and continued at increasingly longer intervals until March 1954. On January 27, 1954 lava flowed into a depression in the inner somma, but did not overflow it. Volcanic tremors during the 1953–1954 eruption were similar to those in the 1950–1951 activity. Geomagnetic observations were made at 10 fixed points on the volcano at frequent intervals since 1950; comparison of intensity in June 1951 with August 1953 showed an increase inside the volcano toward the direction of the present geomagnetic field, with variation amounting to 9×10^{13} e. m. u. (6×10^{14} e. m. u. for the period July–September 1950). Viscosity and elastic properties of the lavas are being studied in the laboratory.

Suwarose Island in the Ryukyu chain, in almost continuous activity from early September 1949, was still active when this report was compiled (May 1954). Tremors at Meakan-dake in Hokkaido and at Yakedake in central Japan have not been followed by volcanic activity, and landslides at Mount Bandai were deemed to be independent of volcanic activity.—*D. B. V.*

169–319. Vlodavets, V. I. O vulkanicheskoy tektonike [The structure of volcanoes]: Akad. Nauk SSSR Lab. vulkanol., Byull. vulkanol. stantsii, no. 23, p. 38–46, 1954.

Analyses of the volcanoes of the Kamchatka Peninsula and the Kurile Islands and comparison with volcanoes in other parts of the world leads to certain conclusions on the relations between the structure of a volcano and the composition of the lava erupted from it. Most volcanoes with mafic lava (basalt or andesite) have radial fractures on the surface and more often have numerous adventive craters. Volcanoes with silicic lavas usually have circular ruptures on the main cones and non-adventive craters. A possible explanation of this difference is the greater eruption of gases with the more silicic lava. These gases produce a greater extension of the inner volume of the crater, which later collapses under the force of gravity producing circular ruptures.—*S. T. V.*

169–320. Macdonald, Gordon A., and Alcaraz, Arturo. Nuées ardentes of the 1948–1953 eruption of Hibok-Hibok: Bull. volcanolog., ser. 2, tome 18, p. 169–178, 1956.

A description of the glowing cloud eruptions of December 4 and 6, 1951 at Hibok-Hibok volcano in the Philippines (see Geophys. Abs. 168–330). The influence of topography on their course clearly indicates the importance of gravity in their movement and their essential similarity to lava flows; a glowing cloud is regarded as essentially an unusually mobile auto-expansive lava flow. Each consists of a lower principal avalanche portion composed of a relatively dense emulsion of incandescent ash and gas bearing a suspended load of partly active and partly inert blocks of rock derived from the dome, overlain by a spectacular billowing and rapidly expanding, but relatively diffuse cloud of fine ash. The principal deposits from such an eruption are produced by the lower avalanche portion, but the relatively thin deposits of fine ash from the upper cloud may extend over much larger areas. The lower portion also causes most of the damage, though the overlying cloud may be hot enough to kill for a variable distance beyond the edge of the avalanche portion. The sequence of development of the explosion cloud as well as the abundance of large blocks of dome debris, the

high temperature, large size, and great force indicate that these definitely were laterally directed glowing clouds. The large proportion of pumice and pumiceous ash also indicates clearly that they were formed by explosion of new magma rather than by crumbling of the dacite dome. The explosions associated with the generation of glowing clouds (though not necessarily causing them) took place low in the flank of the active dome.—*D. B. V.*

169–321. Namba, Munetosi, Murota, Tosisato, and Mitsui, Takanori. Annual volcanic variation of Kujiu. Part 1 *of* Some studies on Volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 1, no. 1, p. 53–59, 1952.

The amount of spouted sulfur of Kujiu volcano is measured for each month of the year and an attempt is made to correlate it with atmospheric pressure, temperature, and precipitation. Volcanic action is little influenced by temperature; however, it depends directly on pressure and precipitation, the effect of the latter being only about 1/50 of the former. One mm variation of atmospheric pressure (monthly average) causes a variation of 25 tons in the amount of spouted sulfur.—*B. T. E.*

169–322. Namba, Munetosi, Murota, Tosisato, and Mitsui, Takanori. On the periodicity of two active volcanoes Aso and Kujiu. Part 2 *of* Some studies on Volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 1, no. 1, p. 60–65, 1952.

Periodic variations of the activity of Kujiu occur in intervals of 6, 12, and 24 years; those of Aso in intervals of 6, 11, and 18 years, signifying that the present sources of activity of the two volcanoes are independent of each other. Both volcanoes, however, are affected similarly by variations in rainfall, atmospheric pressure, and temperature.—*B. T. E.*

169–323. Namba, Munetosi, and Murota, Tosisato. On the shape of old Aso crater and the distribution of the central cones and hot springs. Part 3 *of* Some studies on Volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 1, no. 1, p. 66–73, 1952.

The old crater is found by harmonic analysis to be of distorted oval shape. It is about 70 km in circumference and 350 km^2 in area. The central cones are of two types: distorted diamond-shaped, presumed to have been formed in the earlier period of activity; and elliptical, formed in the later period of activity.—*B. T. E.*

169–324. Murota, Tosisato. On the variation of the water head at Kurokawa, Aso: Part 4 *of* Some studies on Volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 1, no. 2, p. 62–71, 1953.

The mean amplitude of diurnal variation is almost in proportion to the extent of the area of the basin. Annual change in diurnal variation of the water head results from the indirect influence of annual change in atmospheric temperature, and the magnitude of the amplitude of diurnal variation is influenced by the kinds of trees in the forests nearby. Semiannual variation, however, is influenced mainly by the transpiration of annual plants and by freezing and thawing of ground in cold season.—*B. T. E.*

169–325. Namba, Munetosi. Gas-rush in coal mines. Part 5 *of* Some studies on volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 1, no. 2, p. 42–48, 1953.

Observations on the growth rate and frequency of gas rush and on its relation to variations in temperature and atmospheric pressure show that it has the same characteristics as volcanic explosion.—*B. T. E.*

169–326. Namba, Munetosi. A consideration to the process of volcanic explosion. Part 6 *of* Some studies on Volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 1, no. 3, p. 45–57, 1954.

From an analysis of the frequency curves of explosions, Namba divides volcanic explosion into a "boring" stage followed by a "magma" stage. By observing the relation of the two stages to changes in atmospheric pressure it is concluded that the stages differ in mechanism. In the boring stage there is a tendency for volcanic activity to be suppressed by rising of atmospheric pressure, while in the magma stage it is increased.—*B. T. E.*

169–327. Murota, Tosisato. On annual and secular variations of the hydrostatic head of hot spring. Part 7 *of* Some studies on Volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 1, no. 3, p. 64–85, 1954.

The hydrostatic head of hot spring at Uchinomaki Laboratory is high in warm season and low in cold season. As secular trend the head goes down as $H=H_0e^{-\lambda t}$. A deviation of 1 mm of atmospheric pressure causes the hydrostatic head to fall 14 mm. A precipitate of W mm per month causes a rise of the monthly mean hydrostatic head of 0.75 mm. Tables showing daily measurements of the head from April 1942 to December 1949 are given. If the ratio of the head due to virgin water to the observed head is less than ¾, Aso has a tendency to explode within a year. This may be a key toward being able to forecast volcanic activity.—*B. T. E.*

169–328. Namba, Munetosi. A consideration of the process of earthquake frequency followed by a volcanic explosion. Part 8 *of* Some studies on Volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 1, no. 4, p. 1–10, 1954.

A study of the correlation between underground volcanic explosions and surface eruptions. Preliminary tremor, main shock, and aftershocks must generally accompany an earthquake caused by a volcanic intrusion.—*B. T. E.*

169–329. Namba, Munetosi. Geophysical study of Arizona Meteorite Crater. Part 10 *of* Some studies on Volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 2, no. 1, p. 85–89, 1954.

Arizona Meteorite Crater was formed by an incoming meteorite from the direction W 30° N, arriving at an angle of incidence of 75°. It formed a crater of 580 m radius and exploded at a depth of 300 m; meteorite fragments were dispersed within a radius of 1,010 m. The subterranean meteorite consists of two concentrations of fragments. Namba believes that these belong to the same meteorite.—*B. T. E.*

169–330. Namba, Munetosi. Annual variation of internal energy of Volcano Kilauea. Part 12 *of* Some studies on Volcano Aso and Kujiu: Kumamoto Jour. Sci., ser. A, v. 2, no. 2, p. 129–133, 1955.

From analysis of T. A. Jaggar's observations of the lava head in Volcano Kilauea from 1914 to 1923, Namba deduces that the annual variation of the lava head corresponds to the annual variation of the precipitation and atmospheric

pressure, and semiannual variation corresponds to the maximum-minimum range of atmospheric pressure.—*B. T. E.*

169–331. Vlodavets, V. I. K voprosu o proiskhozhdenii nekotorykh vulkanicheskikh treshchin [On the genesis of certain volcanic fissures]: Akad. Nauk SSSR Lab. vulkanol., Byull. vulkanol. stantsii, no. 23, p. 45–46, 1954.

In accordance with Pascal's law of the distribution of hydrostatic pressure in a closed vessel, the pressure in certain parts of a volcanic crater filled with liquid lava can be, at least temporarily, directed vertically upward and this fact must be considered in determining the cause of radial, annular, and other fractures in the cone of an active volcano.—*S. T. V.*

169–332. Grebe, Willi-Herbet. Dampfquellen in El Salvador und ihre wirtschaftliche Bedeutung [Steam vents in El Salvador and their economic significance]: Umschau, Jahrg. 57, Heft 6, p. 176–179, 1957.

A list of the fumarole and solfatara fields of El Salvador and a discussion of their relations to recent or extinct volcanism, and the possibilities for development of geothermal power.—*D. B. V.*

169–333. Cavallaro, Carmelo. L'attività effusiva dello Stromboli del 22 Marzo 1955 [The effusive activity of Stromboli of March 22, 1955]: Stromboli, no. 5, p. 15–17, no date.

Description, mainly petrographic, of the lava that flowed down the Filo della Sciara of Stromboli on March 22, 1955. No tremors preceded or accompanied the eruption and the crater maintained its normal explosive activity. The flow could not be approached until March 30, at which time the maximum temperature was 240° C.—*D. B. V.*

169–334. Sakuma, Shūzō. On the period and amplitude of volcanic tremors [in Japanese with English abstract]: Zisin, v. 9, no. 1, p. 1–7, 1956.

Analysis of volcanic tremors at Mihara indicates that the formula for decline of maximum amplitude holds for smaller amplitudes of the same period; that longer-period tremors are propagated in a mode similar to surface waves, those of shorter period as body waves; and that the observed elongations of the average period during propagation is caused at least in part by the relative abundance of small-amplitude, short-period waves at the origin.—*M. C. R.*

169–335. Gorshkov, G. S. Vulcanicheskoye drozhaniye, svyazannoye s proryvom kratera Bylinkinoy [Volcanic tremor related to the eruption of Bylinkina volcano]: Akad. Nauk SSSR Lab. vulkanol., Byull. vulkanol. stantsii, no. 23, p. 33–37, 1954.

On November 20, 1951, an eruption took place at Bylinkina crater, a new crater on the slope of Klyuchevskaya Sopka. During four days of its eruption some 720 local seismic shocks were recorded. Volcanic tremor started 1 day before the main eruption; at first it was discontinuous and of a period of 1.0–1.1 sec and an amplitude of 0.5–1.0, but later it became continuous for more than 2 days and was of a period of 1.5 sec and an amplitude of 1.5. The tremor was characterized by beats indicating existence of several harmonic vibrations of slightly different periods. The tremor stopped when the main eruption started, so that it was possible to time the eruption by the interruption of the tremor.—*S. T. V.*

169–336. Naboko, S. I. Vulkan Kosheleva i yego sostoyaniye letom 1953 g. [Koshelev volcano and its condition in the summer of 1953]: Akad. Nauk SSSR Lab. vulkanol., Byull. vulkanol. stantsii, no. 23, p. 3–23, 1954.

The Koshelev volcano is the southernmost active volcano in Kamchatka. Its present activity is chiefly fumarolic and solfataric; the amount of erupted gases and vapor is so great, however, that the escaping column can be observed from a distance of more than 25 km, and the noise is so great that conversation in the vicinity of the fumarole is impossible. Detailed petrographic and chemical analyses are given of the lavas and tuffs making up the volcano.—*S. T. V.*

169–337. Zubenko, F. S., Gur'yeva, L. I., and Koshechkin, B. I. Izverzheniye podvodnogo gryazevogo vulkana Buzovninskaya Sopka [The eruption of the submarine mud volcano Buzovninskaya Sopka]: Akad Nauk SSSR Lab. ayerometodov Trudy, tom 4, p. 144–148, 1955.

The submerged volcano, Buzovninskaya Sopka, in the Caspian Sea just north of the Apsheron Peninsula has been quiescent since 1922. On September 11, 1953, a sandbank protruded through the water of the Caspian Sea and continued to rise attaining a height of some 7–8 m until September 14, when an eruption of liquid mud took place. The dimensions of the new island were 50 by 70 m, but as it was formed of clay and volcanic ash it was rapidly eroded by the waves.—*S. T. V.*

Minakami, Takeshi, and Sakuma, Shūzō. On magnetization of Mt. Fuji (Huzi) and other volcanoes in Japan. See Geophys. Abs. 169–235.

169–338. Sicardi, Ludovico. La Solfatara di Pozzuoli [The Solfatara di Pozzuoli]: Bull. volcanolog., Sér. 2 tome 18, p. 151–158, 1956.

A description of the Solfatara di Pozzuoli, unique among the craters of the Campi Flegrei on the Gulf of Naples in that it has maintained constant fumarolic activity for at least 2,000 years. The fumaroles form three groups on the eastern edge of the crater. Among them, the Bocca Grande in the central group is the most important, emitting sulfide and carbonic gases mixed with steam; temperatures during the last 60 years generally varied between 141° and 164° C (with two maximums of 174.5° in 1927 and 215° in 1935). The minor fumaroles emit the same gases, at temperatures around 99° to 99.5°; only between 1921 and 1927 were maximums of 105° to 110° reported. Mud volcanoes ("Fangaia") are secondary phenomena of the solfatara, with pseudo-volcanic eruptions caused by accumulations of gas.—*D. B. V.*

169–339. Grebe, Willi-Herbert. Fumarolen und Thermalquellen in den älteren vulkanischen Gebirgen von El Salvador [Fumaroles and thermal springs in the older volcanic mountains of El Salvador]: Petermanns geog. Mitt., v. 101, no. 1, p. 31–35, 1957.

Similar to the article in Spanish in: *Anales del Servicio Geológico Nacional de El Salvador* (see Geophys. Abs. 167–282).—*B. T. E.*

INDEX

U. S. GOVERNMENT PRINTING OFFICE: 1957