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

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GEOPHYSICAL ABSTRACTS 177, APRIL–JUNE 1959

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INTRODUCTION

EXTENT OF COVERAGE

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

Abstracts are prepared only of material that is believed to be generally available. Ordinarily abstracts are not published of material with limited circulations (such as dissertations, open-file reports, or memoranda) or of other papers presented orally at meetings. Abstracts of papers in Japanese and Chinese are based on abstracts or summaries in a western language accompanying the paper.

LIST OF JOURNALS

Lists of journals published in Geophysical Abstracts 160 (January–March 1955, Bulletin 1033–A) and subsequent issues through 175 (October–December 1958, Bulletin 1086–D) have been compiled into a single list which may be obtained by writing to the U.S. Geological Survey, Washington 25, D.C.

The following references cited in Geophysical Abstracts 177 are not included in this master list:

Akad. Nauk SSSR Inst., teoret. astronomii Trudy—Akademiya Nauk SSSR, Trudy Instituta teoreticheskoy astronomii [Academy of Sciences of the U.S.S.R., Works of the Institute of theoretical astronogy]. Moscow.

Akita Univ. Mining College Research Inst. Underground Resources Rept.—Report of the Research Institute of Underground Resources, Mining College, Akita University. Akita, Japan.

Am. Anthropol. Assoc. Bull.—Bulletin of the American Anthorpological Association. Menasha, Wisconsin.

Cong. Soc. savantes Paris, 82d, Bordeaux and Libourne, 1957, Sec. Sci. Comptes Rendus—82d Congrès des Sociétés savantes de Paris et des Departements, Bordeaux et Libourne, 1957, Section des Sciences, Comptes Rendus [Proceedings of the 82d Congress of the Learned Societies of Paris and the Departments, Bordeaux and Libourne, 1957]. Paris France.

[Finland] Comm. géol. Bull.—Bulletin de le Commission geologique de Finlande (Geologinen Tutkimuslaitos) [Bulletin of the Geological Commission of Finland]. Helsinki, Finland.

Georgia Geol. Survey Mineral Newsletter—Georgia Mineral Newsletter. Georgia Geological Survey. Atlanta, Georgia.

Internat. Ser. Mon. Earth Sci.—International Series of Monographs on Earth Sciences. Pergamon Press, London.

Kazakh. Gorno-Metall. Inst., Geologiya, Gornoye delo, Metallurgiya sbornik—Kazakhskiy Gorno-Metallurgiya Institut. Geologiya. Gornoye delo, Metallurgiya sbornik [Kazakh Mining-Metallurgical Institute Geology, Mining Affairs, Metallurgy, collected papers]. Alma-Ata, Kazakh SSR.

Korea Geol. Survey Bull.—Geological Survey of Korea Bulletin. Seoul, Korea.

Ministerstvo Vysshego Obrazovanii SSSR, Nauch. Doklady Vysshey Shkoly, Geol.-geog. nauki—Ministerstvo Vysshego Obrazovanii SSSR, Nauchnyye Doklady Vysshey Shkoly, Geologo-geograficheskiye nauki [Ministry of higher education of the U.S.S.R., Scientific bulletins of the upper school, Geologo-geographic Sciences]. Moskva [Moscow], USSR.

Tanganyika Geol. Survey Recs.—Records of the Tanganyika Geological Survey. Dar Es Salaam, Tanganyika.

Tschermaks mineralog, petrog. Mitt.—Tschermaks mineralogische und petrographische Mitteilungen [Tschermak's mineralogical-petrographic Reports] Springer-Verlag, Wien (Vienna), Austria.

Univ. Carolina [Prague] Geologica—Geologica. Universitas Carolina [Geologica, The Carolina University]. Prague, Czechoslovakia.

Universum—Universum. Natur und Technik. Gesellschaft für Natur und Technik [Universe. Nature and Technique. Society for Nature and Technique]. Wein (Vienna), Austria.

FORM OF CITATION

The abbreviations of journal titles used are those adopted by the U.S. Geological Survey and used in many geological journals. For papers in most languages other than English, the title is given in the original language as well as in translation. Slavic names and titles have been transliterated by the system used by the United States Board on Geographic Names. This system of transliteration for Russian is given in Geophysical Abstracts 148 (January–March 1952, Bulletin 991–A) and in new "List of Journals" announced above. Titles of papers in Japanese and Chinese are given in translation only.

ABSTRACTORS

Abstracts in this issue have been prepared by J. W. Clarke, Anna Jespersen, Virginia S. Neuschel, I. Roman, and A. J. Shneiderov, as well as by the principal authors. Authors' abstracts are used in many instances. The initials of an abstractor following the notation "Author's abstract" indicates a translation from the original language.

AGE DETERMINATIONS

177–1. Griffin, James B. Bibliography of radiocarbon dates: Am. Anthropol. Assoc. Bull., v. 5, no. 2, p. 1, 1957.

A bibliography of lists of carbon-14 dates published by various dating laboratories.—*D. B. V.*

177–2. McNutt, Charles, and Wheeler, Richard P. Bibliography of primary sources for radiocrabon dates: Am. Antiquity, v. 24, no. 3, p. 323–324, 1959.

A bibliography of carbon-14 dates supplementing those published by Levi in 1955 (Geophys. Abs. 165–2) and Griffin in 1957 (Geophys. Abs. 177–1), cross-referenced by a list of carbon-14 dating laboratories.—*D. B. V.*

177–3. Fergusson, G.J., and Rafter, T.A. New Zealand C^{14} age measurements—4: New Zealand Jour. Geology and Geophysics, v. 2, no. 1, p. 208–241, 1959.

This list gives details of 186 samples dated in the Nuclear Sciences Laboratory of New Zealand in the period from June 1956 to July 1958, continuing previously published results (see Geophys. Abs. 157–139, 161–134, 170–11). Operational procedure and computation of errors were virtually the same as used with the last list. The same modern wood standard was also used, but corrections were made for the Suess effect (see Geophys. Abs. 162–181), 120 years being added to ages of samples that lived on land and 100 years to ages of surface ocean material. Most of the samples (wood, peat, shells, bones, charcoal, and the like) are from New Zealand and Australia, but 4 are from Peru (of archeological interest) and 27 are sediments from the ocean floor off California.—*D. B. V.*

177–4. Broecker, Wallace S., Olson, Edwin A., and Bird, Junius. Radiocarbon measurements on samples of known age: Nature, v. 183, no. 4675, p. 1582–1584, 1959.

In order to define the atmospheric C^{14}/C^{12} ratio over historic time, a large number of samples will have to be measured from many areas and at closely spaced times. As a contribution to the problem, the Lamont measurements on 12 samples of known age are reported here. As these results are related to the international oxalic acid carbon-14 standard distributed by the U.S. National Bureau of Standards, they can be compared directly with those obtained at other laboratories.

The results show a spread of ± 25 permil deviation about a mean of $+3$ permil. As the standard deviation is 17 permil, in contrast to measurement error of about 6 permil, there is little doubt that the results include real differences. As yet it is not certain whether these reflect worldwide or merely local variations. More observations on accurately dated samples are necessary. With present observations it can only be said that the carbon-14 age of an atmospherically derived sample younger than 2,000 years will almost always lie within 250 years of the true age (see also Geophys. Abs. 175–333 through 336, 168–3).—*D. B. V.*

177–5. Pée, W. Van, Crèvecoeur, E., and Capron, P. Détermination des âges par le radiocarbone [Determination of ages by radiocarbon]: Acad. royale Belgique Bull. Cl. Sci., ser. 5, v. 44, no. 11, p. 994–1007, 1958.

The theory of carbon-14 dating and the apparatus and procedure used at the dating laboratory of the University of Louvain, Belgium, are described. The apparatus was first tested by running samples of known age. Then a wood sample from a peat bed at Lommel, dated palynologically as either Alleröd or Bölling, was found to be 12,890 years old, or Bölling. Measurements on the upper and lower layers of the peat show that the duration of the Bölling oscillation was of the order of 700 years.—*D. V. B.*

177–6. German, Rüdiger. Die Bedeutung der C^{14}-Methode für die Eiszeitforschung [The significance of the carbon-14 method in glacial period research]: Umschau, v. 59, no. 8, p. 234–237, 1959.

The Carbon-14 dating method can establish the absolute age of an organic substance, correlate deposits in widely separated areas (northern and southern hemispheres, or land and sea deposits), set up a chronological standard for the Würm period, and solve general questions of the Quaternary such as simultaneity of glaciation over the whole earth, dating of glacial or interglacial terraces, and the like.—*D. V. B.*

177–7. Craig, B. G. Pingo in the Thelon valley, Northwest Territories; radiocarbon age and historical significance of the contained organic material: Geol. Soc. America Bull. v. 70, no. 4, p. 509–510, 1959.

Organic material from the silt of a solitary pingo (a dome-shaped hill rising above an almost flat plain) about 2½ miles north of the Thelon River in the Mackenzie District of the Northwest Territories of Canada has a carbon-14 age of 5,500 ± 250 yr, coinciding with the postglacial thermal maximum. Neither the pingo nor the silt of which it is composed show any indication of having been overriden by glacier ice. From this and other considerations it is evident that the surrounding area was freed of ice considerably more than 5,500 years ago. The formation of the pingo may be due to the marked cooling of climate following the postglacial thermal maximum.

Organic materials have also been found and dated at Back River (4,140 ± 150 yr) and Rankin Inlet (5,220 ± 340 yr), both on the mainland of the Northwest Territories. At both these sites the organic materials are reported to be overlain by glacial deposits; this is inconsistent with the interpretation of the pingo. It is shown that it is either implausable or unnecessary to attribute the overlying deposits to glacial action in either of those cases.—*D. B. V.*

Broecker, W[allace] S., and Walton, A. The geochemistry of C^{14} in fresh-water systems. See Geophys. Abs. 177–254.

Ronselius, Stig, and Östlund, Göte. Natural radiocarbon measurements on surface water from the North Atlantic and the Arctic Sea. See Geophys. Abs. 177–256.

177–8. Moorbath, S. Isotopic composition of lead from British mineral deposits: Nature, v. 183, no. 4661, p. 595–596, 1959.

Preliminary results of an isotopic study of several British lead ores, mainly galena, confirm the relationship between isotopic composition and geologic age

of the common lead. Data are tabulated for 28 well-located samples from 5 groups (Devon and Cornwall; northern Pennines; Lake District; Harlech and Aberystwyth, North Wales; and Abergairn and Ballater, Aberdeenshire). The proved Permo-Carboniferous (Hercynian) ores of southwestern England give a model age of $280 \pm 30 \times 10^6$ yr. Striking agreement in model ages and U^{238}/Pb^{204} and Th^{232}/U^{238} ratios suggests that the northern Pennines and the Lake District are also Hercynian in age. The deposits of North Wales and of Aberdeenshire deposits have considerably higher model ages, suggesting a Caledonian age.—*D. B. V.*

177–9. Gerling, E. K. Vliyaniye metamorfizma na rezul'taty opredeleniya vozrasta po svintsu [The effect of metamorphism on the results of age determination by the lead method]: Geokhimiya, no. 4, p. 287–295, 1958.

The graphic method of calculating the true age of a mineral and the time of its last metamorphism, proposed by Ahrens (see Geophys. Abs. 163–131 and 162–164) and Wetherill (see Geophys. Abs. 167–28 and 166–11) has been applied to the Belomorian uraninites. The true lead isotope age is found to be $1{,}950 \times 10^6$ yr rather than $1{,}800 \times 10^6$ yr as formerly thought. Using this new age, the value of 5.4×10^{-4} yr has been calculated for the K-capture constant of K^{40}. This new value differs by 10 percent from the value of 6.02×10^{-4} yr^{-1} currently accepted in the U.S.S.R. (see Geophys. Abs. 171–42) and only 3 percent from the value obtained in the United States (see Geophys. Abs. 167–229).—*D. B. V.*

177–10. Greenhalgh, D., and Jeffery, P. M. A contribution to the pre-Cambrian chronology of Australia: Geochim. et Cosmochim. Acta, v. 16, no. 1/3, p. 39–57, 1959.

The ages of 16 uranium minerals and 1 galena from various parts of Australia, calculated from the results of chemical and isotopic analyses, in most cases agree with accepted geologic interpretation. Thirteen of the radioactive specimens give age patterns of $(207/206) > (207/235) > (206/238)$, which are characteristic either of radon loss or lead loss, with radon loss more probable.

Two periods of mineralization are confirmed in the uranium fields of the Northern Territory (Late Archean and Upper Proterozoic) and at Crocker's Well in South Australia (Archean and Upper Proterozoic). Two periods are postulated for the uranium mineralization at Radium Hill (Archean and Proterozoic, the latter unexpectedly young) and for the lead mineralization at Broken Hill (Archean and Cambrian, the latter at variance with present geologic opinion). The uranium mineralization at Myponga, South Australia, and Hart's Range, Central Australia, has been dated as Upper Proterozoic; in both cases potassium-argon ages support this result, although the latter has been generally accepted as Archean. A "concordia" plot did not satisfactorily resolve discordant ages; it is concluded that radon loss renders the "concordia" method unsatisfactory.—*D. B. V.*

177–11. Kouvo, Olavi. Radioactive age of some Finnish Pre-Cambrian minerals: [Finland] Comm. géol. Bull., no. 182, 70 p., 1958.

Isotopic, chemical, and radiation damage measurements were made on samples of zircon, monazite, muscovite, biotite, feldspar, and galena from various intrusive groups of Finnish orogenic belts in order to obtain apparent ages from the 206/238, 207/235, 206/232, 207/206, rubidium-strontium, and potassium-argon ratios. Results are tabulated.

Comparison of rubidium-strontium, potassium-argon, and 207/206 ages with concordant, isotopically controlled uranium-lead and thorium-lead ages of zircons from the postkinematic potash granite group in southern Finland indicates a probable true age of 1,620 million years. The average of six 207/206 ages is 2.2 percent higher, rubidium-strontium ages of Bodom biotite granite and biotite-rich viborgite are in good agreement at 1,605 to 1,610 million years, but the age of Bodom hornblende-biotite granite is definitely lower at 1,555 million years.

Zircon results for four out of five samples for which thorium and (or) uranium determinations were made are internally discordant, indicating disturbance since crystallization. No correlation was found between the disagreement and the amount of common lead. Radiation damage measurements on these and on concordant Bodom zircon give apparent ages of 700 to 900 million years. The 207/206 results in 6 zircons and 1 monazite from the Svecofennidic and Karelidic orogenic belts agree closely with rubidium-strontium and potassium-argon ages on micas from the same rocks; the true age is probably slightly higher than 1,790 million years in these zones. The 207/206 age of zircon from the Sotkuma gneiss cupola is 700 million years higher than the rubidium-strontium age of its biotite and the potassium-argon age of its feldspar, and suggests an age of 2,500 million years for the basement underlying the Karelidic sediments.

Average common lead age of eight galenas from the Svecofennidic region is 1,740 million years, with a range of 1,600 to 1,820 million years. These data differ greatly from those on the Rapakivi galenas; the history of the Karelidic province appears considerably more complicated. A lower limit of 1,800 million years is placed on the age of the formations in which probable signs of ancient life have been found. Fractionation of sulfur isotopes from the Karelidic schist belt probably occurred 1,800 million years ago, provided that no fractionation occurred during later metamorphic events. The data agree well with those recorded for other parts of Fennoscandia and the Ukrainian Shield. A six-page bibliography is appended.—*D. B. V.*

177–12. Gerling, E. K., and Polkanov, A. A. Problema absolyutnogo vozrasta dokembriya Baltiycheskogo shchita [The problem of the absolute age of the Precambrian of the Baltic Shield]: Geokhimiya, no. 8, p. 695–717, 1958.

Data are presented on more than 240 age determinations made by the potassium-argon method on micas from Karelia, the Kola peninsula, and Finland in the Laboratory for Precambrian Geology of the U.S.S.R. Four major pre-Proterozoic geologic cycles are indicated in the eastern part of the Baltic Shield: The Karelian cycle, from 1,500 to $1,800\times10^6$ yr; the Belomorian, from 1,830 to $2,000\times10^6$ yr; the Saamian, from 2,200 to $2,400\times10^6$ yr; and the Katarchean, from 2,820 to $3,400\times10^6$ yr.

The orogenic movements were accompanied by 5 or 6 cycles of felsic intrusion reliably dated as follows by means of three methods—the potassium-argon, lead, and rubidium-strontium: the Rapakivi granite and Hoglandian epoch, $1,640\times10^6$ yr, the age of the intrusions of Finland; the Post-Karelian (postorogenic 1,650 to $1,750\times10^6$ yr and synorogenic 1,760 and $1,860\times10^6$) and Post-Svionian (postorogenic 1,550 to $1,660\times10^6$ yr and synorogenic 1,760 to 1, 860×10^6 yr); and the Belomorian granite intrusive complex, 1,900 to $2,000\times10^6$ yr. The coincidence of values suggests that the Finnish intrusions belong to the same period as the Post-Karelian intrusions of Karelia and the Kola peninsula.—*D. B. V.*

177–13. Zhirov, K. K., Baranovskaya, N. V., and Litvina, L. A. Opredeleniya absolyutnogo geologicheskogo vozrasta geliyevnym metodom po monatsitam [Determination of absolute geologic age by the helium method on monazite]: Geokhimiya, no. 2, p. 167–171, 1958.

Eight carefully selected unaltered monazites were studied in order to ascertain the possibilities of dating them by the helium method. It was found that no particular improvement in accuracy of the age values was gained by this careful selection; the external macroscopic and microscopic character of the mineral is not a reliable guide to suitability for dating purposes. Monazites from a Karelian pegmatite give an age that is too low by 300×10^6 to 500×10^6 yr. Most of the helium loss probably occurs during hydrothermal alteration rather than by gradual diffusion.—*D. B. V.*

177–14. Amirkhanov, Kh. I., Bartnitskiy, Ye. N., Brandt, S. B., and Voytkevich, G. V. O migratsii argona i geliya v nekotorykh porodakh i mineralakh [On the migration of argon and helium in some rocks and minerals]: Akad. Nauk SSSR Doklady, v. 126, no. 1, p. 160–162, 1959.

In order to investigate the mechanism of loss of radiogenic gases, the radiogenic argon and helium contents of samples of Precambrian carbonaceous schist, hornblende from a granitoid pegmatite, and pyroxene were measured before and after heating at different temperatures for intervals up to 8 hours. The procedure used is outlined briefly. The results are presented in three graphs plotting the logarithm of the ratios A_t^{40}/A_o^{40} and He_t^4/He_o^4 against time (A_o^{40} and He_o^{40}=amounts before heating, A_t^{40} and He_t^4=amounts after heating).

At 800°C the diffusion coefficients (D) for argon-40 and helium-4 in carbonaceous schists are about 9.5×10^{-11} and 5.5×10^{-11} cm^2 per sec, respectively; low temperature loss was less for argon than for helium. In the hornblende, the diffusion coefficient for both gases is about 1.5×10^{-10} cm^2 per sec; some low temperature loss was observed for helium-4 but not for argon-40. In pyroxene, argon-40 and helium-4 begin to be driven off at 750° C; at that temperature, D is about 8.0×10^{-13} cm^2 per sec, and at 900°C about 8×10^{-11} cm^2 per sec. No low temperature loss was noted for either gas. The equal diffusion of helium and argon in hornblende and pyroxene shows that the migration of radiogenic gases does not depend on the nature of the atom. A possible cause is that vacancies in the crystal lattice, which increase in number with rise of temperature, seize and transport the atoms of radiogenic gas.

Pyroxene is of particular interest for absolute dating purposes, as its activation energy, calculated from a formula given, is 73,500 cal per degree-gram-atom of argon-40 (or helium-4); the diffusion coefficient, extrapolated to normal temperature, is 4×10^{-55} cm^2 per sec. These values, together with the absence of low temperature loss, are evidence of complete retention of radiogenic gases. The final conclusion of the paper is that age determinations should be made only on samples for which the retention of radiogenic gas has first been investigated.—*D. B. V.*

177–15. Amirkhanov, Kh. I., Brandt, S. B., Bartnitskiy, Ye. N., and Gasanov, S. A. O mekhamizme poter' radiogennogo argona v slyudakh [On the mechanism of loss of radiogenic argons in micas]: Akad. Nauk SSSR Izv. ser. geol., no. 3, p. 104–107, 1959.

The thermal stability of radiogenic argon in disseminated micas has been investigated. Samples of the phlogopite fraction having particle dimensions

of 0.03–0.05 micromicrons were calcined at different temperatures and for different lengths of time. It is concluded from the results, which are presented graphically, that up to temperatures of about 600°C argon loss is due to processes of desorption type and are fairly well represented by Langmuir's isotherms; argon loss by diffusion becomes appreciable only above temperatures of about 600°C; and at normal temperatures the coefficient of diffusion in micas should not be more than 10^{-21} cm² per sec.—*D. B. V.*

177–16. Starik, I. Ye., and Litvina, L. A. Primeneniye metoda vyshchelachivaniya dlya otsenki prigodnosti obraztsov pri opredelenii vozrasta argonovym metodom [Use of the method of leaching for determination of the suitability of samples for age determinations by the argon method]: Geokhimiya, no. 2, p. 163–166, 1958.

The leaching of potassium and argon from potassium-bearing minerals by solutions of various acids has been studied. It has been established that biotite is considerably leached by hot concentrated HCl. The solubility of a given biotite appears to depend on its state of preservation. A relationship between solubility of biotite and absolute age of the sample is indicated; this may help establish a criterion for suitability of samples for argon-age determinations.—*D. B. V.*

177–17. Goldich, S. S., Baadsgaard, H., Edwards, G., and Weaver, C. E. Investigations in radioactivity-dating of sediments: Am. Assoc. Petroleum Geologists Bull., v. 43, no. 3, pt. 1, p. 654–662, 1959.

Two samples of glauconite from the Upper Cambrian Franconia formation in Goodhue County, Minnesota, give an average K–A age of 440 million years. Illite from the Siyeh limestone, Belt series, Glacier Park, Montana, is dated at 740 million years by K–A and 780 million years by Rb–Sr techniques. Pipestone from the Sioux quartzite at Pipestone, Minnesota, gives a K–A age of 1.20 billion years, and the time of deposition of the Sioux formation is placed in the early Middle Keweenawan or Lower Keweenawan. Geologic history of sediments subsequent to deposition is most important in attempting to date the time of deposition. X-ray crystallographic studies coupled with radioactivity-dating should lead to a better understanding of the history of sediments and of the changes that commonly are attributed to diagenesis.—*Authors' abstract.*

177–18. Kazakov, G. A., and Polevaya, N. I. Nekotoryye predvaritel'nyye dannye po razrabotke posledokembriyskoy shkaly absolyutnoy geokhronologii po glaukonitam [Some preliminary data on the development of a post-Precambrian scale of absolute geochronology based on glauconites]: Geokhimiya, no. 4, p. 296–306, 1958.

Systematic potassium-argon age determinations have been made on glauconites of different ages from Sinian to Upper Eocene (excepting Gothlandian and Triassic) from Czechoslovakia and the European part of the U.S.S.R. Details of the method are described and results are tabulated. Investigation of the dependence of argon separation on temperature shows that argon begins to separate at a temperature of about 300°C, is almost completely driven off at 500°C to 600°C. The use of glauconites for dating purposes offers the possibility of solving some major geologic problems.—*D. B. V.*

177–19. Vistelius, A. B. K voprosu o proiskhozhdenii krasnotsvetnoy tolshchi p-o. Cheleken. Opyt ispol'zovaniya absolyutnogo vozrasta oblo-

mochnykh mineralov dlya resheniya zadach litologii i paleogeografii [On the question of the origin of the red beds of the Cheleken Peninsula. Attempt at the use of the absolute age of clastic minerals for the solution of problems of lithology and paleogeography] : Akad. Nauk SSSR Doklady, v. 124, no. 6, p. 1307–1310, 1959.

Potassium-argon ages have been determined on minerals from the red beds of the Cheleken peninsula in the Caspian Sea, U.S.S.R. Mica in the Cretaceous deposits is essentially of the same age as the Krasnovodsk granitoids (240 and 250 $\times$ 10^6 yr, respectively) ; evidently the Carboniferous intrusions furnished much detrital material, particularly for the Cretaceous deposits. The micas in the sandy beds on the peninsula are no older than Upper Cretaceous; these must have been derived from an area underlain by Upper Cretaceous intrusives or the products of their decomposition. Though their exact provenance is not yet known, several paleogeographic conclusions can be drawn from comparison of this age with that of micas in the Amu-Dar' alluvium, which are Upper Jurassic.

In general, the results of this first investigation of its kind show that absolute age determinations on minerals in sediments, such as mica, feldspar, zircon, and possibly hornblende, can be successfully applied to the solution of lithological and paleogeographic problems.—*D. B. V.*

177–20. Starik, I. Ye., Ravich, M. G., Krylov, A. Ya., and Silin, Yu. I. Ob absolyutnom vozraste porod Vostochno-Antarkticheskoy platformy [On the absolute age of rocks of the East-Antarctic platform] : Akad. Nauk SSSR Doklady, v. 126, no. 1, p. 144–146, 1959.

Preliminary results are tabulated of potassium-argon age determinations made on 40 samples, ranging from Precambrian to Tertiary in age, collected by the Soviet Antarctic expedition in 1956–58. Gerling's value of $6.02\times10^{-11}yr^{-1}$ for the K-capture constant of potassium-40 was used in the calculations.—*D. B. V.*

177–21. Polevaya, N. I., Titov, N. Ye., Belyayev, V. S., and Sprintsson, V. D. Opyt primeneniya kal'tsiyevogo metoda dlya opredeleniya absolyutnogo vozrasta sil'vinov [Test of the use of the calcium method for the determination of the absolute age of sylvites] : Geokhimiya, no. 8, p. 718–726, 1958.

The age of sylvite has been determined by parallel calcium and potassium-argon measurements. Radiogenic calcium was determined by isotope dilution techniques and the potassium content by the dipycrilamine method. Argon was isolated by melting the sylvite samples in a vacuum and measured volumetrically. The results show that radiogenic argon is retained in samples that have not been subjected to recrystallization. Ages determined by the A^{40}/K^{40} and Ca^{40}/K^{40} ratios agree well for unrecrystallized sylvites. It is concluded that recrystallization does not affect the calcium determinations.—*D. B. V.*

177–22. Angino, Ernest E. Pressure effects on thermoluminescence of limestone relative to geologic age: Jour. Geophys. Research, v. 64, no. 5, p. 569–573, 1959.

Study of the modification of thermoluminescence by pressure suggests a relationship between pressure effect and geologic age. The amount of pressure and the length of time that it was applied caused a marked variation in the ratio

of thermoluminescence of pressed to unpressed samples. Geologically young samples showed a greater variability in the induced time-pressure effect than did older samples. The amplitude of the curve plotting the ratio of thermoluminescence of pressed to unpressed samples against the time the pressure was applied showed an inverse relationship to geologic age for limestones younger than Mesozoic. If further tests substantiate these results, a simple means of determining the relative age of Tertiary carbonate samples might be developed. Further work is in progress.—*D. B. V.*

177–23. Ramazanzade, M. G., and Rostomyan, P. M. Energeticheskii metod opredeleniya vozrasta nefti [Energy method of determination of the age of petroleum]: Ministerstvo Vysshego Obrazovaniya SSSR Izv. Vyssh. Ucheb. Zavedeniy, Neft i gaz, no. 2, p. 19–22, 1958.

A method of determining the age of petroleum is described, based on the theory that the energy in a given amount decreases with time due to the natural process of aging. Samples of 0.66 to 0.82 g were placed in gelatin capsules and then burned. Examples of results from the Balakhano-Sabunchin field in the U.S.S.R. are as follows: 10,773 cal per g (5.52 million yr), 10,673 cal per g (5.95 million yr), and 10,303 cal per g (7.58 million yr). The calories-per-gram index varies exponentially with time, dropping more rapidly for the younger oils than for the older.—*J. W. C.*

177–24. Pettersson, Hans. Frequency of meteorite falls throughout the ages: Nature, v. 183, no. 4668, p. 1114, 1959.

Cosmic spherules have been found in deep-sea sediments dating back to the Tertiary. It is to be hoped that a new chronology for deep-sea deposits can be established on the basis of these fossil meteorites, going back earlier than radiocarbon measurements. This communication is a plea for study of the cosmic spherules obtained by future expeditions. If the project of drilling to the mantle is ever realized, the study of the spherules encountered would alone make the project worthwhile, and the total cost would be only a fraction of the cost of sending a manned rocket to the moon. (See also Geophys. Abs. 173–234, 175–19.)—*D. B. V.*

177–25. Whipple, F. L., and Fireman, E. L. Calculation of erosion in space from the cosmic-ray exposure ages of meteorites: Nature, v. 183, no. 4671, p. 1315, 1959.

The cosmic-ray exposure age of a meteorite is determined from its spallation isotope content, under the assumption that the spallation rate does not vary with time. If erosion occurs in space, the spallation rate in the distant past would have been smaller than in recent times because of the greater amount of shielding material. Hence, owing to erosion in space, the measured cosmic-ray exposure age is less than the interval since the meteorite was exposed to cosmic rays; consequently, the cosmic-ray exposure age gives an upper limit to the rate of erosion in space.

The exposure age of the Sikhote-Alin meteorite, obtained from the number of argon-38 atoms and the decay rate of argon-39, is 5×10^8 yr, and from this the upper limit of erosion is calculated as 1.5×10^{-7} cm per yr for an iron meteorite.—*D. B. V.*

EARTH CURRENTS

177–26. Bukhnikashvili, A. V. Zemnyye toki i ikh izucheniye [Earth currents and their study]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 14, p. 117–170, 1955.

This paper is a preview of a monograph on earth currents. Earth currents are considered to be due to chemical polarization and variations in the earth's electromagnetic field. The contents of the chapters are: introduction, developments from 1800 to 1850, developments from 1850 to 1900, earth currents at magnetic observatories, earth currents in the U.S.S.R., characteristic features according to Krayev's classification (see Geophys. Abs. 149–13728), applications to geological prospecting, and bibliography.—*A. J. S., I. R.*

177–27. Grenet, Gaston. Pulsations telluriques et magnétiques pouvant être produits par les courants électriques maintenant la charge négative de la terre [Earth-current and magnetic pulsations produced by electrical currents maintaining the negative charge of the earth]: Acad. Sci. [Paris] Comptes Rendus, v. 248, no. 18, p. 2617–2618, 1959.

Earth currents are observed at Tamanrasset, Algeria, with periods close to 1 sec and an amplitude of daily variation analogous to that of African equatorial storms; annual variation shows a maximum in summer, when equatorial storms are near Tamanrasset. Examination of the records shows that if these storms are the cause of the earth current pulsations, their effect decreases as distance increases. A relationship to the maintenance of the earth's negative charge, by means of electric charges carried at the time of storms from earth toward the ionosphere, is suggested. The currents produced are probably not continuous, but may have continuous and sinusoidal components; they may propagate from the storm zones into the earth as much as into the ionosphere, each sinusoidal component circulating at a depth, or altitude, determined by its pulsation. Therefore at an observation station there corresponds to each of the components a difference in earth current potential, a magnetic field, and an electrical field. A formula is given for their relationship. The order of magnitude of the observed earth current field is compatible with this theory.—*D. B. V.*

177–28. Lashkhi, A. S. Ovliyanii temperatury, osadkov i groz na zemnyye elektricheskiye toki [Effects of temperature, precipitation, and thunderstorms on terrestrial electric currents]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 15, p. 61–74, 1956.

Lashkhi analyzes Bakhmet'yev's telluric current investigations (Sofia, 1893–96) and presents data of his own research. Contrary to Bakhmet'yev's conclusion, he finds a strong correlation between the intensity of telluric currents and meteorological phenomena, such as air temperature, heavy rain, thunderstorms, cloudiness, and wind. The observations of telluric-current variations were made with nonpolarizing copper electrodes buried 30 cm deep and 570 m apart, and by diffusion nonpolarizing electrodes, 25 to 30 cm deep in the ground. Local telluric currents can be distinguished from the regional earth currents on the basis of the data.—*A. J. S.*

177–29. Vinogradov, P. A. Izmereniye vertikal'noy sostavlyayushchey elektrotellurichеskogo polya v oz. Baykal [The determination of the

vertical component of the electrotelluric field in Lake Baikal] : Akad. Nauk SSSR Izv. ser. geofiz., no. 1, p. 83–86, 1959.

The results of the observations and measurement of the vertical component of earth currents in Lake Baikal are presented. The observations were made at two pairs of points, 500 m apart, along an east-west and a north-south line. The electrodes were lead plates 0.4 m^2 in area. The electrodes on the east-west line were suspended at depths of 5,200 m and 1,000 m, and those along the north-south line at depths of 5 m and 400 m. Special attention was given to the measurement of variations of the vertical component of the geoelectric field. Vinogradov found that the short-period variations occur simultaneously in the water of Lake Baikal and at the Zuye geophysical station, some 80 km from the lake. Several oscillograms showing the vertical currents are reproduced.—*S. T. V.*

177–30. Kebuladze, V. V., and Lashkhi, A. S. O sutochnykh variatsiyakh zemnykh elektricheskikh tokov po dannym Dushetskoy geofizicheskoy stantsii [On diurnal variations of telluric currents according to data of the Dusheti geophysical station] : Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 12, p. 37–55, 1953.

Kebuladze, V. V. Nekotoryye dannyye o vzaimnoy svyazi mezhdu zemnymi elektricheskimi tokami i geomagnitnym polem [Some data on the interrelation between telluric currents and the geomagnetic field] : ibid., v. 12, p. 57–72, 1953.

Kebuladze, V. V. O svyazi zemnykh regional'nykh elektricheskikh tokov s geomagnitnym polem [On the relationship between regional telluric currents and the geomagnetic field] : ibid., v. 15, p. 37–60, 1956.

In the first paper, earth current records at Dusheti observatory in the Georgian S.S.R., obtained with the aid of two 1-km running east-west and north-south, are analyzed ; they show amplitudes of daily variation of 0.67 mv per km in summer, 0.54 mv per km at equinox, and 0.35 mv per km in winter for the north-south component, and values twice as high for the east-west component. Changes in the components were opposite in phase; electrical storms and disturbances had no effect on the rate of change of mean diurnal variation.

The second and third papers examine the relationship of earth current variations to geomagnetic variations, using records obtained at Dusheti during the period 1948–50, in an effort to resolve the problem whether variations in earth currents produce magnetic variations or vice versa. A correlation between regional telluric currents and the geomagnetic field was confirmed, not only during magnetic storms and disturbances but on quiet days also. The simultaneity of magnetic and electrical disturbances and the very good coincidence between the active periods in both show that the relationship between them is inductive in character. A parallelism between the solar diurnal variation of the east-west component of the earth current field and the rate of change in variation of the north-south component of the geomagnetic field of opposite sign also indicates such inductive relationship.—*A. J. S.*

177–31. Bukhnikashvili, A. V. Nekotoryye resul'taty ispol'zovaniya korotkoperiodnykh variatsiy zemnykh tokov dlya resheniya voprosov strukturnoy geologii [Some results of using short-period variations of earth currents for solution of structural geology problems] : Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 15, 75–87, 1956.

An expedition was organized to determine the applicability of short-period

regional variations in earth current intensity for solving problems of structural geology over large areas in the Natakhtari-Mleti region in the Georgian S.S.R. The geoelectric profile between Natakhtari and Mleti showed definite inflections in the telluric current intensity curve corresponding to the boundaries between Recent, Quaternary, Tertiary, Carboniferous, and Jurassic strata, and basalt structures.—*A. J. S.*

177–32. Tikhonov, A. N., and Sveshnikov, A. G. O medlennom dvizhenii provodyashchey sredy v statsionarnom magnitnom pole [The slow movement of a conductive medium in a stationary magnetic field]: Akad. Nauk SSSR Izv. ser. geofiz. no. 1, p. 49–58, 1959.

Effects are discussed that occur during the movement of a conducting medium in a stationary magnetic field, such as ocean currents moving in the geomagnetic field. Applying a rather extensive analysis of the basic equations of electromagnetic fields, Tikhonov and Sveshnikov derive the relations between the velocity of the current and the intensity of the electric field induced by the magnetic field of the earth. In these relations the width of the current as well as the conductivity of the ocean bottom over which the currents move are taken into account. The unknown velocity of the current at different points can be computed and the vertical cross section of the velocity distribution in the moving medium can be obtained by these formulas.—*S. T. V.*

Kalashnikov, A. G. Observation of rapid pulsations of the geomagnetic field and earth currents. See Geophys. Abs. 177–284.

Volland, Hans. On a shell model of the earth, equivalent to the electrical conductivity of its interior. See Geophys. Abs. 177–141.

EARTHQUAKES AND EARTHQUAKE WAVES

177–33. Smith, W. E. T. Bibliography of seismology: Dominion Observatory Ottawa Pubs., v. 22, no. 1, p. 3–29, 1958, and v. 22, no. 2, p. 33–57, 1958.

These two papers are parts of a continuing series of publications listing papers in seismology. Each number covers publications during a 6-month period: no. 1, January to June, 1957; and no. 2, July to December, 1957. A list of publications regularly searched for items to be entered in the bibliography is included in the first number—*V. S. N.*

177–34. Smith, W. E. T. Bibliography of seismology—Author Index: Dominion Observatory Ottawa Pubs., c. 14, p. 471–485, 1958.

This is an author index covering the years from 1947 through 1956 for the Bibliography of Seismology, a continuing series published at 6-month intervals (see also Geophys. Abs. 177–33).—*V. S. N.*

177–35. Grylgewicz, Zofia. Aktywność sejsmiczna 1957 r. [Seismic activity in 1957]: Acta Geophys. Polonica, v. 6, no. 4, p. 384–393, 1958.

Data on the principal earthquakes of 1957, mainly from Polish seismological stations, are reported, with emphasis on European earthquakes. Maps of epicenters are given for the Aleutian Islands, the Mediterranean area, and the world.—*D. B. V.*

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177–36. Richter, C[harles] F. Seismic regionalization: Seismol. Soc. America Bull., v. 49, no. 2, p. 123–162, 1959.

Maps of earthquake risk, on the same plan as that used officially in the U.S.S.R., have been prepared for the Los Angeles Basin and vicinity, for California, and for the United States. The effect of variation of the ground from point to point (microregionalization) can be shown only on a large scale; the Los Angeles map is an example. Smaller scale regional maps require generalization. Prevailing ground is not selected strictly by percentage of area but by considering the foundation likely to be used for construction—in mountainous areas mostly small alluvial patches less stable than the surrounding rock.

Regionalization and especially microregionalization can be used in construction and planning, as indicating maximum effects to be considered in designing permanent structures. In adjusting earthquake-insurance rates and in designing temporary structures, satistical frequency is also involved. Over small areas, regionalization depends largely on local variation of ground and geology; over large areas distance from active faults must be considered. Attention should be given to the effect of structural trends and of wave path on the form of isoseismal curves.

The map for the Los Angeles Basin and vicinity is reasonably reliable; that for California is fairly reliable, but less so in desert and mountain areas; that for the United States is in part highly speculative and subject to substantial change.—*D. B. V.*

177–37. Stewart, J. W. Earthquake history of Georgia: Georgia Geol. Survey Mineral Newsletter, v. 11, no. 4, p. 127–128, 1958.

This brief article lists the earthquakes felt or epicentered in Georgia from 1811 to 1947 and summarizes the effects felt in that State.—*A. J.*

177–38. Stewart, J. W. The effects of earthquakes on water levels in wells in Georgia: Georgia Geol. Survey Mineral Newsletter, v. 11, no. 4, p. 129–131, 1958.

After a general statement regarding the effects of earthquakes on water levels in Georgia, profiles are presented of water-level fluctuation in two wells in Dougherty County resulting from the earthquakes of July 1957 in Guerrero, Mexico, and January 1958 in Ecuador.—*A. J.*

177–39. Milne, W. G., and White, W. R. H. A seismic investigation of mine "bumps" in the Crowsnest Pass Coal field: Canadian Mining Metall. Bull., v. 51, no. 559, p. 678–685, 1958; and Dominion Observatory Ottawa Pubs., v. 18, no. 13, p. 349–356, 1958.

Three seismographs were installed at widely separated stations in the Crowsnest Pass areas of Alberta and British Columbia to investigate the possibility that the "bumps" occurring in the coal mines at Fernie and Coleman were related to minor earthquakes in the area. Earthquakes were recorded at all three stations, and many small disturbances were recorded by the seismographs located near the mines. A closer network of radio-linked seismographs installed near Fernie established the fact that the small disturbances were occurring in both active and inactive mine workings. No relationship was established between bumps and local earthquakes.—*V. S. N.*

177–40. Duke, C. Martin, and Leeds, David J. Soil conditions and damage in the Mexico earthquake of July 28, 1957: Seismol. Soc. America Bull., v. 49, no. 2, p. 179–191, 1959.

A report is given of observations of the effects of soil conditions on damage in Mexico City and Guerrero State in the earthquake of July 28, 1957. An isoseismal map is presented which identifies anomalies in intensity distribution which appear to be closely related to local geology and soil conditions. Comparison is made between Mexico City, 170 miles from the epicenter and founded on the deep alluvium of Lake Texcoco, and several cities and villages 60 miles from the epicenter, founded on firmer deposits or granite.

Mexico City suffered Modified Mercalli intensities of 7 and 4, respectively, in that part of the lake-bed area where tall buildings stand, and on the more compact formations. Of the several cities 60 miles from the epicenter, all suffered intensity 5 or less except Chilpancingo, where the intensity was 7 to 8. Chilpancingo rests on deep unconsolidated deposits; the other places are on rock or shallower unconsolidated deposits.—*Authors' abstract*

177–41. Heezen, Bruce C., and Ewing, Maurice. Orléansville earthquake and turbidity currents: Am. Assoc. Petroleum Geology Bull., v. 39, no. 12, p. 2505–2514, 1955.

The breaking of five submarine cables on the Mediterranean floor immediately following the Orléansville (Algeria) earthquake of September 9, 1954, at a distance of 40 to 70 miles from the epicenter, is further support for the modern occurrence of turbidity currents and the turbidity-current origin of abyssal plains and deep-sea sands. It also emphasizes the importance of earthquakes in triggering these currents in sediments on steep submarine slopes. The role of turbidity currents in producing deep-sea sediments is further supported by petrographic studies of cores from the Balearic abyssal plain, 80 miles east of the area of cable breaks (Bourcart, 1953), that show a sand bed whose constitutent grains can be traced to the "Petite Kabylie" massif in Algeria. Lack of rounding of grains excludes eolian or beach origin, and it is concluded that turbidity currents carried the sands out on the abyssal plain. (See also Geophys. Abs. 175–22).—*V. S. N.*

177–42. Panfilis, M. de. Note sopra un breve periodo sismico svoltosi nel territorio di Montespertoli durante il mese di giugno 1958 [Notes on a brief seismic period occurring in the Montespertoli area during the month of June 1958]: Annali Geofisica, v. 11, no. 3–4, p. 237–240, 1958.

The Montespertoli commune southwest of Florence, Italy, was shaken by a number of shocks between June 6 and 12, 1958. The most intense occured on June 7 at $18^h50^m30^s$, with an intensity of 5 to 6 on the Mercalli scale; felt area was about 900 km^2, epicenter at the Villa Aliano; focal depth is calculated as 3 to 5 km. An isoseismal map is given. Violent earthquakes have occurred previously in the Montespertoli area on September 11, 1812, and on May 18, 1895.—*D. B. V.*

177–43. Bendefy, László. Földrengés okozta kéregdeformációk [Crustal deformations caused by earthquakes]: Geofiz. Közlemények, v. 7, no. 3–4, p. 155–168, 1958.

The Hungarian earthquake of January 1956 occurred while repeated remeasurements of three polygons having large errors of closure were being made in

the course of the precise levelling surveys of 1951–56. This fact has made it possible to determine the amount of crustal deformation which took place before, during, and after the earthquake. In the period preceding the earthquake, wave-like plastic deformation occurred, descreasing in wave length and increasing in amplitude (to a maximum of 6 to 7 mm) toward the epicenter. During the earthquake plastic deformation was also wavelike, but more rapid and more vigorous; maximum deformation in the vicinity of the epicenter was of the order of 10 cm. After the earthquake elastic deformation of 6 mm and 4 mm occurred on lines measured at intervals of 62 and 104 days, respectively; after a year and a half, elastic deformation on a 12-km line was of the order of 10 mm. A plot of the values of changes in level reveals a definite pattern of faults; one of the tectonic directions coincides with the strike of the Central Mountains of Hungary and a second is nearly normal to it. Complete data are tabulated.—*D. B. V.*

177–44. Csomor, Dezső, and Kiss, Zoltán. Magyarország szeismicitása [The seismicity of Hungary]: Geofiz. Közlemények, v. 7, no. 3–4, p. 169–180, 1958; also published in German: Die Seismizität von Ungarn: Československá Akad. Věd Studia Geophys. et Geod., v. 3, no. 1, p. 33–42, 1959.

A map of the seismicity of Hungary has been prepared, based on macroseismic data for the years 1880–1956. In that period 872 earthquakes were felt; for 91 of these isoseismal maps could be made. Data on focal depth, magnitude and energy, intensity, and spatial and temporal distribution are discussed and presented in tables, maps, and graphs.—*D. B. V.*

177–45. Bisztriczány, E., and Csomor, D[ezső]. Microseismical evaluation of the earthquake of January 12, 1956, and the crustal structure of the Hungarian Basin: Acad. Sci. Hungaricae Acta Goel., v. 5, no. 2, p. 235–244, 1958.

An English version of a paper published in Hungarian in Geofizikai Közleinenyek, v. 6, no. 1–2, p. 37–45, 1957 (see Geophys. Abs. 171–61).—*A. J. S.*

177–46. Porkka, M. T., and Vesanen, E. E. Earthquake in Ranua and Pudasjärvi 1956: Geophysica, v. 5, no. 4, p. 226–229, no date.

On December 24, 1956, an earthquake was recorded having an epicentral distance of only 1.5° south of the Sodankylä Observatory, Finland. Preliminary returns of questionnaires sent out by the observatory showed that the earthquake was felt in Ranua and Pudasjärvi; total felt area was about 7,500 km^2 (130 km long in a north-south direction, and about half as wide) with a macroseismic epicenter at lat 65.7° N. and long 27.4° E., origin time 18^{h}32^m. Intensity was 3 to 4 (modified Mercalli-Cancani scale) all over the area; it is typical of Finnish earthquakes that intensity is the same over a relatively wide area. At least three aftershocks were reported, on December 24 at 19^{h}00^m and 20^{h}55^m and on December 25 at 07^{h}00^m.

The trend of the felt area coincides with a lithologic boundary and to a steep change from negative to positive free-air gravity anomaly. Instrumental data from Sodankylä and three Swedish stations show that the crust is approximately 30 to 40 km thick in Finland; this is less than the value for northern Sweden obtained by isostatic computations.—*D.B.V.*

177–47. Gorshkov, G. P. "O seysmicheskom rayonirovanii" [On seismic regionalization] : Geofiz. Közlemények, v. 7, no. 3–4, p. 195–198, 1958.

A revised map of the seismicity of the U.S.S.R. and China has been prepared on a scale of 1:5,000,000, based on an analysis of macroseismic historical accounts during some hundreds of years, instrumental data gathered by seismic stations during the last 50 years, and geological considerations. The map is intended to serve as a guide for industrial planning by indicating the zones of different degrees of seismic activity.—*D.B.V.*

177–48. Tskhakaya, A. D. Obzor zemletryaseniy Kavkaza za 1951 god [A review of earthquakes in the Caucasus for the year 1951] : Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 15, p. 111–125, 1956.

Epicenters of 142 out of the 157 earthquakes instrumentally recorded in 1951 in the Caucasus were located in the Georgian S.S.R.; 82 were on the Akhalkalak highland and 50 on the main ridge in the area of the Kazbek and Barbalo Mountains. Such a grouping of epicenters indicates an increase in seismicity in these two locations. Maximum intensities of 7 (on the Russian OST scale) were recorded.—*A.J.S.*

177–49. Semenov, P. G., and Semenova, V. A. Katalog zemletryasenii, oshchushchavshikhsya na territorii Tadzhikistana za periody 1865–1940 i 1941–1952 gg [Catalog of earthquakes recorded in the territory of Tadzhikistan for the periods 1865–1940 and 1941–1952] : Akad. Nauk Tadzhik. SSR Inst. Seysmologii Trudy, v. 86, no. 3, 137 p., 1958.

An attempt is made to assemble all information on earthquakes that have been detected in the territory which is now the Tadzhik S.S.R. They are listed chronologically, giving location, intensity, and a short description.

Part 1 lists 334 earthquakes for the period 1865–1940; there are no records for 29 individual years during this period. Part 2 deals with the period 1941–1952; 189 earthquakes are listed. This period coincides with the active operation of the Stalinabad seismograph station, established in 1940.—*J. W. C.*

177–50. Kukhtikova, T. I., Gayskiy, V. N., and Bune, V. I. O seysmichnosti Tadzhikistana v 1955 g [On the seismic activity of Tadzhikistan in 1955] : Akad. Nauk Tadzhik. SSR Inst. Seysmologii Trudy, v. 71, no. 2, p. 3–19, 1957.

The instrumental records of 1,189 earthquakes that took place in the Tadzhik S.S.R. in 1955 are analyzed. The distribution of earthquake foci in time and space is examined, and comparisons are made of the regional geology with the earthquake foci of the past.—*Authors' abstract, J. W. C.*

177–51. Kazanli, D. N. Geologiya Severnogo Tyan'-Shanya v svyazi s yego seysmichnost'yu [The geology of the northern Tyan'-Shan in relation to its seismicity] : Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 3, p. 53–80, 1957.

An analysis of the relationship between the geologic structure and the seismicity of the northern Tien Shan is presented. The chronology of recent movements and their sequence is found to be the same as that established in the Caucasus and other regions of Tertiary folding. The geologic structure is dominated by two major fractures. Seismic activity is clearly related to recent tectonic movements; traces can be also noticed of the effects of ancient rup-

tures. The most active zones are at the borders of uplifted areas and in zones of the maximum gravity gradients. These zones are characterized by a relatively recent beginning of uplift or by an abrupt increase of this process in the Quaternary period. Secondary seismicity, expressed in feeble tremors not producing any discharge of energy, does not act as a "safety valve." The greatest density of epicenters coincides with areas of the most violent past earthquakes, but the character of the recent seismicity is quite different from the ancient shocks.—*S. T. V.*

177–52. Florensov, N. A. Katastroficheskoye zemletryaseniye v Gobiyskom Altaye [A catastrophic earthquake in the Gobi-Altay] : Priroda, no. 7, p. 73–77, 1958.

This is a description of one of the strongest earthquakes of historic time which occurred in Mongolia near midday on December 4, 1957, with an intensity of 11. The initial epicenter, determined instrumentally, was in the intermontane depression between the Bakhar and Tsetsen massifs; from here a major facture (the "Bogdo fault") extends eastward for 270 km along the northern foothills of the Gurvan-Bogdo with several more or less parallel secondary faults branching off the main fault, particularly along the Ikhe-Bogdo. In the epicentral area a graben 800 m wide, 27 km long, and 3 to 4 m deep was formed. Vertical displacement ranged from 1.5–2 to 10–12 m, upthrown on the south; horizontal displacement was 3 to 3.5 m, with the upthrown side moving eastward relative to the north side. The cause of the earthquake was attributed to stresses which have existed in the foothills of the northwest Gobi-Altay since the time of Quaternary volcanism in that zone.—*A. J. S.*

177–53. Gorshkov, G. P. O karte seysmicheskogo rayonirovaniya territorii Kitaya [Concerning a map of seismic regionalization of the territory of China]: Ministerstvo Vysshego Obrazovaniya SSSR, Nauch. Doklady Vysshey Shkoly, Geol.-geog. nauki, no. 2, p. 25–32, 1958.

The sources of data on earthquakes in China are summarized. This material includes maps and catalogs, one of which contains 10,000 listings beginning in A.D. 1000. Maximum seismic activity occurs in the zone of Himalayan (Alpine) folding and within areas where ancient folding has been rejuvenated. The latter include examples from Precambrian massifs and from Caledonian, Hercynian, and Yanshan fold zones. Two maps of epicenters, one of isoseismals and one of seismic regionalization, are presented. The latter represents a joint effort of the Russian geophysical institute and the geological institute of the Chinese academy of science.—*J. W. C.*

177–54. Koning, L. P. G. A simple graph for the determination of the approximate values of epicentral distances : Geologie en Mijnbouw, v. 21, no. 2, p. 46–48, 1959.

A net and transparent world map are presented, constituting a variation on the usual principle of graphic determination of epicenters, which may be used for records of all stations. The accuracy of determination of approximate distance between an epicenter and a station with this method, tested by comparing calculated and graphically determined values for 10 earthquakes, is well within the probable limit of error (1°). Rapid location of epicenters is also possible by this method when epicentral distance and azimuth are known.—*D. B. V.*

177–55. Sponheuer, W. Die Tiefen der Erdbebenherde in Deutschland auf Grund makroseismischer Berechnungen [The depths of earthquake foci in Germany on the basis of macroseismic calculations] : Annali Geofisica, v. 11, no. 3–4, p. 157–167, 1958.

A new macroseismic method is described for determining focal depth quickly and accurately for each mean isoseismal distance from the epicenter. For this a diagram based on Kövesligethy's equation is used. The values of focal depths obtained in this manner for those German earthquakes for which isoseismal maps could be drawn show a certain amount of agreement for each epicentral region. Magnitudes calculated from epicentral intensity and radius of felt area or from epicentral intensity and focal depth are in general agreement. The graph plotting strain release as a function of time for all German earthquakes with magnitude of 3.3 or more shows a very definite increase in earthquake activity since 1911.—*D. B. V.*

177–56. Byerly, Perry, and DeNoyer, John. Energy in earthquakes as computed from geodetic observations, *in* Contribution in Geophysics (Gutenberg volume) : Internat. Ser. Mon. Earth Sci., v. 1, p. 17–35, 1958.

The depth (D) of the fault break and the strain energy released (E) are computed for three earthquakes in which there was surface faulting: San Francisco 1906, D=10 km, E=0.9×10^{23} ergs; Imperial Valley 1940, D=12 km, E=9.6×10^{21} ergs; and Fairview Peak 1954, D=23 km, E=1 to 1.5×10^{23} ergs.—*D. B. V.*

177–57. Båth Markus. The energies of seismic body waves and surface waves, *in* Contributions in Geophysics (Gutenberg volume) : Internat. Ser. Mon. Earth Sci., v. 1, p. 1–16, 1958.

Energy computations by means of body waves and surface waves have been made for a number of shallow-focus earthquakes. The energy ratio E/E_{LR} is found to decrease with increasing magnitude according to the formula $\log (E/E_{LR})=5.34-0.54\ M_S$ (where M_S is magnitude calculated from surface wave amplitudes for shallow distant earthquakes). The energy formula $\log E=12.24+1.44\ M_S$ is deduced; this is in very good agreement with Gutenberg and Richter's results (see Geophys. Abs. 167–67) obtained with completely different methods and material. The energy ratio of transverse and longitudinal waves $E_S/E_P=1.5\pm0.4$ is found to be independent of magnitude and epicentral distance.

Extinction is very strong for body waves and may account for a factor of about 20 in the total energy. It is due mainly to scattering within the crust in the focal region, increases with decreasing wavelength, and is larger for transverse than for longitudinal waves. The usually assumed extinction along the total wave path in the mantle amounts to approximately 10 to 15 percent of the crustal extinction. The large extinction of high frequencies in the focal region constitutes the most serious difficulty in determining energy from body waves.—*D. B. V.*

177–58. Hiller, Wilhelm. Zur Mechanik und Dynamik der Erdbeben [On the mechanics and dynamics of earthquakes], *in* Contributions in Geophysics (Gutenberg volume) : Internat. Ser. Mon. Earth Sci., v. 1, p. 57–68, 1958.

This is essentially the same as the paper previously published in the Geologische Rundschau, v. 46, no. 1, p. 39–50, 1957. (See Geophys. Abs. 171–68.)—*D. B. V.*

177–59. Byerly, Perry, and Stauder, William. The mechanism at the focus of an earthquake: Earthquake Notes, v. 29, no. 3, p. 17–23, 1958.

S-wave data have been used in many recent studies to determine the direction of faulting at the focus of an earthquake. In this paper, data from the Fairview Peak earthquake of December 16, 1954, and from that off the northern California coast on July 6, 1934, are studied and indicate that "fling" along the fault may not be the only mechanism generating earthquake waves. The earthquake of July 6, 1934, in particular, indicates that it would be well to be very careful in using data from *S* waves and would be best to consider either a double couple or a single couple as possible mechanisms. The results of the 1934 earthquake also suggest that it might be preferable to study only *SH* and thus avoid many difficulties associated with *SV* or total *S* motion.—*V. S. N.*

177–60. Stauder, William, and Byerly, Perry. Nodal lines for *S* waves: Earthquake Notes, v. 29, no. 3, p. 24–30, 1958.

Study of the variation of the direction of first motion of *SH*, *SV* and total *S* as the fault plane is allowed to dip, in the case of the simple couple, or the plane of action is allowed to vary from the horizontal, in the case of the double couple, shows that the patterns which result vary significantly from those of the simplified cases of a vertical fault or a horizontal plane of action. Comparison of patterns showing the direction of first motion for total *S*-single couple and total *S*-double couple shows that, although there is a different pattern for the two cases, the similarities are very great and it will require careful analysis—or may be impossible, considering the accuracy with which it may be possible to determine the plane of polarization of *S* waves from seismograms— to use *S*-waves to determine whether a simple couple or a double couple is the model of the mechanism at the focus of an earthquake.—*V. S. N.*

Knopoff, Leon, and Gilbert, Freeman. Radiation from a strike-slip fault. See Geophys. Abs. 177–88.

177–61. Hodgson, John H. Direction of displacement in western Pacific earthquakes, *in* Contributions in Geophysics (Gutenberg volume): Internat. Ser. Mon. Earth Sci., v. 1, p. 69–86, 1958.

In an earlier paper it was shown that fault plane solutions for earthquakes associated with a particular geographic feature have null vectors which lie parallel to the strike of that feature. McIntyre and Christie [see Geophys. Abs. 169–52] have suggested that this demands either (1) that the fault strikes be parallel to the feature or (2) that the displacement be perpendicular to the feature.

Solutions based on *P* only are ambiguous. It is shown that, in both the northwest and southwest Pacific, published solutions support McIntyre's conclusion but do not select between the two possibilities. Kogan [see Geophys. Abs. 161–103] has produced 21 solutions for earthquakes in the northwest Pacific. These solutions, which have been made available by Scheidegger [see Geophys. Abs. 165–164], use *S*, and so are unambiguous. In no case do they support possibility (1) above. The displacements tend to be parallel to the northern Marianas; elsewhere they are nearly perpendicular to the associated feature as suggested in (2).

With this as a guide, it is possible to select from the two possible planes obtained in solutions published earlier that which gives displacement most

nearly perpendicular to the feature. There is good agreement between the displacements so selected and Kogan's solutions. Displacements are inclined to the normals to the geographic features at angles of 15° to 30°; the sign of the angle is consistent over most arcs but varies from arc to arc. An exception is the New Hebrides arc, for which the sign of the angle is opposite at the two ends of the arc.

It is concluded that the data support McIntyre and that, while possibility (2) is favored, possibility (1) cannot be eliminated, particularly in the southwest Pacific.—*Author's abstract*

Healy, John H., and Press, Frank. Further model study of the radiation of elastic waves from a dipole source. See Geophys. Abs. 177–87.

177–62. Kirnos, D. P., and Kondorskaya, N. V. O vychislenii istinnogo znacheniya pervoy amplitudy dvizheniya pochvy pri vstuplenii seysmicheskoy volny [On the evaluation of the true value of the initial amplitude of the displacement of the ground on the arrival of a seismic wave]: Akad. Nauk SSSR Izv. ser. geofiz., no. 12, p. 1443–1450, 1958.

The study of earthquake mechanism, the use of dynamic properties of seismic waves in investigations of the internal structure of the earth, as well as some other problems of modern seismology make it imperative to know the initial amplitude of the displacement of the ground on the arrival of a seismic wave. This displacement is always recorded with some distortion which necessitates knowing the dynamic magnification of the seismographs especially during the first wave. Methods of evaluating the initial amplitude of seismograms are discussed, and graphs for this purpose are given. The results of theoretical computations are compared with the observed values. For this purpose seismograms of more than 100 earthquakes in different regions of the U.S.S.R., with epicentral distances ranging from 0° to 150°, have been analyzed. Agreement between the computed and the observed values was found to be satisfactory for *P* waves when Δ did not exceed 20° and foci were not too shallow.—*S. T. V.*

177–63. Caloi, Pietro. About some phenomena preceding and following the seismic movements in the zone characterized by high seismicity *in* Contributions in Geophysics (Gutenberg volume): Internat. Ser. Mon. Earth Sci., v. 1, p. 44–56, 1958.

A close connection between secular movements of the crust and shocks in zones of high seismicity is demonstrated, using Italian examples. The direction of movement (positive or negative) in the strained region is the same as the initial direction (compression or dilatation) of the longitudinal wave of the subsequent shock. A local shock may remove an obstacle to fault-block rotation, which may in fact follow the shock immediately.

Tiltmeters record crustal movements associated with distant or near earthquakes. Stations in the Italian Alps periodically record "tilt-storms," in which all stations of the mountain group under normal climatic and meteorological conditions suddenly begin to record rapid oscillations lasting several days with alternate phases. The cause of this phenomenon is not yet understood.—*D. B. V.*

177–64. Nishimura, Eiichi, Kishimoto, Yoshimichi, and Tanaka, Yutaka. Observed secular tilting motion of the ground which preceded the occurrence of several destructive earthquakes: Tellus, v. 11, no. 1, p. 130–134, 1959.

Ground tilt has been observed continuously for long periods by the highly sensitive fused-silica horizontal-pendulum tiltmeter at the Kamigamo Geophysical Observatory in Japan. Some details of the observations are described in this paper, particularly in connection with seismic activity in the vicinity. After elimination of various disturbing effects it was clearly ascertained, in the case of five destructive earthquakes with epicenters from 70 to 230 km from Kamigamo, that the ground characteristically began to tilt downward toward the epicenter several months before the earthquake and showed a recovering motion afterward. In two other earthquakes studied no tilting was observed, possibly because of their similar magnitude and relatively large epicentral distance.

It is concluded that the relationship of tilting to earthquakes is not accidental, and that study of secular tilt should prove to be of great value in advancement of knowledge of the nature of earthquakes and in the practical matter of earthquake prediction. (See also Geophys. Abs. 169–70, 173–84.)—*D. B. V.*

177–65. Kamitsuki, Akira. On the seismic waves reflected at the Mohorovičić discontinuity: Kyōto Univ. College Sci. Mem, ser. A, v. 28, no. 2, p. 143–159 (part 1), 1956, and v. 29, no. 1, p. 20–33 (part 2), 1958.

Shallow-focus earthquakes are particularly useful for analysis of reflected waves because there is no interference with transformed or direct waves, and at small epicentral distances the amplitudes of the reflected waves are comparatively large and the separation between direct and reflected waves is good.

The seismic waves reflected at the Mohorovičić discontinuity are discussed on the basis of seismograms recorded at stations within 70 km (in part 1), and within 100 to 600 km of the epicenters (in part 2) of earthquakes of shallow origin. Crustal structure determined for three examples of local shallow earthquakes that occurred in the Kyōto, Tokai, and Kii regions of Japan showed good agreement with the crustal structure determined by other methods.

In part 2 two examples of local earthquakes of shallow origin are studied from seismograms recorded at 32 stations at middle distances from the epicenters. At these distances refracted waves begin to appear and the reflected waves are less easy to detect. Observations were made of the travel time, amplitude, and period of various phases of the part of the record between the arrival of the initial *P*-motion and of the principal *S*-motion. Repetitive features of pulses showing about equal time intervals were interpreted as multiple reflections between the outer free surface and the Mohorovičić discontinuity. The difference of the time interval in the two selected earthquakes was found to correspond to local differences in thickness of the crust. The identification of the multiple reflections was verified by amplitude- and period-distance relations.—*V. S. N.*

177–66. Mikumo, Takeshi. On the periods of seismic waves observed in local earthquakes: Kyōto Univ. College Sci. Mem., ser. A, v. 29, no. 1, p. 1–17, 1958.

Analysis of the periods of body waves of local earthquakes observed in Wakayama district, Japan, shows that the periods of the initial impulsive waves increase with increasing distance travelled, but are related neither to the magnitude of the earthquake nor to other observable effects; the rate of increase of the period of the *P*-waves is more rapid than that of the *S*-waves, possibly because the dilatational viscosity of the medium is considerably larger than the shear viscosity; and the average periods of the *P*- and *S*-wave groups

have certain fixed values, irrespective of focal distance or earthquake magnitudes that may be attributed to free oscillations of the superficial layer.—*V. S. N.*

177–67. Lehmann, I[nge]. On amplitudes of *P* near the shadow zone: Annali Geofisica, v. 11, no. 3–4, p. 153–156, 1958.

Examination of 51 short-period vertical seismograph records of the Samoa earthquake of April 14, 1957, obtained in the United States and Canada shows that *P*-wave amplitudes were very large at western stations ($\Delta > 84°$) and small at eastern ($\Delta > 100°$ in 8 of these). At the greatest distance, 108.2°, the *P* waves were not diffracted waves, as the phase was of the same general character as at shorter distances; period was 2 sec. From 70° to about 90° the *P* traveltime curve is steeper than the Jeffreys-Bullen curve. Slight regional variations in composition of the D'' layer of the mantle can explain why the shadow zone seems to begin at different epicentral distances in different shocks and why the relative amplitudes differ.—*D. B. V.*

177–68. Savarenskiy, Ye. F., and Ragimov, Sh. S. Opredeleniye skorosti voln Releya i napravleniya na epitsentr po trem blizkim stantsiyam [Determination of the velocity of Rayleigh waves and of the azimuth toward the epicenter according to three neighboring stations]: Akad. Nauk SSSR Izv. ser. geofiz., no. 12, p. 1485–1490, 1958.

The accuracy of determinations of group velocity of Rayleigh waves can be estimated only by comparison of data of three neighboring stations, where the distance between them is so small with respect to the epicentral distance that the wave paths are essentially parallel. Because of the effect of lateral refraction, observations at three neighboring stations also provide a check of the accuracy of determination of epicenters by means of longitudinal wave arrivals; for this purpose it is necessary that the dynamic parameters of the instruments at all stations be as identical as possible, so that the differences in similar readings are smaller than the tolerable error. Data from three Caucasian stations (Goris, Kirovabad, and Shemakha) each equipped with a three-component Kirnos seismograph, are used to illustrate the determination of group velocities of Rayleigh waves using four 1957 earthquakes (March 17, 22, and 29 in the Aleutians and October 25 in the Kurile Islands). From data from the same stations, epicentral directions are determined for these and one other earthquake (April 10, 1957). In conclusion it is remarked that the ratio of the differences of epicentral distances to differences in arrival time for oscillations of approximately the same period at two stations is equal to the phase velocity of Rayleigh waves of that period; this is illustrated by the examples of the earthquakes of April 14, 1957, (Samoa) and July 28, 1957, (southern Mexico).—*S. T. V.*

177–69. Båth, Markus. Ultra-long-period motions from the Alaska earthquake of July 10, 1958: Geofisica Pura e Appl., v. 41, p. 91–100, 1958.

Ultra-long-period motions from the Alaska earthquake of July 10, 1958, have been studied on records at Uppsala. Mantle Rayleigh waves with up to six passages around the earth were recorded. The dispersion curve for the period range 100–400 sec was deduced, showing a minimum group velocity of 3.56 kmps at a period of 225 sec, thus confirming earlier results by Ewing and Press (see Geophys. Abs. 158–137, 159–128, 165–62). A value of the internal friction in the mantle of 480×10^{-5} for the period range 120–260 sec was obtained. The particle motion of the mantle Rayleigh waves is retrograde elliptical in the plane of propagation, the vertical axis being 0.68 of the horizontal axis. A trans-

verse horizontal wave motion is observed on the *E* component. Both its period (12 min 10 sec) and the delay of its onset (8 hours after the earthquake) confirm the hypothesis that it represents a free torsional vibration of the whole earth, apparently observed for the first time.—*Author's summary*

Press, Frank. Some implications on mantle and crustal structure from *G* waves and Love waves. See Geophys. Abs. 177–240.

Blum, Pierre-Antoine, Jobert, Georges, and Jobert, Nelly. First results obtained by means of inclinometers. See Geophys. Abs. 177–78.

177–70. Teupser, Christian. Der Rückwirkungsfaktor bei elektrodynamischen Erschütterungsmessern [The reaction factor in electrodynamic vibration meters]: Freiberger Forschungshefte, C 51 Geophysik, 62 p., 1958.

In the first part of this monograph the effect of the reaction factor on the records of electrodynamic vibration meters, for any adjustment and any translational ground movement, is investigated. A general solution is possible because the phase angle alone is introduced into the equation in place of the natural frequency and damping. The results are then specialized for those adjustments which are important in vibration measuring techniques. The necessary tools are given for determining the highest permissible reaction factor for an arbitrarily adjusted system, beyond which its effect on the records will be significant. It is particularly interesting that Golitzin's own adjustment is the least favorable with respect to the reaction factor, with the one usually used in explosion seismology (seismometer with low, galvanometer with high natural frequency) the reaction factor should always be negligible.

In the second part, methods of determining the transference and reaction factors are described. A particularly simple method of determining the latter in Golitzin-type seismometers is discussed and applied to the calibration of two instruments (see Geophys. Abs. 177–71).—*D. B. V.*

177–71. Teupser, Christian. Eine Methode zur Bestimmung des Rückwirkungsfaktors bei Seismometern vom Typ Galitzin [A method of determining the reaction factor in seismometers of the Galitzin type]: Československá Akad. Věd Studia Geophys. et Geod., v. 3, no. 1, p. 92–93, 1959.

It is shown that the reaction factor in Galitzin seismometers can be calculated from the ratio between the first and second extreme positions of the galvanometer. A graph is given from which the reaction factor can be read off directly. (See also Geophys. Abs. 177–70).—*D.B.V.*

177–72. Gouin, Pierre. An electronic seismic transducer for visual recording: Annales Géophysique, v. 13, no. 3, p. 234–241, 1957.

Inexpensive visual recording of earth motions through simplified electronic circuits is an important addition in a seismological observatory. The transducer and recorder described, in their simplest form, consist of only two electronic tubes if coupled to a sensitive pen motor. For experimental purposes, however, a more elaborate amplifier circuit is also given.—*Author's summary*

177–73. Rykov. A. V. Fotoelektricheskiy pribor dlya zapisi potoka energii seysmicheskikh voln [A photoelectric device for recording the energy

flux of seismic waves]: Akad. Nauk SSSR Izv. ser. geofiz. no. 1, p. 153–158, 1959.

Rykov describes an apparatus which automatically measures the square of the velocity of displacement of the ground and integrates the obtained quantity with respect to time. The main element of the apparatus is a photoelectric amplifier provided with an opening so shaped that the original beam of light, after passing through the opening, illuminates an area proportional to the square of the original deflection of the galvanometer. Finally an integration of the amplified deflection is produced. The apparatus was tested in the laboratory and showed good results.—*S.T.V.*

177–74. Shakurov, P. F. Vysokochuvstvitel'yye apparaty dlya opredeleniya naklonov poverkhnosti zemli i registratsii voln zemletryaseniy [Highly sensitive apparatus for determination of the inclination of the earth's surface and for the recording of seismic waves]: Akad. Nauk SSSR Izv. ser. geofiz., no. 1, p. 159–161, 1959.

An instrument for measuring small inclinations of the ground with high precision, not yet tested in practice, is described. The principle of the instrument consists in the use of two concentric spherical shells, having the same radii of curvature and polished to optical precision so that the upper shell can roll in the other. To decrease friction during the rolling, a stream of slightly compressed air is blown in through a small opening 0.2–0.3 mm in diameter at the middle point of the lower sphere. This stream keeps the upper shell "floating" in the lower one. The distance between the two shells will be about 10 μ. Shakurov estimates that the amount of air necessary for this, compressed to 0.4 atm, will be about 30 liters for 24 hours. The equilibrium position of the upper shell corresponds to the minimum of its potential energy. The precision is such that an angle of the inclination of 1 sec or even 0.02 sec can be positively determined if a sufficient optical magnification is used.—*S. T. V.*

177–75. Boletin Sismológico del Servicio Geológico Nacional de El Salvador. Informe sobre la instalacion de un sismografo de período largo en el Estación Sismológica de San Salvador [Report on the installation of a long-period seismograph in the San Salvador Seismological Station]: El Salvador Servicio Geol. Nac. Bol. Sismol., v. 4, p. 40–42, 1958 (1959).

The new seismograph equipment installed at the San Salvador station consists of two 100-kg horizontal pendulums each having a 15-sec period and static amplification of 20 times at a damping ratio of 1:3. Recording speed is 30 mm per min; both north-south and east-west components are registered on the same band. Three photographs are given.—*D. B. V.*

EARTH TIDES AND RELATED PHENOMENA

177–76. Melchior, Paul J. Earth tides: Adv. Geophysics, v. 4, p. 391–443, 1958.

A review of present knowledge on earth tides, based on 35 papers listed in the bibliography. The static theory of tides, definition of Love's numbers, amplitude of ocean tides, periodic deflections of the vertical with respect to the crust and to the axis of the earth, measurement of elastic tensions and cubic dilations, variations in intensity of gravity, the role of geologic structure in the indirect effects of ocean and atmosphere, theory of elastic deformations of the earth,

effect of earth tides on speed of rotation, and the IGY program are discussed.—*D. B. V.*

177–77. Pertsev, B. P. Garmonicheskiy analiz uprugikh prilivov [Harmonic analysis of elastic tides]: Akad. Nauk SSSR Izv. ser. geofiz., no. 8, p. 946–958, 1958.

A method of harmonic analysis of a 29-day series of observations of luni-solar elastic tides is described, based on the evaluation of 25 fundamental waves of luni-solar potential producing the tides. Pertsev's scheme makes it possible to separate the five most important waves, M_2, S_2, N_2, K_1, and O_1. The application is illustrated by a detailed example. The method is in many respects similar to Doodson's.—*S. T. V.*

177–78. Blum, Pierre-Antoine, Jobert, Georges, and Jobert, Nelly. Premiers resultats obtenus à l'aide d'inclinomètres [First results obtained by means of inclinometers]: Acad. Sci. [Paris] Comptes Rendus, v. 248, no. 10, p. 1551–1554, 1959.

Preliminary results of observations obtained by the tiltmeters installed in Paris and at Moulis in the Pyrenees are reported. The instruments both operate with a period of the order of 80 sec and at a damping slightly less than critical. Recording is by means of a light beam reflected from a mirror on the pendulum; amplification is of the order of 1 cm at a distance of 1.5 m from the pendulum. Drum speed is 5 cm per hr. Comparative study of the observed earth tides with theoretically computed tides is in progress. Preliminary calculations give a value of about 0.66 for the east component of deflection of the vertical.

The tiltmeters also act as very long period seismographs. Five earthquakes have so far been studied: June 25, 1958 (New Guinea), July 10, 1958 (Alaska), November 6 and 12, 1958 (Kurile Islands), and February 7, 1959 (Peru). In the Alaskan earthquake, Rayleigh and *G*-waves up to the eighth order could be observed. *G*-waves are rather irregular up to the third order, become more regular as the order increases. Group velocity varies from 4.3 to 4.5 kmps as period increases from 1 to 5 min; maximum amplitude corresponds to a velocity of 4.4 kmps.

Mantle Rayleigh waves are less affected by irregularities in the path. Group velocity diminishes from 3.9 to 3.55 kmps as apparent period increases from 70 sec to 4 min. The branch of the dispersion curve obtained is close to that obtained by Ewing and Press (see Geophys. Abs. 159–128). It is difficult to observe Rayleigh waves with apparent periods greater than 4 min, for which dispersion becomes normal again; the two branches of the curve are superposed and the instruments are more sensitive to the periods of the inverse branch.—*D. B. V.*

177–79. Lecolazet, R[obert]. Enregistrement et analyse harmonique de la marée gravimétrique à Strasbourg (huit mois d'observation) [Recording and harmonic analysis of the gravimetric tide at Strasbourg (8 months of observation)]: Annales Géophysique, v. 13, no. 3, p. 186–202, 1957.

Earth tide measurements were made at Strasbourg, France, from October 1954 to March 1955 and from March to May 1956 with a North American gravimeter. Some details are given on the recording techniques and method of harmonic analysis used. Seven diurnal components, 1 of them S_1 with a period of exactly 24 hr., and 6 semidiurnal components could be identified.

The results, analyzed in detail, corroborate and supplement earlier results (see Geophys. Abs. 167–135) but are inconsistent with Jeffreys' theoretical results. An anomaly of the O_1 component is shown clearly. The S_1 component is of very small amplitude, contrary to what is expected according to tilt observations and some tidal gravity observations. The S_2 component shows a negative phase lag of the order of 3°, attributed to deformation of the earth under the influence of the semidiurnal variation in atmospheric pressure.—*D. B. V.*

177–80. Pekeris, C. L., and Jarosch, H. The free oscillations of the earth *in* Contributions in Geophysics (Gutenberg volume): Internat. Ser. Mon. Earth Sci., v. 1, p. 171–192, 1958.

The free oscillations of the earth have been studied systematically by three methods. In the first the periods of free oscillation of a uniform earth having the average properties of the real earth (the "average model") were investigated. Then the periods were determined for the real earth by means of a variational method. Finally an exact solution was obtained for the real earth by integrating the differential equations numerically on an electronic computer. The periods determined for the uniform model by the variational method were found to be very close to those obtained from the exact solution. For radial oscillations, the fundamental mode T_1=20.7 min for both methods, the second mode T_2=9.8 and 10.1 min, respectively; T_1 for the average model is 30 percent larger than the period for the real earth.

Some preliminary results are also given of spherical oscillations. T_1 for the average model is 44.3 min as against 53 min derived by the variational method. Should the latter value be substantiated by an exact numerical solution now in progress, result would support Benioff's identification of the observed 57-min oscillation with the free oscillation of spheroidal type of the earth.—*D. B. V.*

ELASTICITY

177–81. Tsepelev, N. V. Ob otrazhenii uprugikh voln v neodnorodnoy srede [On the reflection of elastic waves in a heterogeneous medium]: Akad. Nauk SSSR Izv. ser. geofiz., no. 1, p. 11–17, 1959.

This article is a continuation of a previous study by Alekseyev and Tsepelev (see Geophys. Abs. 168–61). The problem of the determination of the effect of certain surfaces on the propagation of elastic waves in heterogeneous media is discussed. There are the surfaces on which the gradients of velocity and density are discontinuous. It is shown that such boundaries act as reflecting planes. The corresponding coefficients of reflection and refraction are computed, and the shapes of the reflected and refracted waves are determined; these waves differ in shape from the incident wave. The analysis can be extended to the case when the *k-th* derivatives of velocity and density undergo discontinuities of the boundary.—*S. T. V.*

177–82. Coloma [Pérez], A[ntonio]. Sobre la onda de reflexión relativa a tres medios [On the reflected wave relative to three media]: Rev. Geofísica, v. 17, no. 67, p. 251–260, 1958.

A previous study (see Geophys. Abs. 176–313) is extended to the three-layer case. Reflection travel times are computed from those of corresponding refracted waves for both parallel and nonparallel boundaries. The results are absolutely positive. The Caleya-Dürbaum formula is derived from the travel-

time equation, thus confirming the conclusion of the earlier study that reflection and refraction methods may both be embodied in the same section.—*D. B. V.*

177–83. Chekin, B. S. Otrazheniye i prelomleniye seysmicheskikh voln na slaboy granitse razdela [The reflection and refraction of seismic waves on a weak discontinuity]: Akad. Nauk SSSR Izv. ser. geofiz., no. 1, p. 18–26, 1959.

Assuming as an approximation the beam method of solving the problem of wave propagation in a heterogeneous medium, Chekin discusses the reflection and refraction of seismic waves on a weak boundary plane between two media. Characteristic of the problem is the fact that discontinuities of the velocity gradient and of Lamé coefficients take place on this boundary. In the treatment of the problem the vectorial method is used. As a result of his mathematical analysis, Chekin obtains expressions physically equivalent to the coefficients of reflection and refraction on this boundary.—*S. T. V.*

177–84. Treitel, Sven. On the attenuation of small-amplitude plane stress waves in a thermoelastic solid: Jour. Geophys. Research, v. 64, no. 6, p. 661–665, 1959.

All real materials have a finite thermal conductivity. This means that stress waves propagating through any physically real solid suffer energy losses due to heat conduction. The equations of motion and of temperature for an elastic solid with a finite thermal conductivity are derived with the aid of the irrreversible form of the second law of thermodynamics. Their solution for frequencies of physical interest shows that the attenuation coefficient of a stress wave traveling in such a thermoelastic solid is proportional to the second power of the frequency.—*Author's abstract*

177–85. Mitra, M. The disturbance due to periodic surface traction in a semi-infinite medium of varying elasticity and density: Geofisica Pura e Appl., v. 41, p. 86–90, 1958.

In this paper, the shear displacement due to a transverse periodic surface traction on a semi-infinite elastic solid, in which the rigidity and density vary exponentially with the depth, has been obtained. The normal modes are calculated for high frequencies and the surface displacement obtained numerically in a particular case for a low frequency.—*Author's summary*

177–86. Knopoff, Leon. Scattering of shear waves by spherical obstacles: Geophysics, v. 24, no. 2, p. 209–219, 1959.

The problem of the scattering of plane *S* waves by a perfectly rigid, infinitely dense sphere is formulated. Calculations are made for the case in which the medium outside the sphere has a Poisson's ratio of 1/4. The range of sizes of obstacles used in the calculations includes radii very small compared with the wave length and radii comparable to the wave length. The scattered wave motions include a *P* mode and two *S* modes. One of the *S* modes has a formal correspondence to the *SH* mode of plane seismology; the other corresponds to the *SV* mode. At large distances from the obstacle the scattered *P* and *S* fields are computed together with the phase shifts in time occurring in all the components. For small obstacles, the scattered azimuthal *S* component is circularly symmetric; the scattered meridional *S* component diffraction pattern is generally elongated in the direction of progagation; the scattered *P* component is generally broadside to the direction of propagation.—*Author's abstract*

177–87. Healy, John H., and Press, Frank. Further model study of the radiation of elastic waves from a dipole source: Seismol. Soc. America Bull., v. 49, no. 2, p. 193–198, 1959.

This paper demonstrates a possible mechanism for the origin of the anomalous shear waves observed in ultrasonic model studies, described elsewhere (in press), of the radiation pattern of elastic waves from a dipole source with a slit. A two-dimensional study of elastic waves generated by a singlet source adjacent to a long slit reveals that Rayleigh waves are excited. These waves travel along the edge to the end of the slit, from which point they are transmitted as shear waves into the body of the medium. A reflected Rayleigh wave also occurs.

The fact that earthquake faulting proceeds with a finite velocity over a finite distance suggests very strongly that a secondary source of shear waves may occur at the end of the fault in a manner analogous to that of these experimental results. It is concluded that anomalous shear waves may occur in nature and must be allowed for in studies of the focal mechanism of earthquakes.—*D. B. V.*

177–88. Knopoff, Leon, and Gilbert, Freeman. Radiation from a strike-slip fault: Seismol. Soc. America Bull., v. 49, no. 2, p. 163–178, 1959.

Huygens' principle for elastodynamics has been applied to the problem of the radiation resulting from the introduction of a tear fault of finite length into an otherwise homogeneous medium. The fault has the following properties: it is a surface across which the normal stresses vanish; it has a rectangular shape with one dimension increasing at a constant rate in the direction of faulting; the times of initiation and termination of the fault are both finite. The relative displacement on opposite sides of the fault is prescribed to be a step function of time. This configuration may be imaged in the earth's surface by symmetry, so that the problem is reducible to that of a propagating strike-slip fault of finite length in an infinite elastic medium. The observed events are P and S waves from the two ends of the fault. Simplified "first motion" responses are computed and compared with solutions derived from the usual theory of force couples.—*Authors' abstract*

177–89. Williams, M. L. The stresses around a fault or crack in dissimiliar media: Seismol. Soc. America Bull., v. 49, no. 2, p. 199–204, 1959.

In order to investigate some problems of geophysical interest, the usual consideration of symmetrical or antisymmetrical loading of an isotropic homogeneuos plate containing a crack was extended to the case where the alinement of the crack separates two separate isotropic homogeneous regions. It develops that the modulus of the singular behavior of the stress remains proportional to the inverse square root of the distance from the point of the crack, but the stresses possess a sharp oscillatory character of the type $r^{-1/2} \sin (b \log r)$, which seems to be confined quite close to the point, as well as a shear stress along the material joint line as long as the materials are different.

The off-fault areas of high strain energy release reported by St. Amand [see Geophys. Abs. 166–83] for the White Wolf fault are qualitatively shown to be expected.—*Author's abstract*

177–90. Keylis-Borok, V. I., and Stesin, I. M. Dispersiya Releyevskikh voln v dvukhsloynoy modeli zemnoy kory [The dispersion of Rayleigh waves in a two-layer model of the earth's crust]: Akad. Nauk SSSR Izv. ser. geofiz. no. 1, p. 27–31, 1959.

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This is a continuation of previous studies on vibrations of multilayered media (see Geophys. Abs. 148–13329; 149–14031; 165–84). A theoretical analysis is made of Rayleigh wave dispersion in a crust composed of two layers of different thickness, granitic and basaltic. Each layer is assumed to be homogeneous, isotropic, and perfectly elastic; the contacts on the boundary planes are assumed to be rigid and the upper boundary to be stressfree. The results of the computations are compared with recently published experimental data obtained by Press and Ewing (see Geophys. Abs. 165–62); the correspondence is found to be good.—*S. T. V.*

177–91. Stoneley, Robert [S.] The variation of amplitude and energy with depth in Love waves, *in* Contributions in Geophysics (Gutenberg volume): Internat. Ser. Mon. Earth Sci., v. 1, p. 36–43, 1958.

The variation of the amplitude of surface elastic waves with distance from a free surface is of interest both in seismology and in the vibration of roads and solid structures. The present paper investigates numerically the variation of amplitude for Love waves propagated in a solid having two uniform surface layers, of equal thicknesses, underlain by a very great depth of uniform material. The densities and rigidities of the three media are taken to represent an ultrabasic rock, of great thickness, with surface layers of granitic and basaltic rock in which the granitic layer is the outermost. The relative amplitudes of the vibration have been computed for eight different depths in respect of thirteen different values of the wave velocity, covering the whole permissible range of wave velocities.

The potential energy and kinetic energy in each of the three media are calculated in two representative cases, namely relatively short waves and relatively long waves. As might be expected, in the former case most of the energy, whether potential or kinetic, is confined to the granitic layer, while, in the latter case, most of the energy is located in the ultrabasic material with the remainder divided about equally between the two surface layers.—*Author's abstract*

177–92. Geophysical Prospecting. Changes of shape of seismic pulses: Geophys. Prosp., v. 6, no. 4, p. 457–460, 1958, and v. 7, no. 1, p. 1–17, 1959.

This is the text of the discussion following the symposium on shape of seismic pulses (see Geophys. Abs. 176–71, 72, 73, 323, 324).—*D. B. V.*

177–93. Sałustowicz, Antoni. Górotwór jako ośrodek sprężysto-lepki [Rocks as an elastic-viscous medium]: Archiwum Górnictwa, v. 3, no. 2, p. 141–172, 1958.

In this paper Sałustowicz gives several examples of solutions bearing on strain and deformation of rocks in the neighbourhood of mines. A dependence of such strains and deformation on time was established from consideration that rocks behave as mediums. It was found that although the strains and stresses change with time, the total strain is independent of time. The deformations in the rock were found to vary exponentially with time, asymptotically approaching certain finite values.—*A. J. S.*

177–94. Peselnick, Louis, and Zietz, Isidore. Internal friction of fine-grained limestones at ultrasonic frequencies: Geophysics, v. 24, no. 2, p. 285–296, 1959.

Ultrasonic pulse measurements in the 3 to 10 megacycles per sec frequency range were made of shear and dilatational absorption and velocity for three samples of fine grained, homogeneous, and well compacted limestones at atmospheric conditions. The complex moduli of elasticity were calculated for two limestone specimens of different grain size and porosity. A "hysteresis" or "solid-friction" type of loss for waves of dilatation was found in all three limestone specimens. Shear measurements made in one of the limestones also show a "hysteresis" type of loss.

Comparison of the dilatational loss in a single crystal of calcite to the dilatational loss in the limestones indicates that the internal friction for the limestone specimens probably occurs at the grain boundaries.—*Authors' abstract*

177–95. Kuiper, J., Ryen, W. M. L. van, and Koefoed, O. Laboratory determinations of elastic properties of some limestones: Geophys. Prosp., v. 7, no. 1, p. 38–44, 1959.

Using a resonance method, determinations have been made of the longitudinal bar velocity and of Poisson's ratio of 13 different chemically pure limestones. The relation between the velocity and the density showed far less scatter than in the determinations previously published; this is primarily attributed to the high purity of the specimens used. The measurements further showed a tendency of the values of Poisson's ratio to increase with increasing density.—*Authors' abstract*

177–96. Desbrandes, R., Reverdy, X., and Lagarde, A. Contribution à l'étude de la vitesse des ondes sismiques [Contribution to the study of the velocity of seismic waves]: Inst. Français Pétrole Rev., v. 14, no. 4–5, p. 535–548, 1959.

This article reports on some measurements of acoustic wave velocities in rocks made by means of the apparatus designed by the French Petroleum Institute. It defines the limitations of the apparatus, which is of the conventional piezoelectric crystal type. The corresponding spectrum is obtained by splitting up the pulse into Fourier's integral.

The longitudinal and transverse velocities and Poisson's ratio for two sandstone and two basement rock cores are tabulated. The relationship of longitudinal velocity to porosity in sandstones can be expressed by the formula $1/V=1V_m\times e^{\alpha\omega^2}$ (%), where V=velocity, V_m=velocity in matrix, α=a coefficient depending on the nature of the saturating fluid, and porosity ω is between 0 and 18 percent.—*D. B. V.*

177–97. Silayeva, O. I. Metodika izucheniya uprugikh svoystv obraztsov gronykh porod pod davleniyem [The methods of studying the elastic properties of specimens of rocks under pressure]: Akad. Nauk SSSR Izv. ser. geofiz, no. 2, p. 221–228, 1959.

This paper deals with the elastic properties of rocks and the degree of absorption of energy in specimens subjected to pressure up to 1,000 kg per cm^2. The ultrasonic impulse method (see Geophys. Abs. 169–315) was used. The pressure on the specimens was applied only along one axis. Maximum pressure applied corresponds to a depth of about 4 km underground. The experiments show that with increasing pressure the elastic parameters (Young's modulus, rigidity modulus, and Poisson's coefficient) increase, whereas the absorption of elastic waves decreases. The results prove that the elastic properties of

rocks and the absorption coefficients of elastic waves propagating in them can be reliably studied in the laboratory.—*S. T. V.*

177–98. Petkevich, G. Ĭ. K izucheniyu uprugikh svoystv gornykh porod Predkarpat'ya [Contribution to the study of elastic properties of rocks in Cis-Carpathia]: Akad. Nauk SSSR Izv. ser. geofiz., no. 2, p. 316–319, 1959.

A comparison of the seismic velocity values determined in the laboratory on specimens of rocks under atmospheric pressure, with the values established from well-shooting data on the same rocks, permits individual factors that govern wave velocity under specific geologic conditions to be distinguished; further, the effect of these factors can be calculated, thus eliminating great difficulties connected with the determination of seismic velocity of rocks in place.

Laboratory determinations were made using an ultrasonic impulse seismoscope suggested by Riznichenko (see Geophys. Abs. 172–242) with a frequency of 140 cycles per sec, following the procedure of "resounding". The dimensions of the tested specimens were those recommended by Silayeva and Shamina (see Geophys. Abs. 172–67). Specimens were taken from four drill holes from a depth range of 100 to 3,000 m. The most important conclusion is that it is possible to establish a definite empirical correlation between the results of laboratory measurements and data. The difference between the two sets of values decreases with depth. Results are presented in a table and graphs.—*S. T. V.*

Birch, Francis. Interpretation of the seismic structure of the crust in the light of experimental studies of wave velocities in rocks. See Geophys. Abs. 177–245.

177–99. Jones, Ronald. In-situ measurement of the dynamic properties of soil by vibration methods: Géotechnique, v. 8, no. 1, p. 1–21, 1958.

Experimental techniques are described for determining the dynamic properties of soil in place from measurements made at the surface. In the first part it is shown that the dynamic-shear modulus of soil and the form of its variation with depth can be determined from measurements of the phase velocity of surface vibrations within the frequency range of 35 to 400 cycles per sec over test lengths of about 50 feet. In the second part a method is described for obtaining the dynamic-shear modulus of soil from the resonant frequency of a mass vibrating perpendicularly to the surface. In cases of considerable variation in soil properties the localized measurements thus obtainable are important for supplementing the average data obtained from measurements of the phase velocity of the surface vibrations. An electromagnetic virbrator driven by a variable-frequency oscillator and power amplifier, and a seismic geophone pickup were used for both types of measurements.—*V. S. N.*

177–100. Hodgson, Ernest A. Dominion Observatory rockburst research 1938–1945: Dominion Observatory Ottawa Pubs., v. 20, no. 1, 248 p., 1958.

This paper presents brief summaries of 22 reports covering the progress of a series of rockburst studies made in mines at Kirkland Lake, Ontario, from late 1938 through October 1945. The data obtained from some of the studies utilizing rockbursts as energy sources of precisely known location, accurately timed by the Kirkland Lake seismographs, made it possible to draw up improved traveltime curves for short epicentral distances and to determine surface struc-

ture over the Canadian Shield. For other reports on this study see Geophys. Abs. 135–10558, 138–11275.—*V. S. N.*

177–101. Press, Frank. Seysmicheskoye issledovaniye zemnoy kory [Seismic exploration of the earth's crust] : Priroda, no. 8, p. 33–37, 1958.

The paper describes the explosion-seismic method of exploration of the earth's crust and gives some of the results to date. The lesser depth to the Mohorovičić discontinuity under the ocean and the change in gravity along a line from continent to ocean are considered as evidence of isostatic compensation in the earth's crust. *P*-wave velocities between 8.0 and 8.2 kmps have been found in the mantle under both continents and oceans, 6.0 to 6.2 kmps in the crust under the continents, and 6.7 to 7.0 kmps in the basic rock under the ocean floor. Velocities of *S* waves in the mantle under the continents are found to be 4.6 to 4.8 kmps (no data are yet available for transverse waves in the mantle under the ocean), and 3.5 to 3.6 kmps in the crust under the continents. The refraction-correlation method, phase-velocity method, and *Lg*-wave method are described briefly. The mean thickness of the continental crust has been determined from the curves of the phase velocities of Rayleigh waves as 47 km under the Sierra Nevada block and 30 km under San Francisco Bay. *Lg* waves are instrumental in determining the outline of the continents, as the *Lg*-wave guide disappears at the continental shelf.—*A. J. S.*

Richards, T. C., and Walker, D. J. Measurement of the thickness of the earth's crust in the Albertan plains of western Canada. See Geophys. Abs. 177–246.

177–102. Tardi, Pierre. Enregistrements séismiques de grandes explosions dans les Alpes occidentales en septembre 1958 [Seismic records of the large explosions in the western Alps in September 1958] : Acad. Sci. [Paris] Comptes Rendus. v. 248, no. 8, p. 1069–1072, 1959.

The 1958 program of explosion seismology under the auspices of the Commission Européene de Séismologie was concerned with the crystalline zone of the Alps. Six charges of 1, 5, 5, 10, 10, and 25 tons were exploded at the bottom of Lake Nègre in the Mercantour granite massif some 50 km north of Nice. Two reflection outfits were installed on the access road to the lake by the Compagnie Générale de Géophysique and the Institut Français du Pétrole; a third, operated by the Trieste geophysical observatory, was on the Italian flank of the massif. The 31 refraction outfits included 10 German (representing 7 different organizations), 1 English, 4 Italian, and 1 Swiss, in addition to 10 from the Institut du Physique du Globe in Paris, 4 from the Institut du Physique du Globe in Strasbourg, and 1 from the Service Central Hydrographique de la Marine. The Monaco and Orope seismological stations also participated in the program.

Refraction stations were arranged along 4 profiles: one reference profile outside the Alps, crossing the Esterel and Maures crystallines; one along the outer Alpine zone across the Mercantour, Pelvoux, Belledonne, Mont Blanc, and Aar massifs; one following the folded zone between Lake Nègre and Camp des Rochilles, the reverse of a 1956 profile, and a northern profile following the zone of positive gravity anomalies in Italy. Records were obtained at 149 stations along these profiles (77 in France and 72 in Italy and Switzerland), to distances of more than 300 km from the shot point.—*D. B. V.*

177–103. Bune, V. I., and Konkov, A. A. Opyt ispol'zovaniya mekhanicheskikh seysmografov SMR–II s tsel'yu otsenki razmerov seysmoopasnoy

zony pri massovom vzryve [Experience with the use of mechanical seismographs SMR–II for the purpose of estimating the size of seismic danger zones in large-scale explosions]: Akad. Nauk Tadzhik. SSR Inst. Seysmologii Trudy, v. 71, no. 2, p. 47–58, 1957.

Data are presented on the disturbance of the ground close to an explosion of 1,800 tons of ammonite. A characteristic of the records is the relatively large periods (0.14–0.45 sec) at distances of 600 to 1,200 m from the shot point; these had not been recorded from earlier explosions. According to tentative data the radius of the seismic danger zone is twice as large as was expected from the empirical formulas, which take into account only the weight of the charge and the character of the ground.—*Authors' abstract, J. W. C.*

ELECTRICAL EXPLORATION

177–104. Orellana Silva, Ernesto. Una unidad geofísica de resistividad aparente [A geophysical unit of apparent resistivity]: Rev. Geofísica, v. 17, no. 67, p. 325–329, 1958.

Disadvantages of using the ohm-meter as a unit in resistivity surveys are pointed out, and a new unit of apparent resistivity is proposed, called the "geohm" (more exactly, the "geohm-meter"), which is the ohm-meter multiplied by 2π. If in the fundamental equation of electrical prospecting, $\Delta V = K\rho I\left(\frac{I}{r_1} - \frac{I}{r_2}\right)$, if potential V is expressed in volts, intensity I in amperes, potential electrode distances r_1 and r_2 in meters, the definition of resistivity ρ depends on the factor K; but this is a "parasite coefficient" to which we can and should give a value of 1, with which 2π does not appear. The unit of resistivity thus naturally defined is the geohm.—*D. B. V.*

177–105. Šumi, Franc. Električna i elastična anizotropija [Electrical and elastic anisotropy (with English summary)]: [Serbia] Zavod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 311–324, 1957.

A general equation and diagram are given for calculating apparent resistivity in any direction in anisotropic layers in an electrode spread, and applied to the determination of the electrical anisotropy of Upper Cretaceous limestone in the Trebinje region and of Upper Cretaceous Flysch in the Savnik region of Serbia.

Two cases of elastic anisotropy are then investigated: one when the individual layers in an anisotropic medium are thick in comparison to seismic wave length, the other when the layers are small in comparison to wave length. Examples are worked out for two ideally elastic mediums, then the results of anisotropy measurements on the Flysch of the Savnik area, which is an example of the second case, are tabulated. The difference between the theoretical and observed results is small. It is concluded that for accurate interpretation of electrical or seismic surveys it is necessary to determine anisotropy in the field along with other characteristics of the ground.—*D. B. V.*

177–106. Chetayev, D. N. Obratnaya zadacha teorii elektrorazvedki neprovodyashchikh plastov, vykhodyashchikh na poverknost' [The inverse problem of the theory of electrical prospecting of nonconducting

strata cropping out at the surface]: Akad. Nauk SSSR Izv. ser. geofiz., no. 1, p. 73–82, 1959.

The method developed in his previous study (see Geophys. Abs. 170–102) for the solution of the inverse boundary value problem in two-dimensional electrical exploration is applied to the case of nonconducting strata that crop out and strike parallel to the surface contours. The suggested method of analytical interpretation of the results of the surveying makes it possible to check the validity of its use. The computed topography deviates considerably from the real, owing to inconsistent assumptions made in the solution of the problem; therefore, the results must be considered doubtful.

The results of this study can be extended to solving analogous problems in the case of ore bodies that are good conductors.—*S. T. V.*

177–107. Berdichevskiy, M. N., and Zagarmistr, A. M. Voprosy interpretatsii dvustoronnikh elektricheskikh zondirovaniy dipol'nymi ustanovkami [Problems of interpretation of bilateral electric profiling by dipole arrangements]: Prikladnaya Geofizika, no. 19, p. 57–108, 1958.

This is a comprehensive discussion of dipole electric depth profiling, especially of bilateral forms. At present four basic arrangements—azimuthal, radial, parallel, and perpendicular—have been completely worked out and are being used successfully in various geologic provinces of the U.S.S.R. Each dipole arrangement is characterized by four parameters, the line AB of the feeding electrodes, line MN of the measuring electrodes, the distance R between the centers of these lines (O and Q, respectively) and the angle Θ between MN and OQ. When $\Theta=0°$ the parallel and radial arrangements become the "axial" arrangement, when $\Theta=90°$ they become the "equatorial."

Cases are still found where complex geology creates difficulties which could only be resolved by supplementary seismic surveys. In addition to the theoretical investigation of the dipole arrangements, the All-union scientific research institute of geophysical methods of exploration (VNIIG) has started an extensive program of model studies, particularly for the exploration of complex geologic forms. Of the known dipole arrangements the most convenient for practical application are the azimuthal and the equatorial. These two have deeper penetration with an electrode spacing only half as great as with the classical setup. This is important in swampy, populated, or industrial regions. Berdichevskiy and Zagarmistr especially discuss bilateral arrangements in horizontally heterogeneous media. Much space is devoted to the interpretation of the curves obtained by bilateral depth profiling over areas with inclined layers. Practical examples are given. In addition to many mathematical developments and some new formulas, the paper contains numerous graphs constructed for areas of difficult geologic conditions with the use of the different electrode arrangements.—*S. T. V.*

177–108. Shuval-Sergeyev, N. M. Vliyaniye vertikal'noy granitsy razdela dvukh sred na resul'taty izmereniy ρ_k pri dipol'nykh zondirovaniyakh [The effect of a vertical boundary between two media on the results of ρ_k measurements in dipole depth profiling]: Kazahk. Gorno-Metall. Inst., Geologiya, Gornoye delo, Metallurgiya, sbornik, v. 14, p. 203–218, 1956.

Formulas are derived and master curves computed for the effect of a vertical boundary on apparent resistivity.—*A. J. S., I. R.*

177–109. Hrdlička, L[adislav], and Pouba, Zd[aněk]. Geofysikální kontrola geologických profiloů frekvenční odporovou metodom [Geophysical control of geological profiles by the frequency resistivity method]: Univ. Carolina [Prague] Geologica, v. 1, no. 1, p. 111–130, 1955.

The frequency resistivity method, a method of determining the parameters of geological profiles with alternating current of variable frequency, is discussed in this paper. Frequencies in the range of several cycles to tens of kilocycles are used with fixed electrodes. The measured specific resistances are different for different frequencies because of the increasing skin effect produced by the higher frequencies of the alternating current impressed into the earth. The method was tested in the southern part of the Permo-Carboniferous basin of Plzeň in central Bohemia; the results obtained differed only by a few decimeters from the actual dimensions.—*A. J. S.*

177–110. Blokh, I. M., Zagarmistr, A. M., and Faradzhev, A. S. Method ekranirovannogo elektroda i opyt yego primeneniya dlya kartirovaniya ugol'nykh plastov [The screened electrode method and test of its application in the mapping of coal seams]: Razvedka i okhrana nedr, no. 10, p. 34–39, 1958.

The method of screened electrodes involves placing one current electrode in a borehole below the deposit under investigation and the second electrode on the surface of the earth either at the top of the borehole or at any distance from it. The method is especially valuable if the body has a much higher electrical resistivity than that of the surrounding materials, as is true for coal deposits, asphaltites, building media, and a few other deposits. Potential differences are measured along radii from the top of the borehole. As the potential electrodes pass over the edge of the deposit, the apparent resistivity decreases. The effect is more pronounced for horizontal strata than for inclined beds.

Laboratory results with models show good agreement with tests in boreholes. Results are most satisfactory when the resistivity of the bed is at least seven times as large as that of the imbedding materials and when the extent of the deposit is commensurate with the depth.—*S. T. V., I. R.*

177–111. Cassinis, R. Un criterio pratico di trasformazione fra diagrammi di resistività apparente ottenuti con differenti dispositivi [A practical criterion for converting between apparent resistivity diagrams obtained with different arrangements]: Annali Geofisica, v. 11, no. 3–4, p. 233–236, 1958.

A rapid approximate method is proposed for converting curves of apparent resistivity obtained with any electrode configuration into Schlumberger diagrams, or vice versa. The procedure is of practical value in correlating different sections of the diagrams when distance between potential electrodes is variable.—*D. B. V.*

177–112. Zavadskaya, T. N. O transformatsii krivykh sondirovaniya [On the transformation of curves obtained in electric profiling]: Prikladnaya Geofizika, no. 19, p. 47–56, 1958.

This article is a continuation of Al'pin's article on the same subject (see Geophys. Abs. 176–124). Zavadskaya discusses the practical conversion of the curves obtained by any of the electrode arrangements into those of another arrangement. She analyzes the effect of errors or inaccuracies in the first arrangement and "the effect" on the formulas of the new arrangement. The possi-

bility of obtaining simpler, if only approximate, formulas is also explored. The article contains several numerical tables facilitating the procedure. Zavadskaya also analyzes the geologic conditions under which a given electrode arrangement gives more accurate results and should preferably be used.—*S. T. V.*

177–113. Nepomnyashchikh, A. A. Interpretatsiya polya zaryazhennogo tela metodom sravneniy logarifmicheskikh krivykh [Interpretation of a charged-body field by the method of comparison of logarithmic curves] : Kazakh. Gorno-Metall. Inst., Geologiya, Gornoye delo, Metallurgiya, sbornik, no. 14, p. 144–160, 1956.

This is an analysis of the potential field of a charged ore body enclosed in a medium of different conductivity. The electrodynamic potential is developed, and the horizontal components of the anomalous field intensity are determined. Differentiation of these two components leads to an anomalous potential for the charged body. Expressions are given in a similar form for the gravitational potential of the ore body, and analogous results are presented for the electric potential of a body placed in a constant current field. The three potentials are interrelated. The formulas lead to logarithmic master charts for two-dimensional bodies, confirming observations with fair reliability.—*A. J. S., I. R.*

177–114. Nedyalkov, I. P. Ustroystvo dlya interpretirovaniya elektricheskikh anomaliy provodyashchikh rudnykh tel [Method for interpretation of electrical anomalies of conducting ore bodies] : Bolgar. Akad. Nauk Doklady, v. 11, no. 3, p. 177–180, 1958.

A method is described for the interpretation of the electrical anomalies of conducting ore bodies (see Geophys. Abs. 176–95) by the aid of an electrolytic tank model. An electronic potential comparator, designed as a combination of an electronic commutator and a high inertia electrodynamical voltmeter is proposed for substantially accelerating the interpretation. The method is suitable also for interpretation of anomalies obtained by the charged-body method, and can be adjusted for interpretations of anomalies obtained from an uneven terrain over the ore body explored.—*A. J. S.*

177–115. Nedyalkov, I. P. Ustroystvo dlya interpretirovaniya struktury sloistykh sred po elektrometricheskim dannym [Device for interpretation of the structure of layered media from electrical survey data] : Bolgar. Akad. Nauk Doklady, v. 11, no. 4, p. 263–266, 1958.

An electrical device is described which permits rapid interpretation of the results of resistivity surveys ("vertical electrical sounding", "lateral electrical sounding," and "horizontal electrical profiling") for horizontal structures.—*D. B. V.*

177–116. Gel'bukh, L. A. Raschet ustanovivshegosya polya vysvannoy polyarizatsii tel, imeyushchikh formu vytyanutogo i szhatogo sferoida [Computation of the equilibrium field produced by the induced polarization of bodies having the shape of an elongated and an oblate spheroid] : Akad. Nauk SSSR Izv. ser. geofiz., no. 10, p. 1192–1201, 1958.

The problem of the potential value and the distribution of electrical moment caused by induced polarization has been solved for very simple geometrical bodies such as a sphere and an ellipsoid. In this article the problem is solved

for elongated or oblate spheroids placed in a homogeneous electric field, the conductivity of the spheroid and of the surrounding medium being known. The problem is solved by introducing spheroidal coordinates and Legendre functions, and the solution is based on the analysis of the Laplace equation which must be satisfied by the solutions of the electrical potential. The corresponding expressions are given for the points of the spheroid and for the external field. The article is purely mathematical.—*S. T. V.*

177–117. Komarov, V. A., and Ryss, Yu. S. Nekotoryye rezul'taty primeneniya metoda vyzvannoy polyarizatsii na polimetallicheskikh mestorozhdeniyakh Rudnogo Altaya [Some results of the application of the method of induced polarization on polymetallic deposits of the Rudnyy Altay]: Razvedka i okhrana nedr, no. 2, p. 31–36, 1959.

The method of induced polarization was applied in a survey of ore deposits in the Zmeynsgorsk and the Zyryanovsk regions in the Rudnyy Altay of the U.S.S.R., which are rich in sphalerite, galena, pyrite, and chalcopyrite. The current electrodes in the customary four-electrode arrangement were spaced 100 to 1,500 m apart, with the potential electrodes from a tenth to a fiftieth of these values. A current of from 5 to 10 amp was fed into the earth for a period of from 2 to 5 min; the potentials during this period furnished the resistivity. After the current was cut off, the decay potentials were read every half-sec. The effects are greatest over thin sedimentary layers, large volumes of ore, and richest ore, as usually confirmed by drilling. However, some conclusions were found to be erroneous. The method is promising but needs further study.—*S.T.V., I.R.*

177–118. Tarasov, G. A. Vliyaniye nanosov v metode estestvennogo elektricheskogo polya [The effect of alluvia on the method of natural electric field]: Leningrad Univ. Uchenyye Zapiski, no. 249, ser. fiz. i geol. nauk, no. 10, p. 157–169, 1958.

Continuing the studies of Novozhilova (Geophys. Abs. 171–115) and Semenov (Geophys. Abs. 171–118), Tarasov analyses the natural or spontaneous potential method of prospecting for metallic ores, and presents theoretical computations of the effect of alluvial layers. He concludes that electrically conducting alluvium produces an increase in the width and decrease in the intensity of the measured anomaly, whereas poorly conducting alluvium decreases the width and increases the intensity of the anomaly, as compared with the anomaly observed over an ore body in a homogeneous medium. Also the depth of disturbing bodies covered by alluvium will be either increased or decreased depending upon the ratio of the resistivity of the alluvium to that of the formations surrounding the body.—*S. T. V.*

177–119. Overholt, K. J. The field of a D. C. element, applied to conductively energized pencilformed ore bodies: Geophys. Prosp., v. 7, no. 1, p. 64–76, 1959.

The electric and magnetic field of a direct-current element, embedded in a space consisting of two halfspaces differing in conductivity and permeability, is given in a form suitable for integration along a cable. From these formulae, is obtained the field when one end of a D. C. cable is grounded in a highly conducting, pencilformed ore body, considered as a line electrode with uniform current leakage. Numerical examples are given for a horizontal line electrode.

The formulae should be useful as a first approximation to the A. C. case. The validity of this is shortly discussed.—*Author's abstract*

177–120. Loeb, J. Impédances et matrices caractéristiques en prospection électromagnétique [Characteristic impedances and matrices in electromagnetic prospecting]: Geophys. Prosp., v. 7, no. 1, p. 77–90, 1959.

An analogy established between the propagation of an electromagnetic field in a horizontally stratified conductive medium and that of currents in a linear electric network makes it possible to determine in which case measurements made at the surface can provide information about the properties of deeper layers. First established for plane waves, the analogy is extended to any system of waves described by means of the coordinates $x_1=z$, x_2, x_3, where the surfaces z=constant are the planes parallel to the stratification. For the system of waves created by a point source, the solution can be expressed as a sum or integral of different modes. For each of these modes, a bilinear relationship can be written from which can be calculated the characteristic impedance z and the "phase constant" Γ ($\Gamma=2\pi D/\lambda$, where D=layer thickness and λ= wavelength). A general solution is given.—*D. B. V.*

177–121. Netunakhin, V. I. Opredeleniye sdviga gornykh porod metodami elektrorazvedki [Determination of rock dislocation by electric prospecting methods]: Kazakh. Gorno-Metall. Inst., Geologiya, Gornoye delo, Metallurgiya, sbornik, v. 14, p. 273–276, 1956.

In studies of rock deformation caused by mining excavations, or of the phenomena of sagging, karst, and earth creep it is often necessary to determine a displacement of underground layers along a vertical line. The charged-body method is suggested by Netunakhin. Small charged metal bodies are put into a number of uncased boreholes in the area investigated, several in each hole at equal intervals, each body having an insulated wire leading to the surface; then the hole is filled and plugged. These charged metal bodies are displaced along with the rock layers, and the amount of displacement can be determined at the surface by the displacement of equipotential lines of the buried electrodes.—*A. J. S.*

177–122. Norris, S. E., and Spicer, H. C[ecil]. Geological and geophysical study of preglacial Teays Valley in west-central Ohio: U.S. Geol. Survey Water-Supply Paper, no. 1460–E, p. 199–232, 1958.

As a part of a program of water resources investigation, an earth-resistivity survey was made in Madison, Champaign, and Clark Counties, Ohio, to trace the course of the buried Tertiary Teays Valley and to obtain data on the character of the unconsolidated deposits and the depth to bedrock in the area. Results of the survey, followed by test drilling, showed that the extensive lacustrine clays and sand deposits comprising the bulk of the valley fill are not an important source of water. Moreover, in most of the area the lacustrine deposits overlie Ordovician shales which are also a poor source of water. The information revealed by the survey should prevent future economic losses caused by drilling in unfavorable valley fill. The need for additional prospecting was indicated downstream from Urbana, where the Teays River was dammed by an early glacier and where the lacustrine clays and sands can be expected to give way to glacial deposits more productive of water such as buried outwash sands and gravels.—*V. S. N.*

177–123. Milošević, Ljubomir. Određivanje podzemnik vodenih tokova i pécina geoelektričnim metodama u karstu u okolini Trebinja [Determination of ground water flows and caverns by geoelectrical methods in the Karst in the vicinity of Trebinje (with English summary)]: [Serbia] Zavod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 337–346, 1957.

An electrical resistivity mapping and profiling program was carried out in 1956 in the karst area near Trebinje, Serbia, in order to determine the direction of ground water flow and to locate caverns. Measurements were made over the Vjetrenica cavern, over the Dražin Do swallow-hole, and over Estavela Šumet on Mokro Polje. The first two were found to be dry, the third to be filled with water. The geoelectrical method was found to be entirely suitable for mapping in this not-too-rough karst terrain.—*D. B. V.*

177–124. Ristić, V., and Djordjović, V. Geofizička ispitivanja na magnezitima Goleša [Geophysical investigation on the Goleš magnesite (with English summary)]: [Serbia] Zavod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 353–360, 1957.

Magnesite veins in the Goleš peridotite massif in Serbia were investigated by the potential-drop-ratio method, as the nearly 1:4 ratio of specific resistivities, sharp contacts, steep dip, and great extent of the veins were favorable conditions for use of this method. The results located magnesite veins beneath the soil cover and within deeper layers. Potential-drop-ratio curves are given. Exact correlation of the numerous parallel and branching veins was difficult, but interpretation was facilitated by the density of the net of profiles.—*D. B. V.*

177–125. Milanović, Božidar, and Damnjanović, Konstantin. Prikaz geofizičkih ispitivanja na ležištima silikatnih ruda gvozđa u jugozapadnoj Makedoniji [Use of geophysical investigations on silicate iron ore deposits in southwestern Macedonia (with English summary)]: [Serbia] Zavod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 347–352, 1957.

The results of field investigations in southwestern Macedonia show that iron silicate ore deposits can be investigated by means of magnetic surveys, and if the ore is limonitized, by the self-potential and resistivity methods. A combination of all three is most successful.—*D. B. V.*

Mladenović, Milan M. Surface geothermal exploration in the Kursumliska Banja area. See Geophys. Abs. 177–225.

177–126. Rao, M. B. Ramachandra, and Rao, M. N. Suryanarayana. Geophysical exploration for ground water in crystalline rocks, *in* Proceedings of the symposium on ground water: [India] Central Board Geophysics Pub., no. 4, p. 196–204, 1958.

In regions of crystalline rocks, favorable sources of ground water are usually found in those areas having a thick mantle of weathered rock. These areas may be detected in an electrical survey by the comparatively lower resistivity values recorded from the weathered crystalline rocks. Surveys of granite areas in India have shown that where several such anomalies are found, preference for locating borewells should be given on the basis of topography; the anomalies on low flanks of ridges or in lower valley flats usually prove to be more

favorable sources of water. From 1946–48, electrical resistivity surveys were made at seven localities in India; the surveys at Malur, Kolar district, and Sirigere, Chitaldrug district, are discussed briefly.—*V. S. N.*

177–127, Kondo, Chuzo. Results of electrical prospecting and well-boring at at the Oshuku Hot Springs in Iwate Prefecture: Jour. Geography [Tokyo], v. 67, no. 4, p. 19–26, 1958.

Self-potential surveys were made in the Oshuku hot-springs area in Iwate Prefecture, Japan, to locate new hot-water veins and structural lines which could not be detected by surface geological exploration. The hot-water veins appeared in the survey as negative anomalies with maximum gradients of 2.8 mv per m. A successful well bored at a site selected from the results of the survey intersected a new vein at 71.5 m depth. The maximum temperature of the borehole was 30°C to a depth of 70 m; a sudden rise in temperature began at 71.1 m to reach a maximum of 56.5°C at a depth of 79.3 m. The flow of water from this well had no effect upon the flow from preexisting hot springs.—*V. S. N.*

ELECTRICAL LOGGING

177–128. Mann, F. H. More precise resistivity log analysis: Canadian Oil and Gas Industries, v. 12, no. 3, p. 56–63, 1959.

Water saturations in the uncontaminated and invaded zones of a reservoir formation surrounding a borehole can be found more accurately from measurements of the diameters of the filtra-flushed and "low" zones than from the resistivities of the various zones. For complete analysis, it is necessary to have five logs of which only two suitable ones are currently available: the 40-inch Induction Log and the Laterolog "7". The three additional logs required should be insensitive to borehole wall conditions, should have a resolution of 6 ft or less, and their responses should be expressable in a simple manner and should be as dissimilar as possible to those of the present induction logs and laterologs and to each other. Various assumptions are proposed to take the place of the three missing logs and thus make the method immediately usable; these assumptions lessen the emphasis placed on resistivity formation factor versus porosity correlation.—*V. S. N.*

177–129. Glanville, C. R. Laboratory study indicates significant effect of pressure on resistivity of reservoir rock: Jour. Petroleum Technology, v. 11, no. 4, p. 20–26, 1959.

The effect of overburden and of fluid pressure in reservoir rock has generally been ignored in interpreting resistivity logs. Laboratory tests were made on sandstone, limestone, and dolomite in order to determine the manner in which changes in reservoir stress are reflected in the resistivity. The net effect of overburden and fluid pressure on the resistivity of reservoir rock is variable; it depends on depth (or degree of stress), porosity, texture, and degree of water saturation. It is probably significant in formations of medium to low porosity and should be considered in quantitative interpretation of their resistivity logs. The formation resistivity factor is increased by reservoir stress. This is probably a function in general of porosity and is greater in rocks of low porosity. Considering the trend toward exploitation of deeper reservoirs of low porosity, more resistivity studies of pressurized rocks are in order.—*J. W. C.*

177–130. Gray, D. A. Correlation of strata in water-filled boreholes by electrical resistivity methods *in* Proceeding of the symposium on ground water: [India] Central Board Geophysics Pub., no. 4, p. 205–213, 1958.

This is essentially the same as the report published in Bull. 15 of the Geological Survey of Great Britain, p. 85–95, 1958. (See Geophys. Abs. 176–126.)—*V. S. N.*

177–131. Arkharov, L. V., and Agamaliyev, G. M. O svyazi mezhdu koeffitsiyentami poristosti i neftenasyshchennosti plasta i yego udelnym elektricheskim soprotivleniyem [On the relation between the coefficient of porosity and the oil saturation of a stratum and its specific electrical resistance]: Ministerstvo Vysshego Obrazovaniya SSSR Izv. Vyssh. Ucheb. Zavedeniy, Neft i gaz, no. 4, p. 7–9, 1959.

The importance of determination of reservoir properties by resistivity logs is emphasized, and the results of laboratory experiments designed to elucidate this subject are reviewed. The physical properties of more than a hundred specimens from the Baku area were determined and compared with logging data. A coefficient (R) is introduced, which is the ratio of the specific resistance of a bed in which the pores are completely filled with water to the specific resistance of the water. This parameter is equivalent to formation factor. A graph is presented in which the coefficient R is related to specific surface and to porosity. Another graph shows a relationship of the oil saturation coefficient to porosity and resistivity.—*J. W. C.*

177–132. Graham, John W. Reverse-wetting logging: Jour. Petroleum Technology, v. 10, no. 12, p. 304–309, 1958.

This paper treats the problem of recognition of hydrocarbons where their presence on the electric log is obscured because of small thickness of the pay zone, invasion of the formation, high shale content, or high water content of the oil-bearing stratum. Core samples were flooded with a brine containing a chemical, called a reverse-wetting agent, that renders sand and clay surfaces preferentially oil wet. After treatment, very little change in resistivity was observed in cores that contained only water, but increases in resistivity of 100 to 200 percent marked cores that contained residual oil. For all practical purposes the resistivity increase is attained almost instantly after introduction of the agent. The limited experiments peformed indicate that time, temperature, and type of hydrocarbon do not influence this resistivity increase.

Field tests in California and Texas gave positive results. Short-spacing logs made after reverse wetting exhibited marked increases in resistivity opposite oil-bearing zones. The reverse-wetting logging technique may be particularly valuable in identifying hydrocarbons in thin beds, in highly invaded formations, in shaly formations, and in formations that contain high water saturations.—*J. W. C.*

177–133. Colombo, U., Salimbeni, G., Sironi, G., and Veneziani, I. Differential electric log: Geophys. Prosp., v. 7, no. 1, 91–118, 1959.

A new logging method, which makes use of specific chemical reactions to locate petroleum or other minerals has been developed. The method has been named "Differential Electric Log" (CED).

In this paper the application to the CED method of redox (reduction/oxidation) reactions is discussed. A series of organic oxidants was found, capable of undergoing reaction with crude oil, sulphur, mineral sulphides, lignite. A small amount of an oxidant of this type is added to the drilling fluid and pumped into the borehole where reaction takes place in correspondence with layers containing oxidizable minerals. Two *SP* logs, recorded before and after the oxidation, are compared and the presence of such minerals is thus detected.

A theoretical hypothesis explaining the mechanism of the potential change due to the chemical reaction is proposed both in the case of electronically conducting and nonconducting minerals. The influence of redox potential on *SP* is discussed.

The results of laboratory experiments on several different oxidizable ores and those of field tests performed on pyrite, lignite, and oil wells are reported on and discussed on the basis of the theoretical hypothesis proposed.—*Authors' abstract*

177–134. Aksel'rod, S. M., and Chernyak, G. Ya. Dielektricheskiy karotazh skvazhin [The dielectric logging of drill holes] : Razvedka i okhrana nedr, no. 1, p. 28–31, 1959.

Until the present time the dielectric properties have not been used in well logging, probably owing to the fact that with existing instruments these properties have not been investigated. An experimental apparatus adapted to high-frequency measurements was recently constructed by a research laboratory of the "Azneftegeofizika" of the Azerbaijan S.S.R., and tested in the field. The apparatus lowered into the drill hole consists of a high-frequency oscillator and a tuned circuit. Changes in the dielectric constant and in the dielectric losses of the formations affect the tuning of the circuit and can be measured at the surface. The diagrams reproduced in the article show a clear differentiation of the strata pierced by the hole. It is hoped that this new method of logging will be very effective in solving problems such as the location of aquifers, of the water-oil interface, and of coal seams.—*S. T. V.*

177–135. Shapiro, D. A. Nekotoryye voprosy teorii diffusionno-adsorbtsionnykh (membrannykh) potentsialov v burovykh skvazhinakh [Certain questions on the theory of diffusion-adsorption (membrane) potentials in drill holes] : Prikladnaya Geofizika, no. 19, p. 129–169, 1958.

Problems concerning the determination of the electromotive force appearing at the boundaries between different rocks and their contact surface with the drilling mud are discussed. This electromotive force is determined by the properties of the rocks as well as by the mineralization of the water contact with the rocks. A differential equation is derived, based on Nernst's equation, for the diffusion-adsorption electromotive force. In the case of equilibrium between two media, characterized by the absence of diffusion, the total concentration of salt becomes higher in the more dispersed medium. If a monovalent salt is present in the solution the geometric mean of the concentrations of free anions and cations is a constant, equal to the concentration c_o of the free solution which is in equilibrium with the given medium or with the system of media. An equation is also derived which determines the coefficient of surface conductivity. At the contact between a free solution having a concentration c_o and a medium characterized by the total sum λ of the parameters defining their lithological characteristics, a boundary potentional E_{bp} (c_o, λ) appears.

If two media saturated with fluids of different mineralization remain in contact for a longer time, a leached-out layer is formed within the less permeable medium. For this layer the equilibrium conditions with the more permeable medium are fulfilled and a boundary potential is generated. Adjoining the leached-out layer a layer of weakly permeable medium with a varying concentration of ions is formed; this layer produces a "diffusion emf." The diffusion-adsorption electromotive force at the boundary of these media is equal to the sum of the boundary electromotive force and the diffusion electromotive force. An expression is also given for the value of the spontaneous potential.—*S. T. V.*

177–136. Grujić, Nikola, and Damnjanović, Konstantin. Mogućnost određivanja krivih sondiranja primenom metode OPP iz krivih prividnog otpora [Possibility of determining *PDR* logging curves from apparent resistivity curves (with English summary)]: [Serbia] Zavod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 293–305, 1957.

A method is shown for calculating potential-drop-ratio (*PDR*) logging curves from logs of apparent resistivity for a horizontally stratified ground. The potential value at any potential electrode of a *PDR* electrode arrangement can be calculated using only one potential and two current electrodes; as this is one of the apparent resistivity logging arrangements, the *PDR* potential values can be obtained by potential measurements made with the apparent resistivity method, and the *PDR* curve can be calculated from the apparent resistivity curve.

Equations are given relating *PDR* and apparent resistivity curve for four- and five-electrode arrangements. It is necessary to know several apparent resistivity curves, obtained by Schlumberger or Wenner methods. The general relationship between the Schlumberger ρ_1^0 curve and any other apparent resistivity curve $\rho^m/_1$ is given.—*D. B. V.*

177–137. Sarkisov, I. K. Mnogoelektrodnyi gradient-zond dlya kompleksnogo issledovaniya skvazhin [Multielectrode gradient sonde for integrated investigation of wells]: Ministerstvo Vysshego Obrazovaniya SSSR Izv. Vyssh. Ucheb. Zavedeniy, Neft i gaz, no. 9, p. 11–16, 1958.

The simultaneous use of several sondes in well logging leads to error owing to mutual interference. The instrumental requirements for reduction of such error are: minimum interaction of the sondes, reduction to a minimum of the parts of the well not measured, and least possible number of electrodes. An integrated sonde with two sections is proposed. Each part is equipped with an electrode on the sonde and one on the surface. The total length of the sonde is 9 m, and the two electrodes appear to be about 3.5 m apart.—*J. W. C.*

177–138. Aksin, Vladimir, and Nedeljković, Vlastimir. Primeri primene elektrokarotažnih ispitivanja pri istraživanju nafte i gasa u Vojvodini [Examples of the application of electrical logging in exploration for oil and gas in Vojvodina (with English summary)]: [Serbia] Zavod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 371–381, 1957.

Segments of electrical logs from the Je–23 borehole in the Jermenovci oil field in the Vojvodina region of Yugoslavia are discussed, and a geological cross section and contour map of the Miocene-Pliocene contact in the Velike Grede gas structure are drawn on the basis of logging data.—*D. B. V.*

177–139. Zav'yalov, V. A. O svyazi elektricheskoy kharakteristiki razreza Domanikovykh otlozheniy s litologo-geokhimicheskimi osobennostyami poslednego [On the relationship of the electrical characteristics of a section of the Domanik sediments and the lithogeochemical features of the series]: Akad. Nauk SSSR Doklady, v. 121, no. 4, p. 693–696, 1958.

The correlation of apparent resistivity with lithology was investigated in this study of 70 core samples through the bituminous Domanik series (Upper Devonian) in the Bashkir A.S.S.R. One graph shows resistivity and *SP* logging diagrams for the formation, and another the relationship between apparent resistivity, organic carbon content, and carbon dioxide content for clay, clayey marl, marl, clayey limestone, and limestone layers. Tables show the percentage of calcium carbonate and carbon dioxide, and the relationship between resistivity value, which increases slowly to clayey limestone (270–1,300 ohm-m), then abruptly to limestone (1,300–2,550 ohm-m), and organic content, which has its maximum of 108.5 kg per m^3 in clayey marl, diminishes to almost 1.6 kg per m^3 in limestone. It is concluded that lithologic facies and distribution of organic carbon can be mapped without coring, by means of electrical logging data.—*A. J. S.*

177–140. Pernikov, M. Sh. Opredeleniye poristosti terrigennykh otlozheniy razrezov Bashkirii po diagrammam *PS* [The determination of porosity of continental deposits in sections in Bashkiria from *SP* diagrams]: Prikladnaya Geofizika, no. 17, p. 293–305, 1957.

Numerous spontaneous potential (*SP*) curves measured in different parts of the Bashkir A.S.S.R. are reproduced; these show that a close correlation exists between the value of the spontaneous potential and the porosity of the formations pierced by the drill hole. This is not the usual case, but a specific geologic characteristic of the Bashkir A.S.S.R. where the *SP* diagram is determined primarily by the diffusion process and where filtration and oxidation-deoxidation are negligible. It is ordinarily assumed that other disturbing effects (such as eddy currents, or galvanic corrosion) can be neglected. Pernikov recommends measuring the *SP* curve over known formations for use as a datum line. Many practical examples are given.—*S. T. V.*

ELECTRICAL PROPERTIES

177–141. Volland, Hans. Über ein dem elektrisch leitfähigen Erdinnern Äquivalentes Schalenmodell der Erde [On a shell model of the earth, equivalent to the electrical conductivity of its interior]: Gerlands Beitr. Geophysik, v. 68, no. 1, p. 31–36, 1959.

For the currents induced in the earth's interior by geomagnetic variations with periods smaller than one day, the earth's conducting core is equivalent to a conducting shell, whose conductivity is equal to that of the core multiplied by the penetration depth of the disturbance. Its distance from the earth's center is the radius of the core reduced by half of the penetration depth.—*Author's summary*

177–142. Ananyan, A. A. Zavisimost' elektroprovodnosti merzlykh gornykh porod ot vlazhnosti [Dependence of the electrical conductivity of

frozen rocks on saturation]: Akad. Nauk SSSR Izv. ser. geofiz., no. 12, p. 1504–1509, 1958.

The electrical conductivity in finely dispersed frozen rocks is governed by the progressive advance of the not yet frozen portion of the water. The electrical conductivity of such rocks is determined by the phase relations of the water. The smaller the amount of ice and the larger the amount of unfrozen water, the higher the electrical conductivity. The conductivity of the frozen rocks reaches its maximum when the moisture content approaches the lower limit of plasticity.—*S. T. V.*

177–143. Fritsch, Volker. Der Eifluss der geoelektrischen Bodeninhomogenität auf die Blitzgefährdung [The effect of geoelectric inhomogeneity on lightning risk]: Geofisica Pura e Appl., v. 41, p. 125–132, 1958.

Austrian statistics show that the places struck by lightning are distributed irregularly over the country. They are observed most frequently in areas of inhomogeneous ground. Laboratory experiments showed the same effect. The author develops a hypothesis for the explanation of this phenomenon. (See also Geophys. Abs. 169–126, 176–134.)—*Author's summary*

EXPLORATION SUMMARIES AND STATISTICS

177–144. Routledge, N. O. Russian contribution to the International Geophysical Year: Nature, v. 183, no. 4668, p. 1087–1088, 1959.

Eighty-six scientific Russian institutions have been participating in the IGY. Particular attention has been given to the Antarctic, with three stations (at Mirny near Haswell Island, on the coast; and near the south magnetic pole and pole of inaccessibility, both more than 1,400 km inland). Activity in the Arctic concerned drifting ice stations mainly. The nonmagnetic ship Zarya and oceanographic ship Vityaz made extensive voyages in the Atlantic and Pacific, respectively. Three satellites were put into orbit and 59 rockets were fired, one reaching a height of 473 km. Observations were made of zodiacal light in Egypt and in the Kazakh S.S.R.; of meteors at 8 radar stations in the U.S.S.R.; and of earth currents in the Arctic, Antarctic, and middle latitudes. Seismic stations included 6 in the Artctic and 2 in the Antarctic. Microseisms were studied by many stations in the U.S.S.R. Crustal structure in the Kamchatka-Kurile region was studied extensively. Chief results of each of these studies are outlined very briefly.—*D. B. V.*

177–145. Garland, G. D. Current research in geophysics in Canada: Royal Astron. Soc. Geophys. Jour., v. 2, no. 1, p. 45–50, 1959.

This is an outline of recent developments in geophysics in Canada that appear most promising in furthering our understanding of the behavior of the earth's crust and of the deeper interior. Work has been done in seismology, gravity, geomagnetism, radioactive age determinations, isotope geology, heat flow, and physical properties of glaciers.—*D. B. V.*

177–146. Wilson, J. Tuzo. Geophysical institutes of the U.S.S.R. and of the People's Republic of China: Am. Geophys. Union Trans., v. 40, no. 1, p. 3–24, 1959.

This is a brief account of the organization, personnel, equipment, and work of various institutes in the U.S.S.R. and China visited by Professor Wilson in the summer of 1958.—*D. B. V.*

177–147. Smellie, D. W. Mining exploration, *in* Mining in Canada, pt. 4—Technology: Canadian Mining Jour., v. 80, no. 2, p. 155–158, 1959.

A brief review of mineral exploration in Canada during 1958 including technological developments in exploration geophysics (both airborne and ground), geochemistry, and exploration geology.—*V. S. N.*

177–148. King, Anthony J. A geophysical investigation of auriferous reefs in southern Tanganyika: Tanganyika Geol. Survey Recs., v. 5, p. 60–62, 1955 (1958).

Resistivity and magnetic surveys were made in the area of the central Lupa goldfield in southern Tanganyika to delineate a possible southern extension of quartz reefs occupying shears in Archean granite and bearing uneconomic quantities of sulfides and some gold. The surveys obtained evidence of a southward extension of the reefs with a probable swing to the southeast, which explained the failure of trenching to discover the extension.—*V. S. N.*

177–149. Cantos Figuerola, José. La geofísica y el petróleo [Geophysics and petroleum]: Minería y Metalurgia, v. 19, no. 214, p. 57–60, 1959.

The status of geophysical prospecting in Spain is discussed. A program is outlined, calling for gravity profiles in the Ebro valley, the Guadalajara-Cuenca-Albacete region, the Guadalquivir valley, and Castilla la Vieja. Extensive gravity profiles in Spanish Africa are also recommended.—*J. W. C.*

177–150. Aranđelović, Dušan. Osvrt na dosadašnja geofizička ispitivanja u Banatu [Review of geophysical investigations up to the present in Banat (with Engilsh summary)]: [Serbia] Zavod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 361–370, 1957.

Banat province in northeastern Yugoslavia is a broad plain, forming the southeastern part of the Pannonian Basin, underlain by Pliocene and Miocene sediments. Conditions are favorable for use of most geophysical methods. The gravity map (Bouguer) shows a general north-south trend of numerous local anomalies of relatively small extent (max 50 mgal), reflecting basement relief; there is no regional gravity effect. The magnetic anomalies (vertical component) also trend chiefly north-south, but for the most part do not coincide with the gravimetric anomalies. Two large highs (max 800 γ) occur, one from Banatski Sololac to Seleus, the other in the Centa-Kovacica-Ovca area. The magnetic anomalies express the effect of qualitiative petrographic changes in basement rock, not structure. Seismic exploration yielded many reflections of good quality; those from the basement are distinctive and obvious. Thickness of the weathered layer varies from a few to 50 m; velocity is more or less constant throughout the province; and the seismic results are in good agreement with the gravimetric in most of the area explored. Most recently, electrical resistivity surveys were attempted, with satisfactory results.—*D. B. V.*

177–151. Kazakov, M. P., Charygin, M. M., Bykov, R. I., Vasil'yev, Yu. M., Znamenskiy, V. V., and Seyful'-Mulyukov, R. B. Tektonicheskoye stroyeniye i istoriya razvitiya Prikaspiyskoy vpadiny i smezhnykh oblastey v svyazi s voprosami neftegazonosnosti [Tectonic structure and history of development of the Pri-Caspian depression and adjacent districts in connection with problems of oil- and gas-bearing capability]: Ministerstvo Vysshego Obrazovaniya SSSR, Gostoptekhizdat, 402 p., 1958.

This book is a comprehensive review of the geology of the Pri-Caspian depression, one of the most actively prospected oil-bearing structures of the U.S.S.R. today. The first chapter traces the history of the study of the region. In spite of an inhospitable climate and a Pliocene-Pleistocene cover, the area has been under study since the eighteenth century. Active investigations, however, began in 1911 when the first oil well was brought in. The second chapter is a rather detailed discussion of the stratigraphy, emphasizing facies distribution and thickness.

The third chapter deals with the results of geophysical investigations in the area. Geophysical methods were first introduced in 1925, but systematic use began only in 1933 and general use dates from 1946. Gravity and seismic methods have been most extensively employed and the results of their use are described. Gravity surveying has been applied with success regionally, and to a lesser extent in revealing local structures. Salt domes in particular have been detected by this method. By 1955 almost all the Pri-Caspian depression had been covered by gravity survey. The Caspian Sea has also been surveyed by this method. A gravity map of the region is presented. Seismic investigations in the Pri-Caspian depression have been continuous with ever increasing volume since 1930. The principal method is that of reflection; the refraction method is used only for special purposes. Reflection shooting is used for detailed outlining of structures in preparation for exploratory drilling. Several seismic maps and profiles are given.

The fourth chapter is a review of the structural history of the depression; several maps are presented that reflect various ideas on this subject. The fifth chapter deals with the oil and gas prospects of the depression. Twenty-three zones are discussed and evaluated. A bibliography of 349 items and an appendix of 39 maps are included.—*J. W. C.*

177–152. Fotiadi, E. E. Geologicheskoye stroyeniye Russkoy Platformy po dannym regional'nykh geofizicheskikh issledovaniy i opornogo bureniya [The geologic structure of the Russian platform according to the results of regional geophysical investigations as well as the data of support drilling]: Vses. nauchno-issled. inst. razved. geofiziki Trudy, no. 4, p. 1–244, 1958.

The abundant material obtained in geophysical and geological investigations combined with exploratory drilling on the Russian platform is generalized and analyzed. A detailed description is given of the geological structure of the surface of the crystalline basement, based on an analysis of the geological interpretations that have been made of geophysical surveys in different parts of this area. Basic information is given on physical properties of the rocks, particularly density and magnetic susceptibility. The magnetic anomalies can be produced by heterogeneities in the Precambrian basement, by undulations of its relief, and by tectonic dislocations within it.

Procedures of quantitative interpretations of regional gravitational and magnetic anomalies are shown and discussed. Detailed suggestions as to further geological studies of the Russian platform are given. A bibliography of 392 titles is given, and a special album containing typical geophysical curves, geological profiles and other illustrative material, is appended.—*S. T. V.*

177–153. Kailasam, L. N. Application of geophysical methods to ground water problems in the Purna and Narmada Basins, *in* Proceedings of the

symposium on ground water: [India] Central Board Geophysics Pub., no. 4, p. 224–241, 1958.

This is a detailed report on geophysical surveys in India in the Purna River basin between long 76°15′ and 77°55′ E. and lat 20°45′ and 21°30′ N., and in the Narmada River basin for about 200 miles between Harda on the west to Jabalpur on the east. The resistivity survey of the Purna alluvial tract was made to trace variations of salinity of the ground water from the fresh-water belt in the north to the saline tract in the south, as well as within the saline tract, that would lead to location of portable water; to study the variation of salinity with depth and the nature of the underlying beds; and to determine the thickness of the aquifers where possible. Resistivity and seismic surveys were made in the Narmada basin to determine the thickness of the alluvium and the nature of the underlying rocks for the purpose of locating suitable tube-well sites.—*V. S. N.*

177–154. Ahmad, Mioduddin, and Thirlaway, H. I. S. The application of integrated geophysical surveys for estimating ground water resources in the mountain valleys of West Pakistan: Pakistan Jour. Sci., v. 10, no. 5, p. 211–226, 1958.

This paper describes the effective use of results from gravity and seismic surveys supplemented by a few test bores (2 per 150 sq. miles) in estimating ground-water resources in the mountain valleys of West Pakistan. The structure, origin, and alluvial fill of the valleys were determined at a cost considerably below that of exploratory drilling alone. Principles, techniques, and limitations of the geophysical methods are discussed. Details of practical application will be published later.—*V. S. N.*

177–155. Wiebenga, W. A. Exploration geophysics applied to the dolerites of Tasmania *in* Dolerite—A symposium: Hobart, Tasmania University, Department of Geology, p. 170–183, 1958.

The seismic refraction method of exploration has been used in Tasmania to determine the thickness of weathered dolerite and the presence of joints, fractures, shear zones, and veins of calcite or zeolite in dolerite. It is proposed to use seismic reflection to determine the thickness of dolerite overyling a sedimentary succession in the Great Lake North area. Magnetic methods are useful in accurate determination of dolerite-sandstone contacts; weathered shear zones are commonly indicated by minima in the vertical magnetic profile. Micromagnetics may yield interesting results in the Tasmanian dolerites, but this method is probably of not great exploratory value. Electrical resistivity traverses can indicate clearly the presence of shear zones.—*Symposium editor's abstract.*

GENERAL

177–156. Oil and Gas Journal. Exploration, *in* Petroleum Panorama: Oil and Gas Jour., v. 57, no. 5, p. B–11–B–32, 1959.

World Oil. Oil discovery techniques, *in* A century of oil, chapter 2: World Oil, v. 148, no. 1, p. 148–158, 1959.

These two articles are a historical review of the technological progress made in oil discovery techniques in the last 100 years. They include discussion of improvements in geologic methods; the development of logging techniques and such geophysical methods as the gravity, airborne and ground magnetic, and

seismic surveys; the worldwide extent of the search for oil; and oil reserves for the future.—*V. S. N.*

177–157. García Siñeriz, José. Los métodos modernos para la investigación del petróleo. [Modern methods for the investigation of petroleum]: Minería y Metalurgia, v. 19, no. 214, p. 49–52, 1959.

García Siñeriz reviews briefly the gravity, seismic, electrical, radioactive, and aeromagnetic methods of explorations.—*J. W. C.*

177–158. Pakiser, L[ouis] C. Geophysical exploration (Petroleum exploration in the United States, Chapter 3), *in* Petroleum exploration and research in the United States and a review of world supply, 1957, Economic Commission Asia Far East (ECAFE) symposium on development of petroleum resources of Asia and Far East Contr., U.S. Dept. Interior, Bur. Mines and Geol. Survey, p. 9–18, 1958.

This paper discusses the increased use of the seismograph in geophysical exploration for oil since World War II and recent improvements in the seismic reflection method, the gravity meter, and the airborne magnetometer. The gravity and magnetic methods, primarily used for reconnaissance surveys, will probably be of relatively greater importance than the seismic methods in exploring for oil in the Far East.—*V. S. N.*

177–159. Roberts, Albert E., Maher, John C., and Bunker, Carl M. Subsurface stratigraphic tools and techniques. (Petroleum exploration in the United States, Chapter 5) *in* Petroleum exploration and research in the United States and a review of world supply, 1957, Economic Commission Asia Far East (ECAFE) symposium on development of petroleum resources of Asia and the Far East Contr., U.S. Dept. Interior, Bur. Mines and Geol. Survey, p. 23–44, 1958.

This paper discusses some of the more important subsurface stratigraphic tools and techniques used in the search for oil and gas, including electrical, radioactivity, and sample logging or their modifications, and micropaleontology. A selected bibliography is included.—*V. S. N.*

177–160. Nepomnyashchikh, A. O. O vozmozhnosti ispol'zovaniya metodov interpretatsii anomaliy dvukhmernykh tel dlya istolkovaniya anomal'nykh poley geologicheskikh ob"yektov [On the possibility of using the methods of interpretation of the anomalies of two-dimensional bodies for an interpretation of the anomalous fields of geological objects]: Kazakh. Gorno-Metall. Inst., Geologiya, Gornoye delo, Metallurgiya, sbornik, no. 14, p. 161–170, 1956.

The effect of the strike of a geological body on its geophysical anomaly is analyzed. The limitations of the application of methods of interpreting two-dimensional bodies to interpreting the anomalies of three-dimensional bodies are discussed, and the probable errors in the methods determined. It was found that accuracy of interpretation depends on the ratio of the strike to the width of the body and to the depth of its basement. The interpretation is more accurate when based on the shape of the anomaly, rather than on its intensity. The method analyzed is considered applicable to any geophysical potential fields.—*A. J. S.*

177–161. Nepomnyashchikh, A. A. Pryamaya zadacha geofiziki v sluchaye trekhmernykh tel s ploskimi granyamy [The direct problem of geophysics in the case of three-dimensional bodies with plane sides]: Kazakh. Gorno-Metall. Inst., Geologiya, Gornoye delo, Metallurgiya, sbornik, no. 14, p. 197–202, 1956.

Formulas are derived for the solution of the direct problem for any three-dimensional body having plane sides. Solutions are given for gravimetric interpretation (second derivatives of V_{xz} and $V\Delta$ of the gravitation potential), for magnetometric interpretations (H_x and H components of the magnetic field intensity), for the method of natural electric field (the component E_x of the electric field intensity), and for the direct current method (components E_x and E'_x of the field intensity).—*A. J. S.*

177–162. Zidarov, D. Prolongement expérimental des fonctions harmoniques et son application dans la géophysique [Experimental extension of harmonic functions and its application in geophysics]: Bolgar. Akad. Nauk Doklady, v. 11, no. 1, p. 17–20, 1958.

With a view to the requirements of applied geophysics, a rapid experimental method is worked out, with the aid of which any function $U(x,y,z)$ harmonic in the half space $z<0$ can be analytically extended into the half space $z>0$ if the value of U $(x_o y_o,0)$ in the plane $z=0$ is known. Advantage is taken of the fact that the value of $U(x,y,z)$ in the half space $z<0$ is proportional to the magnetic potential $W(x,y,z)$ which would exist if the plane $z=0$ were covered by electrical circuits of current intensity $I=U(x_o,y_o,0)$. The sought values of U are expressed by a Taylor series in which the terms are determined experimentally. (See also Geophys. Abs. 177–163, –164, –196, –197.)—*A. J. S.*

177–163. Zidarov, D. Solution expérimentale du problème de Dirichlet pour le demi-espace $z>0$ [Experimental solution of Dirichlet's problem for the half space $z>0$]: Bolgar. Akad. Nauk Doklady, v. 11, no. 3, p. 181–184, 1958.

Dirichlet's problem for the half space $z>0$ is to determine the harmonic function $U(x,y,z)$ in the space $z>0$ whose values are known in the plane $\sigma\equiv z=0$. An experimental solution is proposed using an electromagnetic model analogous to that used for Neumann's problem (see Geophys. Abs. 177–164). The induced voltage is measured by means of a Rogowsky spiral 30 cm long, 1 cm^2 in cross section, and wound 60 turns per cm. See also Geophys. Abs. 177–162, –196, –197.)—*D. B. V.*

177–164. Zidarov, D. Solution expérimentale du problème de Neumann pour le demi-espace $z>0$ [Experimental solution of Neumann's problem for the half space $z>0$]: Bolgar. Akad. Nauk Doklady, v. 11, no. 4, p. 267–270, 1958.

Neumann's problem consists of finding the function $U(x,y,z,)$ in the half space $z>0$ when values of the vertical gradient $U_z x_o,y_o,0)=(\partial U/\partial z)x_o,y_o,0$ in the plane $\sigma\equiv z=0$ are known. If the plane is covered by uniformly distributed identical electrical currents of intensity $I(x_o,y_o,0)=U_z(x_o,y_o,0)$, the magnetic potential of the system will be proportional to $\partial U/\partial z$ in the plane $z>0$. The voltage induced in a specially designed "integrating frame" (an adaptation of the Rogowsky spiral) placed in the field is proportional to the integral, that is, to the sought function U. (See also Geophys. Abs. 177–162, –163, –164, –196.)—*D. B. V.*

177–165. Khalfin, L. A. Informatsionnaya teoriya interpretatsii geofizicheskikh issledovaniy [Information theory of interpretation of geophysical investigations]: Akad. Nauk SSSR Doklady, v. 122, no. 6, p. 1007–1010, 1958.

An application of the information theory to geophysical interpretation is proposed and analyzed. Since neither the master-chart method nor the analytical method are capable of producing a complex geological-geophysical inetrpretation of the field measurement data, Khalfin proposes an inclusion of the interference data into the mathematical formulas of geophysical interpretation, and works them out to the exclusion of the interference data by means of an irreversible transformation of the field $\psi(r)=\phi\rho(r)+n(r)$, where $\psi\rho(r)$=the data of the field, and $n(r)$=the interference field. By determining the probability of a datum ρ and eliminating the ρ's of low probability, an interrelation between geophysical and geological data is established, and only the high probability data are selected. The proposed scheme of the information theory of interpretation results in an algorism that can be processed by a memory-bank calculating machine and provides for a complex interpretation of data obtained by several different geological-geophysical methods.—*A. J. S.*

177–166. Shuleshko, P. A new method of solving boundary value problems of mathematical physics: Australian Jour. Appl. Sci., v. 10, no. 1, p. 1–8, 1959.

A new method is given for the solution of boundary value problems of mathematical physics. In this method a wider class of functions than usual (Rayleigh-Ritz, Boobnoff-Galerkin, Biezeno-Koch, Trefftz, etc.) can be used. Those used must satisfy only one condition, namely, that the set of functions should be complete.

By way of placing additional conditions on chosen functions a series of special methods has been derived. One example is given illustrating the application of the method to the condition.—*Author's summary*

177–167. Shuleshko, P. Generalization of previous methods of solving boundary value problems of mathematical physics: Australian Jour. Appl. Sci., v. 10, no. 1, p. 9–16, 1959.

In the present paper a generalized method of orthogonalization for the solution of boundary value problems of mathematical physics is given. Also a generalized Biezeno-Koch method, a generalized collocation method, and a generalized method of least squares are given. In these methods a wider class of functions than in the usual known methods can be used. It is shown that a generalized Biezeno-Koch method and a generalized method of least squares can be derived as particular cases of the generalized method of orthogonalization.

From these methods a series of special methods has been derived by placing additional conditions on chosen functions.—*Author's summary*

177–168. Aero Service Corporation. Radan—A new radar Doppler aid to aerial navigation: Mines Mag., [Colorado], v. 49, no. 2, p. 15–18, 1959.

Aerial surveys over any terrain without maps or photos and requiring no ground stations are possible with Radan, a new Doppler navigation aid which provides a continuous and highly accurate measurement of the aircraft's position. Aero Service estimates that Doppler navigation cuts the cost of geophysical surveys by 50 percent or more, compared with other radio-guided surveys, and

cuts the surveying time by 40 percent. An airborne magnetometer survey for oil of 40,000 square miles of the central Sahara Desert in Libya, using Radan-navigated planes is now nearing completion and a second one to cover 15,000 square miles in southwestern Morocco in Spanish Sahara has been started.—*V. S. N.*

GEODESY

177–169. Heiskanen, W. A. On the gravimetric undulations of the geoid and the deflections of the vertical: Geofisica Pura e Appl., v. 41, p. 1–18, 1959.

The results expected from the world-wide gravity project established in Columbus, Ohio, in 1950 are outlined. The computational procedure for determining the undulations N and vertical deflection components ξ and η are outlined. As there are large areas still unsurveyed gravimetrically it is of vital significance to determine which gravity anomalies are best used for these regions. Figures on the accuracy of theoretical and observed values of N, ξ and η indicate that in the well-surveyed parts of the world such as Europe and the United States, N values can be determined from existing gravity data with an accuracy of 5 to 10 m, and ξ and η with an accuracy of about 1 in. Geoid undulations, N, have already been computed in Columbus for more than 6,000 points in the northern hemisphere. Maps of the gravimetrically computed geoids for northern and southern Europe (contour interval 2 m) are illustrated and discussed. These are based on more than 1,000 N values at the corners of $1° \times 1°$ squares. It is interesting that the undulations are all positive, with maximum values between 40 and 50 m. Large gradients in the eastern Mediterranean make that region particularly interesting from a geophysical point of view.

Gravimetric N, ξ, and η values can be used for connection of the geodetic systems of different continents to the World Geodetic System, for getting control points for maps on a scale of 1:100,000 or smaller without triangulation, for obtaining higher accuracy in determination of the dimensions of the earth, and for several other purposes of minor significance. The gravimetric method is unique in that it can be used to determine the detailed shape of the geoid anywhere in the world where sufficient gravity observations exist, not only on the continents but also on the oceans.—*D. B. V.*

177–170. Zhongolovich, I. D. Ob opredelenii razmerov obshchego zemnogo ellipsoida [On the determination of the dimensions of the earth's general ellipsoid]: Akad. Nauk SSSR Inst. teoret. astronomii, Trudy, no. 6, p. 3–66, 1956.

This monograph is an extension of Zhongolovich's study of the external gravity field of the earth and its basic constants. The purpose of the study is to determine the true dimensions of the earth from the materials accumulated in astronomical-geodetic measurements on the continents. Zhongolovich assumes that the basic parameters of the earth's external gravity field and the flattening of the earth's spheroid (1/296.6) are known, and seeks a solution for the major axis $\bar{a}$ of the earth's general spheroid.

The value obtained for $\bar{a}$ is 6,378,077 m; the average of 72 earlier values is 6,378,071 m, and Jeffreys' value is 6,378,099 m.—*A. J. S.*

177–171. Kazinskiy, V. A. Interpolyatsionnyye polynomy v primenenii k issledovaniya figury zemli [Interpolation polynomials applied to the

investigation of the figure of the earth]: Akad. Nauk SSSR Izv. ser. geofiz., no. 2, p. 301–303, 1959.

The use of polynomials in the interpolation of different formulas or numerical tables is useful in geophysics. Kazinskiy discusses the use of interpolation polynomials in computations of the earth's figure. He starts with Stokes' formula for the deviation of the geoid from the spheroid. The expression is developed into an interpolation formula using Lambert's table. Similarly, an interpolation formula can be constructed for the approximate computation of plumb-line deviation, using Vening Meinesz formulas.—*S. T. V.*

177–172. Markowitz, William. Use in geodesy of the results of lunar observations and eventual observations of artificial satellites: Bull. géod., no. 49, p. 33–40, 1958.

Markowitz, William. Geocentric coordinates from lunar and satellite observations: ibid., no. 49, p. 41–49, 1958.

Whipple, F. L., and Hynek, J. A. The IGY optical satellite tracking program as a source of geodetic information: ibid., no. 49, p. 50–52, 1958.

The size and shape of the geoid, as we know it now, is based on observations which depend on the direction or intensity of gravity at the observation sites. The possibility of obtaining geocentric coordinates from lunar and satellite observations opens up a new approach, the geometric, to the determination of the geoid. The first of these papers, all three of which were presented at the Toronto General Assembly of the International Union of Geodesy and Geophysics, outlines the way in which the moon may be used to obtain the geocentric coordinates of a station *S*, providing a large number of observations are made at *S*. The second develops the necessary mathematical equations. The third outlines the optical satellite tracking program of the IGY, which is expected to represent a fundamental step forward in geodesy (see also Geophys. Abs. 176–158, –159, –160; 177–173).—*D. B. V.*

177–173. King-Hele, D. G., and Merson, R. H. A new value for the earth's flattening derived from measurements of satellite orbits: Nature, v. 183, no. 4665, p. 881–882, 1959.

Combining data from Sputnik 2 and Vanguard 1 satellites, the coefficients J and D of the earth's gravitational potential are found to be $J=(1{,}624.6\times0.3)\times10^{-6}$, $D=(6\pm1)\times10^{-6}$, corresponding to a value of $1/(298.20\pm0.03)$ for the earth's flattening.—*D. B. V.*

177–174. Jeffreys, Harold. The reduction of gravity observations: Royal Astron. Soc. Geophys. Jour., v. 2, no. 1, p. 42–44, 1959.

The values of the earth's ellipticity given by artificial satellites and by the analysis of gravity differ by about three times the standard error. Investigation of the possible effects of nonorthogonality between P_2, P_3, and P_4 in the normal equations suggests that allowance for it would not multiply the standard error by more than 1.1, and that the explanation is more likely to lie in the comparison of base stations.

The method of weighting used in the determination of the geoid by Heiskanen is criticized as leading to serious systematic error.—*Author's summary*

Egyed, L[ászló]. The change in the dimensions of the earth on the basis of paleogeographic data and its geodetic consequences. See Geophys. Abs. 177–178.

GEOTECTONICS

177–175. Hapgood, Charles H., with collaboration of Campbell, James H. Earth's shifting crust: New York, Pantheon Books Inc., and Toronto, McClelland and Stewart, Ltd., 438 p., 15 figs., 1958.

In writing this book Mr. Hapgood had three objectives in mind: to establish beyond reasonable doubt that numerous displacements of the earth's crust have occurred; to describe a mechanism to account for displacements (primarily the work of Mr. Campbell) and present evidence that this mechanism alone can account for the facts; and to show that the hypothesis of crustal displacement provides an acceptable solution of many of the problems of the earth. Extensive displacement of the rigid outer crust of the earth over the inner layers may take place as a consequence of comparatively slight forces exerted on the crust by the earth's rotational momentum; in turn this will tend to alter the axis of rotation of the earth's crust. The earth's rotation acts on the asymmetrically distributed masses of polar ice (particularly Antarctica), and produces centrifugal momentum which is transmitted to the rigid crust. When this constantly increasing centrifugal momentum reaches a certain point, it will produce movement of the crust over the inner layers and displace the polar regions toward the equator.

The book has 12 chapters: past theories of polar shift, the ice ages, ancient climates, the mountains, continents and ocean basins, the shape of the earth, North America at the pole, the great extinctions, earlier displacements of the crust, life, Campbell's mechanism of displacement, and conclusion; an excellent bibliography is appended.—*V. S. N.*

177–176. Gussow, W[illiam] C[arruthers]. Metastasy or crustal shift: Alberta Soc. Petroleum Geologists Jour., v. 6, no. 10, p. 253–257, 1958.

A theory is presented that the horizontal shifts of the earth's crust necessary to produce continental drift and polar wandering are caused by the centrifugal force of the earth's rotation acting on the moment of inertia-distribution of the earth's surface, which is slowly and relentlessly being disturbed by the erosion of the continental land surfaces and the deposition of vast tonnages of sediments on the continental shelves and in the ocean deeps. Equilibrium has been restored in the geologic past by horizontal shifts of the crust in latitude and longitude with respect to the earth's axis of rotation or pole positions. Gussow has named this phenomenon "metastasy"; the adjustment is largely achieved by sudden shifts of considerable magnitude of the earth's entire crust over the interior at or near the Mohorovičić discontinuity; between these sudden shifts, metastasy is visualized as a slow relentless creep of the entire crust. Thus continental drift also includes drift of the oceanic crust; during drifting, snagging of some parts of the crust would cause local buckling, such as mountain building along some coasts, overthrusting of the oceanic crust to form mid-oceanic ridges, or tearing and fracturing. Sedimentary sequences and hiatuses represent periods of quiet or slow creep, and worldwide unconformities mark times of sudden shifts. The old concept of continental drift, that is, the drifting of continents alone, is completely untenable.—*V. S. N.*

177–177. Odhner, Nils H. Fundamental argument in Cenozoic geology dynamic factors: crustal undulations, thermal dilatation and constriction: Arkiv Mineralogi och Geologi, v. 2, no. 4, p. 353–367, 1958.

Uplift and subsidence of different parts of the earth's crust can be explained without invoking isostasy, according to Odhner's constriction hypothesis in which thermal conditions and changes at the surface are of dominant importance. Geanticlines are likened to an arch bridge, geosynclines to the cables of a suspension bridge. In the former heating increases the curvature, raising the surface of the bridge, whereas in the latter heating lowers the level of the bridge; cooling produces the reverse effect. The source of heat is in the interior of the earth; cooling is brought about superficially by ice or ocean waters. Depression of a glaciated anticlinal land is not necessarily caused by the load of the ice but by its cooling effect.

Negative regional gravity anomalies may be due to dilatation upon heating and thus to a decrease in specific gravity, as in mountain ranges; to tension and even fracturing within the crust, as in deep grabens; or to various combinations of both. Positive anomalies likewise have a double cause. Some arise because of cooling and constriction which increase the specific gravity of crustal masses, others by addition of material (igneous intrusion); both factors may enter into the subsidence of volcanic islands, in which case the anomalies attain extreme values. The fact that the negative anomalies of the Indonesian and West Indies achipelagos do not always coincide with the orogenic zones is inconsistent with the plastic buckling hypothesis, whereas the orogenic nature does not affect the phenomenon of constriction.

Finally it is mentioned in passing that if the remaining icecaps should be melted away, terrible inundations all over the world would not result; according to the constriction theory such an eventuality would also imply an increase in the capacity of the ocean basins.—*D. B. V.*

177–178. Egyed, L[ászló]. Die Änderung der Dimensionen der Erde auf Grund paläogeographischen Daten und ihre geodätischen Konsequenzen [The change in the dimensions of the earth on the basis of paleogeographic data and its geodetic consequences]: Acad. Sci. Hungaricae Acta Tech., v. 23, no. 1–3, p. 243–248, 1959.

If the earth is shrinking the continents must become progressively flooded by water, whereas if it is expanding the amount of flooded area should decrease. Paleogeographic data support the latter alternative. It can be established that the earth's radius increases by about 0.5 mm per year. The geodetic consequences of this expansion are discussed briefly. Horizontal or vertical movements in any region can be determined by geodetic measurements. The former are particularly difficult to ascertain. Present data indicate that horizontal movements of great extent are real, not in the form of continental drift as conceived by Wegener, but modified or generalized. Distortion due to expansion of the earth is revealed by altitude changes. The results of gravity surveys show more and more that the crust in many places departs from the principle of isostasy; expansion of the earth explains the discrepancies. The principle of isostasy needs to be thoroughly revised.—*D. V. B.*

177–179. Hilgenberg, O. C. Die Bruchstruktur von Ungarn and seinen Nachbarländern, verglichen mit der Bruchstruktur der restlichen Sialkruste und bezogen auf die früheren Pollagen de Erde [The fault structure of Hungary and its neighboring countries compared with the fault structure of the rest of the sialic crust and related to the earlier pole positions of the earth]: Geofiz. Közlemények, v. 7, no. 3–4, p. 199–207, 1958.

The predominant strike of the fault system of Hungary and adjacent countries is found to lie between N. 50° W. and N. 70° W. This is compatible with Hilgenberg's concept of crustal rupture as a result of expansion. According to this hypothesis, the diameter of the earth was once hardly larger than its present radius, at which time the sial shell was continuous. This shell burst open under expansion pressure, leaving the sialic continents and continental shelves separated from one another by the deep sea basins.—*D. B. V.*

177–180 Meshcheryakov, Yu. A. Sovremennyye dvizheniya zemnoy kory [Contemporary movements of the earth's crust] : Priroda, no. 9, p. 15–24, 1958.

The oscillatory secular rising and sinking of the earth's crust observed geodetically has an average amplitude of several millimeters a year. Leveling networks established all over the world have determined not only the absolute altitudes of land points, but also their variation with time, or first derivatives $\partial H/\partial T$ (H=absolute altitude, T=time). The problem at present is to determine the second derivatives $\partial^2 H/\partial T^2$, or rate of variation in the oscillation; this should make it possible to predict earthquakes, as it has been found in Japan that substantial changes in the rate of secular variations of crustal tilt precede the earthquakes. Deep tectonic processess, differentiation of crustal material, displacements of magma, and other phenomena that produce the geological structure and relief of the crust are considered to be the causes of its secular oscillation.—*A. J. S.*

177–181. Saxov, Svend [E.] The uplift of Western Greenland: A preliminary note: Dansk Geol. Foren. Medd., v. 13, no. 6, p. 518–523, 1958.

Techniques used at the present time by the Danish Geodetic Institute for measuring vertical movements of western Greenland were established by Froda (1925) who measured the difference in height between a fixed point and the mean value of a series of balanus (barnacle) stripes. Results of recent measurements at two of Froda's stations, at two established in 1950 by the institute (all in the Disko Bay area), and one established in 1957 by Saxov (at the mouth of Strømfjord) show an uplift of about 14 mm per yr for the last 10 years, replacing an annual subsidence of the same amount prior to 1946.

Astronomical observations made at Qôrnoq in 1927 and 1948 show that no horizontal displacement of Greenland is taking place. This invalidates the findings of Jensen (1923), based on a comparison of astronomical observations made in 1863 and 1882–83 with observations made in 1922, that Greenland is moving westward at a rate of 36 m per yr.—*V. S. N.*

Scheidegger, A[drian] E[ugen]. Physics of marine orogenesis. See Geophys. Abs. 177–377.

GLACIERS

177–182. Nye, J. F. A method of determining the strain-rate tensor at the surface of a glacier: Jour. Glaciology, v. 3, no. 25, p. 409–418, 1959.

The rate of strain tensor at a point on the surface of a glacier may be determined by setting up a number of stakes in a pattern and measuring the rate of change of the distances between them. A suitable pattern consists of four stakes at the corners of a square with one stake at the center. Five such patterns were used on Austerdalsbreen, Norway, in August 1956. The problem is to deduce the best values of the 3 independent components of the strain-rate tensor from 8

measured quantities, and, for this purpose, a least-squares method invented by Bond for the analogous problem in crystal physics is used. The principal strain rates are found to within about $\pm$ 0.005 yr^{-1} and their directions relative to the stake system to within about $\pm$ 0.5°. The direction and magnitude of the principal stresses are then deduced from Glen's flow law and a suitable general theory. The directions of the principal strain rates are in good agreement with the directions of the crevasses, but the experiment is inconclusive on the question of the magnitude of the stress needed to form the crevasse.—*Author's abstract*

177–183. Nye, J. F. The deformation of a glacier below an ice fall: Jour. Glaciology, v. 3, no. 25, p. 387–408, 1959.

The pattern of deformation over the first three waves from the Odinsbre ice fall, Austerdalsbreen Glacier, Norway, was studied by measuring the absolute and relative motions of 35 stakes during August 1956, to test the theory that wave ogives at the foot of an ice fall are formed by pressure. It was concluded that the waves are not formed by pressure in this area and that the pattern of deformation can be explained by improving the existing theory of glacier flow. The deformations are essentially independent of the presence of the waves and are primarily due to compression which occurs in the ice as its slope decreases and it becomes thicker, and to the bending and unbending of the ice as it passes over a bed of changing curvature. Additional deformation is caused by widening of the glacier channel at the immediate foot of the ice fall and by annual ablation. The theory explains quantitatively the rotation and bending of a horizontal tunnel excavated in the glacier in 1955. If the glacier bed is the primary cause of the oscillations of the longitudinal strain rate, then remeasurement of the strain rate at a later date in the same position relative to the bed should show closely similar oscillation; this prediction was verified by measurements made in July 1957.

The positions and amplitudes of the observed waves are fully accounted for by the combined plastic deformation and ablation mechanism described by Nye in an earlier paper (see Geophys. Abs. 177–182).—*V. S. N.*

177–184. Pounder, E. R., and Little, E. M. Some physical properties of sea ice. 1: Canadian Jour. Physics, v. 37, no. 4, p. 443–473, 1959.

This preliminary study is based mainly on work done at a shore station in Shippegan, New Brunswick, during the winter of 1956–57, with some data from an icebreaker expedition in the summer of 1956. The Shippegan site had unrafted ice, tides of 5 feet or less, and negligible fresh-water runoff. The thickness of the ice was about proportional to the square root of the freezing exposure. Tritium dating of sea ice is an unsatisfactory method because of variable tritium concentration in Arctic water. The jaggedness of ice crystals is suggested as a measure combining age effects and thermal regime. Measurements of specific gravity, salinity, electrical resistivity, and permeability profiles all show progressive changes in annual sea ice throughout the winter. The tensile strength of sea ice at —20°C was around 200 to 500 psi, at various angles to the grain. For fresh-water ice, with stress parallel to the grain, it was in the range 500 to 1,000 psi. Shear strengths, with the shear plane parallel to the grain, were 80 to 160 psi for sea ice at —20°C and 160 to 280 psi for pond ice, also at —20°C.—*Authors' abstract*

177–185. Wexler, H. Geothermal heat and glacial growth: Jour. Glaciology, v. 3, no. 25, p. 420–425, 1959.

In a 300-m-deep hole drilled in the 3,000-m-thick ice at Byrd Station (lat 80° S., long 120° W., 1,513 m above sea level), the temperature was observed to decline with depth below 45 m. This profile was extended to the bottom of the ice with the aid of heat = conduction theory under these assumptions: that as the ice was deposited the climate became warmer at the rate of 0.45°C per 1,000 yr; the conduction of geothermal heat is 31.6 cal per cm^{-2} per yr^{-1}.

It is estimated that the first 2,000 years of geothermal heat conducted to this ice, whose annual accumulation is 30 cm, is dissipated to the atmosphere and space. When the ice becomes thicker, it retains all the geothermal heat given to it for a long time.

An alternative, nonclimatic-change explanation of the decreasing temperature in the Byrd Station hole is based on colder ice from higher elevations moving under the warmer ice accumulated locally. However, an examination of the topography of the Marie Byrd Land ice does not appear to support this explanation.—*Author's abstract*

International Geophysical Year Bulletin (No. 21). Oxygen isotope studies. See Geophys. Abs. 177–263.

GRAVITY

177–186. Gutiérrez Díez, José Luis. Método de medidas absolutas de la gravedad [Method of absolute measurements of gravity]: Rev. Geofísica, v. 17, no. 67, p. 261–273, 1958.

Methods of measuring the absolute value of gravity (reversible pendulum, long pendulum, free-falling body) are reviewed very briefly. Medi's method of rotating liquids (see Geophys. Abs. 161–8) is described more fully, and a new formula is proposed, based on a property of parabolic mirrors: $g=\omega^2 R \tan \beta$, where g=gravity acceleration, ω=angular velocity, R=radius, β=angle between the resultant of the forces applied to the liquid and the horizontal. With R a constant of the instrument, g can be measured as a function of ω if β is kept constant, or as a function of β if ω is kept constant. The method is sufficiently accurate and more rapid than the reversible pendulum method. The easy movability of the apparatus will permit extension of the system of points for which absolute gravity values are determined.—*D. B. V.*

177–187. Reichender, K. Zur Neubestimmung der absoluten Schwere in Potsdam [On the redetermination of absolute gravity in Potsdam]: Acad. Sci. Hungaricae Acta Tech., v. 23, no. 1–3, p. 251–255, 1959.

Essentially the same as the paper published in Zeitschrift für Geophysik, v. 23, p. 1–3, 1957 (see Geophys. Abs. 174–200).—*D. B. V.*

177–188. Goguel, Jean. Isostasie et géologie [Isostasy and geology]: Rev. Géographie phys. et Géologie dynam., v. 2, no. 2, p. 70–80, 1959.

An attempt is made to outline a real concept of isostasy, independently of the historic evolution of the ideas; this concept must take into account all the structural irregularities which may involve the crust. The postglacial readjustment furnishes a control, but the essential verification is furnished by the study of the gravity field: the true field is compared to the field calculated for an ideal model in which compensation is realized according to an arbitrary

scheme. The observed discrepancies (anomalies) are undoubtedly due more to inadequacy of the scheme than to a lack of equilibrium. It is shown, by the example of the Rhine graben, how measurements can be interpreted by a suitable crustal structure within the framework of isostatic equilibrium. Finally, the possible effect of deep fluctuations in density are examined.—*Author's summary, D. B. V.*

177–189. Klushin, I. G. K voprosu geologicheskoy interpretatsii anomaliy vertikal'nogo gradienta sily tyazhesti [On the question of the geologic interpretation of anomalies of the vertical gravity gradient]: Prikladnaya Geofizika, no. 17, p. 178–184, 1957.

Two approximate formulas for the vertical derivatives of gravity are derived: the first for use in the case of small geologic structures, the second for the determination of the shape of larger structures. These make it possible to compute the elevation of points of complex buried relief with respect to the average relief.—*S. T. V.*

177–190. Tyapkin, K. F. Interpretatsiya gravitatsionnykh anomaliy, obuslovlennykh konechnymi tsilindricheskimi telami [Interpretation of gravity anomalies produced by finite cylindrical bodies]: Akad. Nauk SSSR Doklady, v. 125, no. 6, p. 1249–1251, 1959.

In order to determine whether discrepancies between the gravity anomalies calculated for two- and three-dimensional bodies are due to the assumption of infinite extent of the latter, and thereby possibly to improve the accuracy of gravitational interpretation, Tyapkin examines the gravitational effect of a finite cylindrical body of arbitrary length, lying parallel to the earth's surface. Approximate formulas are developed.—*D. B. V.*

177–191. Andreyev, B. A. Sootnosheniye mezhdu strukturnym rel'yefom i anomaliyami sily tyazhesti v sluchaye neskol'kikh razdelov plotnosti [A correlation between structural relief and gravity anomalies in case of several density discontinuities]: Akad. Nauk SSSR Doklady, v. 124, no. 2, p. 311–313, 1959.

This paper considers the case where an anomalous gravity field is the result of several layers of identical form but different densities, equally distant along the vertical. Andreyev describes a regional structural relief by means of trigonometrical functions, assuming that the transverse profiles of typical regional anomalies, negative and positive, can be roughly considered as a combination of harmonics of 200 to 400 km wave length. Formulas are derived, and the problem of the gravity effect owing to the relief of the boundary between the granitic and basaltic layers of the crust is analyzed.—*A. J. S.*

177–192. Nedyalkov, I. P. Analiticheskiy metod gravimetricheskoy interpretatsii [Analytical method of gravimetric interpretation]: Bolgar. Akad. Nauk Doklady, v. 10, no. 6, p. 461–464, 1957.

A method is given for interpreting the gravity anomaly of a homogeneous ore body, based on a nonlinear integro-differential equation of the first order in which the function sought is the radius vector describing the surface of the body and the known function is the function of the anomaly distribution on the earth's surface. This equation is replaced by a system of nonlinear algebraic equations that is solved by Newton's method. The concept of "gravimetric

family" is introduced, consisting of all surfaces that describe homogeneous ore bodies having the same gravity anomaly. If the density of the body is known its volume can be calculated, and knowing the volume the member of the family corresponding to the true ore body can be selected. If density is not known a unique interpretation is not possible, but knowledge of the family gives information on the approximate depth and orientation of the body.—*D. B. V.*

177–193. Nedelkov [Nedyalkov], I. P. On the interpretation of gravity anomalies with unknown body density: Bolgar. Akad. Nauk Doklady, v. 11, no. 5, p. 347–350, 1958.

In this paper some properties of "gravimetric families" (see Geophys. Abs. 177–253) are outlined and a method is proposed which reduces their approximate determination, when density is unknown, to a multiple solution of Neumann's problem.—*D. B V.*

177–194. Nedyalkov, I. P. Radioaktivnaya model' gravimetricheskoy interpretatsii [Radioactive model of gravimetric interpretation]: Bolgar. Akad. Nauk Doklady, v. 10, no. 4, p. 285–288, 1957.

The vertical gradient of the gravity field of a homogeneous ore body can be established by means of intensity of radiation from a model having the same shape, uniformly filled with radioactive matter; such a model can easily be made from radioactive threads. The possibility of making the anomaly visible electronically is also shown. Interpretation can be accelerated substantially by means of rapid measurement of the total quadratic error corresponding to the difference between the anomaly of the hypothetical and that of the real ore body.—*D. B. V.*

177–195. Nedelkov [Nedyalkov]. I. P. Quick-acting models for interpretation of gravity anomalies: Acta Geophys. Polonica, v. 6, no. 4, p. 321–330, 1958.

Models for rapid interpretation of gravity anomalies are given. In an electromagnetic model the form of the body is imitated by a system of wires, each in a different horizontal plane, and connected in series. The potential function of the electromagnetic field created when a-c current is passed through the model is analogous to the vertical gradient of the gravity potential of a body of the same shape.

Three models of more readily changeable shape are known at present. An electrolytic model is based on the analogy between the vertical gravity gradient V_z and the gravitational potential of surface gravitational masses whose density is $\sigma \cos \theta$ (where σ is density of the body and θ is the angle between unit vectors). In the radioactive model, the body is replaced by some uniformly distributed radioactive substance such that the effects of absorption can be neglected; the intensity of radiation at each point of the horizontal plane is proportional to the value of V_z of the body at the same point. The light model is a variation of the radioactive model in which radioactive threads are replaced by glow discharge tubes, lead tubes by opaque tubes, and radiation counters by photoelements.

A special method is described for instantaneously comparing the model and the original anomaly that avoids the intermediate step of drawing of isoanomalies.—*D. B. V.*

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177–196. Zidarov, D. Solution expérimentale du problème inverse gravimétrique et magnétométrique [Experimental solution of the inverse gravimetric and magnetometric problem]: Bolgar. Akad. Nauk Doklady, v. 10, no. 5, p. 351–354, 1957.

A method is proposed for automatizing the "selective method" of determining the form of a body of homogeneous density when the vertical gradient of gravity is known in a horizontal plane. An electromagnetic model is constructed in which the induced magnetic potential is proportional to the vertical gradient sought and can be measured by means of a "Rogowsky spiral." (See also Geophys. Abs. 177–162, –163, –164, –197).—*D. B. V.*

177–197. Zidarov, D. Sur les corrections gravimétriques et magnétométriques [On gravimetric and magnetometric corrections]: Bolgar. Akad. Nauk Doklady, v. 11, no. 5, p. 351–354, 1958.

The present method of correcting gravity measurements leads in some cases to a gravimetric picture entirely different from that which would be obtained if the measurements could be made at sea level, or on some other horizontal plane α under the earth's surface with the subjacent masses removed. A more exact method of correction is proposed here, based partly on the fact that the function G_D (vertical gravity gradient of the disturbing mass D) is a harmonic function in the space above plane α, and partly on an electromagnetic model of the harmonic field of the functions.

If the plane α is covered by identical closed electrical circuits, a current of given intensity and frequency can be made to flow in each. If the intensity of this current in each circuit is equal to the sought value of G_D at a point B in plane α, the magnetic potential of the entire system of closed circuits will be proportional to G_D at every point A in the space above α. This potential can be measured by means of a suitable instrument such as a Rogowsky spiral (magnetic voltmeter); the voltage induced in the spiral is proportional to the magnetic potential sought at the corresponding point, and should be comparable to the probable value of G_D at the corresponding point A.

The method is applicable to the correction of magnetic observations as well as gravimetric. Isostatic anomalies will be treated in a later paper. (See also Geophys. Abs. 177–162, –163, –164, –196.)—*D. B. V.*

177–198. Romanyuk, V. A. O vozmushchemiyakh sily tyazhesti atmosferoy [On disturbances of the gravity force by the atmosphere]: Akad. Nauk SSSR Izv. ser. geofiz., no. 2, p. 320, 1959.

Attention is called to the necessity of taking into account in precise gravimetric measurements a correction ordinarily neglected, but which may be as important as that for the lunisolar effect. This correction is for local atmospheric disturbance and is equal to $\Delta g = 2\pi f\rho\ (P_o - P_a)$ where ρ is the density of mercury, f the gravitational constant, P_a the barometric pressure in millimeters of Hg at the point of measurement, P_o is the average pressure in the surrounding region. Inserting the values of P_o and P_a, this correction can be readily computed. Romanyuk gives a short table of the computed values of Δg for different values of P_a and P_o.—*S. T. V.*

Smith, R. A. Some depth formulae for local magnetic and gravity anomalies. See Geophys. Abs. 177–305.

Stupak, M. [N.] K., and Tyapkin, K. F. The interpretation of certain magnetic and gravitational anomalies of the Krivoy Rog type. See Geophys. Abs. 177–308.

177–199. Sandberg, C. H. Terrain correction charts or transition from Hammer charts to Hayford-Bowie charts: Geophysics, v. 24, no. 2, p. 323–329, 1959.

Recently it has been found desirable in specific instances to incorporate the results of local gravity surveys into larger surveys, making it necessary to be able to convert terrain corrections based on the Hammer charts (usually used in the United States for detailed surveys), which extend out to radius of 13.6 miles and emphasize the effects of local terrain, into those based on the Hayford-Bowie charts (usually used in regional surveys in the United States), which cover the entire earth. Two tables are presented, the first giving the dimensions (inner and outer radii, width, and number of compartments) of the Hammer and Hayford-Bowie zones, the second giving the correction per compartment in units of 10^{-5} gal, based on a density of 2.67, for nine conversion zones.—*D. B. V.*

177–200. Steiner, Franz. Zur Ermittlung des Koeffizienten der gravimetrischen Höhenreduktion [On determination of the coefficient of the gravimetric altitude reduction]: Gerlands Beitr. Geophysik, v. 68, no. 1, p. 15–20, 1959.

After a discussion of Jung's method (1943) a simple method of determining the coefficient of the altitude correction for gravimeter-network measurements is described, based on Egyed's form of Nettleton's postulate (see Geophys. Abs. 98–5014, 165–172). The coefficient is calculated from the gravimeter and altitude observations for every group of four neighboring stations, approximately forming a parallelogram on the map.—*D. B. V.*

177–201. Bott, M[artin] H[arold] P[hillips]. The use of electronic digital computors for the evaluation of gravimetric terrain corrections: Geophys. Prosp., v. 7, no. 1, p. 45–54, 1959.

A program is outlined in which the major part of gravimetric terrain corrections may be estimated by digital computing methods. In its crude form the method depends on dividing the region into a grid of equal squares of convenient size, the average heights of which need to be estimated. In Great Britain the 1-km^2 national grid squares are of a suitable size. The correction may then be estimated for each gravity station by summing the incremental contributions from all squares. The contributions of squares whose centers are less than 0.99 km from the station still need to be calculated by conventional methods.

Formulas are given for two possible timesaving approximations of the actual contribution of the square, and the errors involved in these approximations are discussed. Computing time may also be reduced by grouping squares beyond a certain distance from a station and treating them as a single square. The general procedure is probably also applicable to the estimation of isostatic corrections and to certain geodetic calculations.—*D. B. V.*

177–202. Mužijević, Ranko S. Prilog računanju topografskih korekcija za gravimetriska merenja [Contribution to the computation of topographic corrections to gravity measurements (with English sum-

mary)]. [Serbia] Zavod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 281–291, 1957.

Simplified formulas are developed for computing the vertical component of the gravitational attraction of a curved sector with inclined surface, and a graph is given showing altitude A (mgal per m) as a function of α, the maximum slope angle, for $k=6.67\times10^{-5}$ and density $\sigma=2.00$ cgs units. Three examples are given, and the results compared to those obtained by the more complicated calculations in which the surrounding terrain is divided into compartments and the average elevation determined for each. The error caused by smoothing out variations of mass distribution is discussed for the case when the surface is comparable to a plane dipping through the observation point; a curve is given showing the relative error for a particular case.—*D. B. V.*

177–203. Fedynskiy, V. V. O razrabotke apparatury dlya gravimetricheskikh izmereniy v dvizhenii [On the development of instruments for gravimetric measurements in motion]: Akad. Nauk SSSR Izv. ser. geofiz., no. 1, p. 146–152, 1959.

The article deals with the introduction of airborne gravity surveying as a new branch of exploratory geophysics. High precision is necessary; even steeply dipping salt domes produce a gravity anomaly of only 20 to 30 mgal, and in most cases the anomalies over oil and gas deposits reach only a few milligals and over ore deposits only fractions of a milligal. Such precision in an airplane is not possible with present gravity instruments. It is important to note that the speed of the airplane creates new difficulties, produced by the Eötvös effect resulting from the difference in centrifugal acceleration between the rotating earth and the moving observer, an effect which can amount to as much as 1,500 mgal. The time of a reading therefore must be exceedingly short.

Fedynskiy finds promise in Balabushevich's suggestion to measure the second derivative of gravity, especially the quantity V_{zz}, using Joly's method with an additional attachment suggested by Schmerwitz. In this form, built as a double vertical balance and made astatic, the instrument seems to be capable of attaining the necessary precision and sensitivity, but so far only as an immovable laboratory instrument. Another type of vertical gravity gradientmeter can be built as a combination of two vertical gravimeters in one housing. By making it astatic, it will be possible to attain the necessary precision. It will also be less sensitive to airplane jerks. In any case much experimental work will be necessary to adapt any of these instruments to airborne measurements.—*S. T. V.*

177–204. Thompson, Lloyd, G. D. Airborne gravity meter test: Jour. Geophys. Research, v. 64, no. 4, p. 488, 1959.

Airborne tests have been made with a LaCoste and Romberg gravity meter at Edwards Air Base in California. Several traverses were made flying north, south, and west at 20,000 and 30,000 ft at different airspeeds. In all runs the instrument performed much better than it would have on a surface ship, for which it was designed. Final results are not yet available, but accuracy is believed to be about ±10 mgal. These tests show that airborne gravity surveying is feasible. It seems possible to develop a system which will provide data over the entire world in a few years.—*D. B. V.*

177–205. LaCoste, Lucien. Surface ship gravity measurements on the Texas A. and M. College ship, the "Hidalgo": Geophysics, v. 24, no. 2, p. 309–322, 1959.

Gravity meter readings taken at sea are disturbed by the motion of the ship and thus involve accelerations thousands of times greater than the permissible error. These accelerations must be averaged out and/or correction made for them. A meter which allows this to be done is described, and data obtained on a surface ship are presented with such checks as were available.—*Author's abstract*

177–206. Boulanger, J. D. [Bulanzhe, Yu. D.] Mitschwingen des Stativs bei Quarzgravimetern mit horizontalem Torsionsfaden [Co-vibration of the support in quartz gravimeters with horizontal torsion fibers]: Československá Akad. Věd Studia Geophys. et Geod., v. 3, no. 1, p. 25–32, 1959.

The steadiness of the supports of the Nörgaard, SN–3, and GAE–3 gravimeters was investigated in the aerogravimetric laboratory of the Russian geophysics institute. In the case of the SN–3 instrument, vibration of the support may introduce a systematic error of 5 mgal or more when set up on a somewhat unsteady base such as grass-covered or boggy ground; in the Nörgaard gravimeter the effect is 2 to 3 times less; and in the GAE–3, vibration of the support was hardly detectable. To minimize the effect of vibration of the support it is necessary to carry out observations with maximum steadiness and to adjust the quartz system to its minimum range. For complete compensation for the effect, it is necessary to measure the angle of torsion of the quartz system that is produced by vibration of the support, and reduce the observed value to that of an absolutely rigid support.—*D. B. V.*

177–207. Bacon, L[loyd] O. Relationship of gravity to geological structure in Michigan's Upper Peninsula *in* Snelgrove, A. K. and others. Geological exploration: Michigan College Mining Technology Inst. Lake Superior Geol., p. 54–58, 1957.

Gravity measurements in the Upper Peninsula of Michigan were made to determine the relationship between gravity variations and known geologic structures which for the most part are hidden beneath glacial drift in the western part and beneath Paleozoic sediments in the eastern half. In general, major gravity anomalies in the western half of the peninsula are associated with the middle Keweenawan lava flows (Keweenaw Peninsula) and with Huronian synclinal structures. A broad regional gravity anomaly characterizes the eastern half of the peninsula. From the gravity data the magnitude and depth of various structures were calculated as follows: throw of fault separating Keweenawan lava flows from sandstones in central Keweenaw Peninsula, 12,000 ft; depth of syncline of Huronian sediments forming the Iron River-Crystal Falls district, 6,000 ft; depth of syncline forming Marquette Iron Range, 8,000 ft; and dome structure of Archean granite, separating the two synclines, 15 by 20 miles in extent. In the eastern half of the Upper Peninsula the major gravitational anomalies are the anomaly associated with the Marquette iron formation and the broad regional anomaly extending southeast across most of the southeastern part of peninsula. This latter gravity and magnetic anomaly increases in magnitude to the east and may reflect the ridge or dividing line between the Lake Superior and Lake Michigan basins. It continues across the Straits of Mackinac into lower Michigan and probably merges with the gravity high extending nearly the length of the Lower Peninsula. It also branches to the north and may reflect the dense lavas which are exposed on the north and east shores of Lake Superior in Ontario.—*V. S. N.*

177–208. Garland, G. D., and Burwash, R. A. Geophysical and petrological study of Precambrian of central Alberta, Canada: Am. Assoc. Petroleum Geologists Bull., v. 43, no. 4, p. 790–806, 1959.

It is shown that the major part of the Bouguer gravity anomaly field over central Alberta must be attributed to lithological changes in the Precambrian basement beneath the sedimentary section. By making use of the petrology and physical properties of samples from wells that have reached the Precambrian, in conjunction with the gravity data, a lithological map of the basement has been produced. The covered shield can be traced to the region beneath the Rocky Mountains, at least as far west as Banff. Depth estimates made from gravity profiles strongly suggest that the Precambrian has been uplifted beneath the mountains.—*Authors' abstract*

177–209. Day, A[rthur] A[lan] Gravity anomalies in the Channel Islands: Geol. Mag., v. 96, no. 2, p. 59–98, 1959.

Bouguer gravity anomalies have been determined at 79 stations on Alderney, Guernsey, and Jersey. On Alderney the anomalies are clearly dependent on the nature of the outcropping rock-types, and permit approximate values for the thickness of two outcropping rock masses to be obtained. On Guernsey the anomalies are not closely related to the surface geology, and suggest that the north-eastern coastal area is underlain by a body of dense rock, possibly of ultrabasic composition. The anomalies on Jersey indicate that the sedimentary rocks of western Jersey are underlain at no great depth by rock of density comparable to that of granite. In eastern Jersey the dominating feature of the anomalies is a pronounced "high" centered near Grande Charrière. It is shown that this feature is most reasonably considered to be the effect of a large buried gabbro intrusion.—*Author's abstract*

177–210. Kejlsø, Elvin. The European gravimetric calibration line, Danish part: [Denmark] Geod. Inst. Medd., no. 37, 35 p., 1958.

The results of measurements on the Danish part of the European gravimetric calibration line, made with a Frost gravimeter C–1–20 and a Worden gravimeter 142 in 1956 and 1957, are presented. Six tables are given: preliminary values, Worden observations, Frost observations, adjusted values, gravity differences between successive stations, and comparisons with earlier measurements. An appendix by H. Dürbaum connects the German and Danish gravity nets.—*D. B. V.*

177–211. Saxov, Svend [E.]. Kalkundergrunden ved Taastrup [The Cretaceous subsurface near Taastrup]: Dansk Geol. Foren. Medd., v. 13, no. 6, p. 514–517, 1958.

A gravity survey near Taastrup, Denmark, shows that the buried valley in the Danian Bryozoan limestone is about 250 m wide and 50 to 75 m deep. A density contrast of 0.4 was used. Thickness of glacial drift is 15 m.—*D. B. V.*

177–212. Ivković, Dragiša; Aćimović, Ljubomir; and Roksandić Miodrag. Gravimetriska ispitivanja tercijarnog basena Čačak-Kraljevo [Gravimetric investigation of the Čačak-Kraljevo Tertiary basin (with English summary)]: [Serbia] Zavod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 325–335, 1957.

The Čačak-Kraljevo Tertiary basin in Serbia, drained by the Western Morava River, was surveyed gravimetrically in 1956. In this paper the results, pre-

sented as a Bouguer anomaly map, are interpreted geologically. The low near Čačak is produced by the eastward continuation beneath the sediments of the structural trough of Mala Jelica. The low near Kraljevo is caused by a structural depression in the basement at the intersection of the Dinaride and Vardar zones; this depression is older and deeper than the Čačak. The high near Slatina reflects the block of basement that is relatively uplifted between these depressions. The high near Vranić is due chiefly to relief in the serpentine massif, and the smaller highs near Mojsinje and Baluga also reflect basement features.—*D. B. V.*

177–213. Renner, J[anos]. Schwerkraftsuntersuchungen in Ungarn seit Roland Eötvös Tätigkeit [Gravity investigations in Hungary since Roland Eötvös' activity (with discussion)]: Acad. Sci. Hungaricae Acta Tech., v. 23, no. 1–3, p. 227–242, 1959.

A review of gravity research in Hungary in the past four decades. In that time improvements have been made on the Eötvös torsion balance, and a large part of the country has been surveyed in detail (about 60,000 torsion balance and about 40,000 gravimeter stations have been occupied). Of particular importance is the establishment in 1950–55 of the gravimetric base network of the first and second order.—*D. B. V.*

177–214. Scheffer, Viktor, Az erdélyi ősmasszivum problémája [The problem of the ancient Transylvanian massif]: Geofiz. Közlemények, v. 7, no. 3–4, p. 209–227, 1958.

Recent geophysical measurements in Rumania have considerably broadened the understanding of the structure of the southeastern part of the Carpathian Basin. Maps of regional gravity (isostatic and Bouguer) and vertical magnetic anomalies are reproduced. The basement structure is evidently not homogeneous; a crystalline mass underlies the center of the basin, and older strata rise in anticlinoria at the northeastern and southern margins.—*D. B. V.*

177–215. Lebedev, T. S. O prichinakh Chernigovskoy anomalii sily tyazhesti [On the causes of the Chernigov gravity anomaly]: Priroda, no. 5, p. 79–81, 1958.

The gravity anomaly of +94 mgal (Bouguer), found in 1927 near Chernigov at the juncture of Dnepr-Donets and Pripet depressions, is discussed in the light of a previous interpretation and borehole data. An upper Devonian complex of volcanic and sedimentary rocks having a mean density of 2.66 g per cm^3 was discovered at a depth between 1,587 and 2,751 m lying on Precambrian rock having a similar mean density (2.71 g per cm^3). Denser (up to 3.18 g per cm^3) magmatic intrusions fill fissures and fractures in the Precambrian basement; these may be more widespread and thicker than the present data suggest.

A density contrast of 0.55 to 0.60 g per cm^3 would account for about 30 mgal of the anomaly; adding to this the effect of the structure (a horst) would bring it to about 50 mgal. To explain the rest of the anomaly, Devonian flows extruded through the known fissures and necks, or basic and ultrabasic intrusions deeper in the Precambrian must be postulated.—*A. J. S.*

177–216. Ayzenberg, M. A. Opyt interpretatsii regional'noy gravitatsionnoy kartiny Gruzii [Attempt at interpretation of the regional gravity map of the Georgian SSR]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 14, p. 229–236, 1955.

As the regional gravity field in the Georgian S.S.R. is very complex, a dependable interpretation of local anomalies is difficult without subtracting regional anomalies from the total anomaly. A study of the regional gravity field, isolating different parts of the field and classifying its elements, is presented in this paper. Geological interpretations of regional anomalies are given for the following geological subdivisions: eastern Caucasus minimum; Argun' maximum; Koysu minimum; Trans-Katal' maximum; Kakhetia minimum; Kolkhida-Dzirul' maximum; Akhalkaka minimum; Tbilisi maximum; and Batumi maximum. Both Bouguer and free-air reductions were made; differences between Bouguer and free-air anomalies in the same region are attributed to the presence of dense extrusive masses.—*A. J. S.*

177–217. Abakeliya, M. S. Problema geologicheskoy interpretatsii regional'nogo gravitatsionnogo polya Zakavkazskoy nizmennosti [The problem of geological interpretation of the regional gravity field of the Transcaucasian depression]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 14, p. 219–228, 1955.

The interpretation of the regional gravity field in the Transcaucasian depression is discussed, and some suggestions are given as to methods of solving the problem. Section one of the paper gives a historical review of gravimetric observations in the depression from 1898 to the present time. Section two gives a geological interpretation of regional gravity anomalies. The Batumi–Black Sesa and Kurdamir anomalies are positive (in Bouguer reduction), the Kolkhida-Kartali, Alazan-Kurd, and eastern Azerbaijan anomalies are negative. The mean density was found to be 2.24 g per cm^3 for the Black Sea basin, and 2.56 g per cm^3 for the Caspian basin. The mean land-and-water density was found to be 1.579 g per cm^3 for both basins.—*A. J. S.*

177–218. Balavadze, B. K. K voprosu primeneniya gravitatsionnogo variometra v podzemnoy razvedke [On the problem of application of the gravity variometer to underground prospecting]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 15, p. 29–34, 1956.

A gravity variometer of Z–40 type was used in underground prospecting in a horizontal mine gallery 250 m deep at Dashkesan, Azerbaijan S.S.R. The purpose of the survey was to find out by gravimetric measurements the extent of the local deep granodiorite massif under the complex topographic conditions of the area. Anomalies of the horizontal components U_{xz} and U_{yz} of gravity gradients were calculated and are presented in a table, and the total gravity gradient is represented by a graph. A comparison of the gradient vectors with a geological map indicates that the vectors are directed toward dense granodiorite masses that reach the level of the gallery at a distance of 0.5 km away.—*A. J. S.*

177–219. Harada, Yoshimichi; Suzuki, Hiromiti; and Ohashi, Shin-ichi. Report on the gravity measurements by the Japanese Antarctic Research Expedition [in Japanese with English abstract]: Antarctic Rec., no. 6, p. 34–45, 1959.

Observation of gravity values at Syowa Base, Antarctica, by means of a *GSI* pendulum apparatus was not carried out as planned by the second Japanese Antarctic Research Expedition because the ship was locked in ice during the mission. Pendulum observations made at Singapore and Capetown relative to

Japan's fundamental gravity station at Kyoto gave values of 978.0805 and 979.6470, respectively.

Further gravity observations were made with a Worden gravimeter at Singapore, Capetown, and on the pack ice at Lützow-Holm Bay, Antarctica. The values determined at Singapore and Capetown showed a reasonable agreement with those of Woollard's group and of the Cambridge pendulum apparatus. At Lützow-Holm Bay, where gravity values are always larger than normal, the average magnitude of the positive anomaly was about +50 mgal; this value far exceeded the value of the estimated observational error.

Detailed results of the observations are tabulated.—*V. S. N.*

177–220. Grushinskiy, N. P. Fundamental'nyy gravimetricheskiy punkt GAISh [The fundamental gravimetric station GAISh]: Astron. Zhur., v. 34, no. 3, p. 469–473, 1957.

Two values of gravity are given for the fundamental gravimetric station at the new building of the Sternberg State Astronomical Institute on Lenin Hills near Moscow: 981,519.5±0.75 mgal in the gravimetric laboratory and 981,520.5 ±0.75 mgal in the gravimetric basement. The values at three other fundamental gravimetric stations at Pulkovo (near Leningrad), Kazan', and Poltava (Ukraine), have been determined as 981,900.5±0.54, 981.558.7±0.68 and 981,006.4±0.67 mgal, respectively. The four stations are referred to Potsdam, and through them the entire gravimetric network of the U.S.S.R. is tied to the Potsdam system.—*A. J. S.*

HEAT AND HEAT FLOW

177–221. Safronov, V. S. O pervonachal'noy temperature zemli [The primordial temperature of the earth]: Akad. Nauk SSSR Izv. ser geofiz., no. 1, p. 139–143, 1959.

The question of the primordial temperature of the earth is closely related to the problem of the earth's origin and development. High temperatures have influenced its development and in turn been affected by different phases of the earth's growth. The high potential energy of the earth suggests that at the time of its formation a vast amount of energy was evolved. Most of this energy was dissipated as heat into space, but only a small fraction of the initial amount of energy may have been sufficient to bring the temperature of the earth to several thousand degrees K. The analysis of the process of growth of the earth as a result of precipitation on terrestrial nuclei of matter falling from the protoplanetary cloud leads to the conclusion that the formation of earth was completed in about a hundred million years, during which time the temperature of the earth's center reached about 1,000° K. The sources of this heating were disintegration of radioactive elements and compression of the matter during the growth of the earth. Heating due to the impact of falling bodies was relatively unimportant. The subsequent heating of the earth was due to radioactivity. Over a period of 5 billion yr the radioactive elements could have raised the temperature of the earth's interior a few thousand degrees. This heating strongly influenced the evolution of the earth, particularly the formation of its crust.—*S. T. V.*

177–222. Jaeger, J. C. The analysis of aquifer test data or thermal conductivity measurements which use a line source: Jour. Geophys. Research, v. 64, no. 5, p. 561–564, 1959.

A simple numerical method for analyzing observations of drawdown in the neighborhood of a pumped well is described, that is also applicable to the determination of thermal conductivity.

The method uses the ratio of the values of drawdown (or temperature) at any two times, and a graph computed from the theory. The advantage over existing procedures is that the method is available for analysis of isolated results and for small values of time. Practical examples are given. The method is not confined to the case of a line source but is also applicable to many other situations.—*D. B. V.*

177–223. Stegena, Lajos. A Nagyalföld geotermikus viszonyai [The geothermal relationships of the Great Hungarian Plain]: Geofiz. Közlemények, v. 7, no. 3–4, p. 229–238, 1958.

The vertical heat flow and geothermal gradient in the Great Hungarian Plain are analyzed, mainly on the basis of temperature measurements made on artesian wells by Sümeghy (1929). The functional relationship between temperature and depth is approximately quadratic. The average heat flow value is in good agreement with values found in other parts of the earth. A map of geothermal anomalies is constructed, and some relationships to values of the heat conduction coefficient are discussed.—*D. B. V.*

177–224. Boldizsár, T[ibor]. Geothermic investigations in the Hungarian Plain: Acad. Sci. Hungaricae Acta Geol. v. 5, no. 2, p. 245–254, 1958.

The average temperature gradient in the territory of the Hungarian Plain was determined from statistical analysis of water temperature measurements in 431 bore holes to be 4.76×10^{-4} ° C per cm. Investigation carried out in 10 boreholes to a depth of 2,000 meters gave temperature gradients ranging from 5 to 7×10^{-4} ° C per cm. The heat flow from the earth was determined as at least 1.9×10^{-6} cal per cm^2 probably 2.4×10^{-6} cal per cm^2 on the average.—*A. J. S.*

177–225. Mladenović, Milan M. Površinska geotermička ispitivanja u Kuršumliskoj Banji [Surface geothermal exploration in the Kuršumliska Banja area (with English summary)]: [Serbia] Zavod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 383–389, 1957.

The results of surface temperature measurements and electrical resitivity profiling across the Kuršumliska Banja thermal springs area in Serbia are presented. The hot springs rise along a fault zone between Paleozoic schist and Cretaceous Flysch, clearly shown by a high of 44.9° C to 56.5° C in the temperature curve and a drop in the resistivity profile. The direction of the fault zone was determined by means of the electrical measurements, and the distribution and intensity of temperature maximums and minimums by the thermal measurements. The geothermal sonde used is described with schematic diagram.—*D. B. V.*

177–226. Makarenko, F. A. Podzemniye vody—Istochnik teplovoy energii [Ground water-source of thermal energy]: Priroda, no. 9, p. 89–91, 1958.

Use of geothermal energy is now being explored in many parts of the world and for a variety of purposes. In the U.S.S.R. its use is now largely confined to health resorts. Hot waters have recently been discovered beneath the permafrost in northern and northeastern U.S.S.R. These waters reach the surface

with temperatures up to 90° C or 100° C. Many geosynclinal and platform basins contain large amounts of hot water. The West Siberian artesian basin is probably the largest of these. The Caucasus region is particularly noteworthy for basins that contain large amounts of very hot water under high pressure; temperatures range up to 150° C and 270° C. Volcanic areas of Kamchatka and the Kurile Islands are suitable for generation of electric power and for hothouse agriculture.

Extensive development of hot ground water is planned in the Soviet Union. These waters are also expected to yield large quantities of sulfur, boric acid, bromine, iodine, carbon dioxide, helium, lithium, and others as byproducts.—*J. W. C.*

177–227. Makarenko, F. A. Underground waters are source of heat energy: Current Sci., v. 28, no. 3, p. 104–105, 1959.

The hydrothermal resources of the U.S.S.R. are practically unlimited. The first general summary published on possible sources of underground hot water and steam for heating and power production recommends that more than 60 towns can be centrally heated and suggests more than 100 districts where hot underground waters should be used regionally for agricultural, residential, communal, technical, and sanitary-hygienic purposes. Use of geothermal resources could save the national economy millions of tons of fuels and relieve pressure on transport. (See also Geophys. Abs. 177–226.)—*D. B. V.*

177–228. Miroshnikov, M. V. Geotermicheskaya kharakteristika razreza Mezokaynozoyskikh otlozheniy Stavropol'skogo podnyatiya [Geothermal nature of the section of the Meso-Cenozoic sediments of the Stavropol uplift]: Ministerstvo Vysshego Obrazovaniya SSSR Izv. Vyssh. Ucheb. Zavedeniy, Neft i gaz, no. 5, 21–27, 1958.

Systematic measurements of temperature in wells have been carried out on the Stavropol uplift since the discovery there of rich gas fields in 1948. Geothermal measurements are being made in 28 wells at the present time. The geothermal "step" (depth interval per degree) was determined for individual stratigraphic horizons. The steepest gradients (8.9 to 22.4 m per °C) are characteristic of argillaceous rocks that have low thermal conductivity. The lowest gradients (40 to 60 m per °C) correspond to sandstones, limestones, and schists, which have high thermal conductivity.

Data on the geothermal gradient are presented for 11 areas of the uplift. The section is characterized by three divisions: an older, highly conducting unit (Eocene, Paleocene, and older), a middle weakly conducting unit (Maikop stage), and a younger highly conducting unit (Neogene).

In one area of the uplift, where the Paleozoic basement is closer to the surface than in the surrounding areas, the temperatures are not as high at any given depth as they are in the surrounding rocks. This lower temperature is attributed to the absence of Maikop sediments, which act as a thermal insulator in the surrounding areas.—*J. W. C.*

177–229. Von Herzen, R. Heat-flow values from the southeastern Pacific: Nature, v. 183, no. 4665, p. 882–883, 1959.

New heat-flow values are given for 18 points in the southeastern Pacific Ocean, obtained during the period October 1957–February 1958. The field technique was to measure the temperature gradient in the upper few meters of ocean floor sediment with apparatus first described by Revelle and Maxwell (see

Geophys. Abs. 152–14355) and also the thermal conductivity of a cored sample of this sediment by a transient method. Accuracy was about ± 10 percent. The East Pacific Rise appears to be associated with a narrow band of high heat flow for at least 6,000 km of its length. Areas of low heat flow appear to be roughly parallel and on each side of this high heat-flow band. The axes of trenches bordering the eastern Pacific appear to be associated with low heat flow. The range of heat-flow values—from 0.14 × 10^{-6} cal per cm^2 per sec to 8.09 × 10^{-6} cal per cm^2 per sec—is of surprising magnitude; this may be due in part to irregularities in bottom topography, or to an irregular surface of rocks of good thermal conductivity buried by a smooth sediment surface. Most of the variations are undoubtedly due to differences in heat flow from the mantle. The pattern suggests a large convective cell in the upper mantle, with the East Pacific Rise representing the rising part.—*D. B. V.*

Lloyd, E. F. The hot springs and hydrothermal eruptions of Waiotapu. See Geophys. Abs. 177–391.

Wexler, H. Geothermal heat and glacial growth. See Geophys. Abs. 177–185.

Clayton, Robert N. Oxygen isotope fractionation in the system calcium carbonate-water. See Geophys. Abs. 177–261.

INTERNAL CONSTITUTION OF THE EARTH

177–230. Shmidt, O. Yu. A theory of the earth's origin—Four lectures: Moscow, Foreign Languages Publishing House, 3d ed., 139 p., 1958.

This English language edition of the third edition of the "Four Lectures" was edited by A. Lebedinsky following Shmidt's plan for revision. Papers published between 1951 and 1955 and various manuscripts in preparation at the time of his death have been used in revising the lectures to reflect the present state of Shmidt's theory (see Geophys, Abs. 164–188). The four lectures treat, respectively, the present state of the problem, formulation of the problem, and fundamental ideas and facts; fundamental regularities of the planetary system as a result of gas-dust cloud evolution; the problem of the origin of the gas-dust cloud; and the planet earth. Three appendices give details of calculations and a bibliography of papers on the Shmidt theory.—*V. S. N.*

177–231. Berlage, H. P. The basic scheme of any planetary or satellite system corrected and reanalyzed: Koninkl. Nederlandse Akad. Wetensch. Proc., ser. B, v. 62, no. 1, p. 63–72 (part 1) and p. 73–83 (part 2), 1959.

In the first part the calculations of the basic scheme of any planetary or satellite system, developed in an earlier paper (see Geophys. Abs. 172–138), are revised. Berlage shows that all actual systems conform to the unified picture, thus supporting his theory of the origin of the planets and satellites from disks of nebular matter rotating around their primaries by the mere mechanical transformation of these disks into sets of concentric rings, through loss of energy owing to viscosity. The arrangement of the actual systems in the basic scheme and the relation between their Bode ratio and the dimensions and mean densities of their primaries are surprisingly strict. These rules suggest that a solar gaseous envelope still existed at the time when its dust content gathered into the rings which gave birth to the planets, whereas the planetary disks generating

satellite rings consisted from the beginning of solid particles. Saturn and its system probably condensed first in the solar nebula, and Pluto probably is a normal planet byond Neptune in the terrestrial class, with a mean density of 2.9.

In the second part Berlage gives a direct proof of the tendency of secondaries to revolve around their primaries at distances which obey a geometric progression. It is concluded that every satellite system crosses the basic scheme from right to left. Our moon is probably the remainder of a system to two significant satellites, the central one having been assimilated by the earth; Mars probably has assimulated a third moon. The four-significant-member systems of Jupiter and Uranus are the more normal results of satellite development.

Planetoids and plutoids are very similar bodies; the question is raised whether tektites may originate from the plutoids as stony and iron meteorites may originate from the asteroids.—*D. B. V.*

177–232. Ringwood, A. E. On the chemical evolution and densities of the planets: Geochim. et Cosmochim. Acta, v. 15, no. 4, p. 257–283, 1959.

If the planets have accreted at low temperature from a cloud of cosmic dust and gas, subsequent melting may cause reduction of metallic oxides by carbonaceous compounds trapped during accretion. The metal so produced would segregate and form a core; the higher the temperature, the higher the silicon content in this nickel-iron. The density variation of the terrestrial planets may be explained by differing degrees of reduction of the primitive nonvolatile material. Mars thus would be comprised of completely oxidized material; Mercury of highly reduced material with most of its silicon in the metal phase; and Venus, Earth, and meteorites would represent intermediate stages. The chemistry and mineralogy of meteorites support this theory of origin.

The earth's core must contain about 20 percent silicon. Its presence would explain the probable density and elasticity of the core, which are not satisfactorily explained by the properties of nickel-iron. When the metal produced near the surface segregates to form a core, it is out of chemical equilibrium with the mantle because of the high temperatures and pressures at the core-mantle boundary. Reactions between iron and nickel and between iron and silicon generate a substantial electromotive force at the boundary; this may be of importance in connection with the theory of the earth's magnetic field. Accompanying ionic diffusion effects near the boundary may cause density changes and convection in the core. Resultant changes in composition of the mantle near the boundary may be responsible for the observed change in gradient of seismic velocities. A further effect of this process is to cause a steady contraction in the volume of the core.—*D. B. V.*

177–233. Bernasconi, Carlo. Sulla variazione della densità nell' interno della Terra [On the density variation in the interior of the earth]: Geofisica Pura e Appl., v. 41, p. 19–27, 1958.

Bernasconi first considers mathematically a geoid of rotation, introducing its density by development in a power series of the radius vector ρ, with coefficients dependent on latitude. The Poisson equation is solved relative to the geoid; it is demonstrated that the potential function develops through power series even of ρ; and the effect of the terms dependent on latitude in the ratio between the moments of inertia and the variations of gravity at the surface is pointed out. Then a spherical geoid is considered and its density variations are calculated, assuming that the energy of the gravity field is the highest

possible one compatible with the present state of the earth; the result gives a central density ranging between 15 and 19 g per cm^3.—*D. B. V.*

177–234. Lehmann, I[nge]. The interior of the earth as revealed by earthquakes: Endeavour, v. 18, no. 70, p. 99–105, 1959.

The study of seismic waves resulting from earthquakes has long been a means of investigating the inner structure of the Earth. Recent improvements in recording instruments and in methods of analyzing results obtained by them have added considerably to knowledge in this field, although much still remains to be done. Analysis of the waves resulting from atomic explosions offers a new way of progress, of which some advantage has lately been taken.—*Author's abstract*

177–235. Bullen, K. E. Solidity of the inner core, *in* Contributions in Geophysics (Gutenberg volume): Internat. Ser. Mon. Earth Sci., v. 1, p. 113–120, 1958.

A summary of available evidence supports the solidity of the inner core in the sense that it is capable of transmitting *S* waves, should these be excited in it. It will be some time before PKJKP data can be used as a definite test. If the PKJKP phase can be shown to exist, the solidity of the inner core will be definitely established. If this phase fails to be detected in a sufficient number of appropriate cases, then it will follow either that the inner core is not solid, or, more probably, that the transition between the outer and inner core is gradual. More direct evidence may be forthcoming in the meantime from theoretical considerations.—*D. B. V.*

177–236. Lill, Gordon G., and Maxwell, Arthur E. The earth's mantle: Science, v. 129, no. 3360, p. 1407–1410, 1959.

Although some reasonable arguments have been presented against the project, the advantages of a borehole to the mantle would make such an undertaking entirely worthwhile. Some believe that the sectioning of ocean bottom sediments, which will afford a compressed and complete history of the ocean basin, would be as important as all other phases of the drilling program (see Geophys. Abs. 177–24). In the central Pacific the mantle, 5 km below the ocean floor, is well within the reach of present drilling equipment; the chief problem is reaching the bottom through 15,000 to 18,000 ft of water. Either a completely new drilling barge will have to be designed, or power will have to be delivered at the bottom rather than from the surface, thus eliminating that much drill stem. Choosing the site will be one of the most difficult problems. All promising areas must be investigated as to depth of the mantle; adequacy of obtainable sedimentary section; nearness to a good supply port; suitable ocean currents, swell, and water depth; and favorable prevailing weather conditions. The cost of the project is estimated at 5 million dollars, not overly ambitious compared to moon rockets and nuclear weapons.—*D. B. V.*

177–237. Ringwood, A. E. Constitution of the mantle—a revision: Geochim. et. Cosmochim. Acta, v. 16, no. 1/3, p. 192–193, 1959.

In previous papers (see Geophys. Abs. 173–241, 175–242, and 176–224) the large width of the phase transition zone in the mantle was attributed primarily to the presence of a high temperature gradient in this region combined with a high pressure gradient, dP/dT, and secondarily to solid solution effects. Sub-

sequent data show that the relative importance of these factors should be reversed. The gradient dP/dT is smaller than estimated; therefore, the width of the transition region for any plausible temperature distribution is less than previously assumed.

Studies by others have shown that solid solution effects are more important than previously supposed in spreading the transition region. It seems reasonable to attribute the transition range in the mantle largely to solid solution effects. The influence of temperature gradient is still important, but not dominant.—*D. B. V.*

177–238. Magnitskiy, V. A., and Kalinin, V. A. Svoystva obolochki zemli i fizicheskaya priroda perekhodnogo sloya [The properties of the earth's mantle and the physical nature of the transition layer]: Akad. Nauk SSSR Izv. ser. geofiz., no. 1, p. 87–95, 1959.

An attempt is made in this paper to evaluate different hypotheses concerning the physical causes of the change of seismic velocity in Bullen's transition layer C in the mantle. One of the first explanations was a change in chemical composition, corresponding to the generally assumed theory that the proportion of heavy atoms, mainly of iron, increases with depth. As this assumption led to contradictions with seismological data, a correction was introduced having the percentage of iron increase only to the depth of 500 km, but this in turn led to contradictions of the resulting properties of the underlying D layer with the seismological evidence.

Others have advanced the idea of a polymorphic change without changes in chemical composition. A stumbling block, however, is the suddenness of such changes, whereas the change in seismic velocity takes place gradually over several hundreds of kilometers.

Magnitskiy explains the changes in velocity by a modification of the substance from ionic type of bonds to covalent bonds. This change can take place gradually. Certain other physical properties could be mentioned as confirming this hypothesis. Insufficient knowledge of the state of solids under high pressure and temperature makes all conclusions on this subject still conjectural—*S. T. V.*

177–239. Zharkov, V. N. O fizicheskoy prirode volnovodov (sloyev s ponizhennoy skorost'yu) v verkhnikh oblastyakh obolochki na glubinakh 50–200 km [On the physical nature of wave guides (low velocity layers) in the upper parts of the mantle at depths of 50–200 km]: Akad. Nauk SSSR Doklady, v. 125, no. 4, p. 771–774, 1959.

On the basis of experimental data on the relationships of elastic wave velocities, internal friction, relaxation phenomena, and temperature, the temperature gradient in the mantle at a depth of 50 to 200 km is calculated to be about 1+1.5° per km, two or three times greater than the adiabatic gradient at a depth of 600 to 800 km. This is a mean value; the gradient should be somewhat higher in the upper part of this layer and lower in its lower part.—*D. B. V.*

177–240. Press, Frank. Some implications on mantle and crustal structure from *G* waves and Love waves: Jour. Geophys. Research, v. 64, no. 5, p. 565–568, 1959.

G-wave velocities for continental and oceanic paths do not differ by more than about 2 percent. Since the *G*-wave velocity is controlled by the low velocity zone in the mantle, this zone is present beneath continents and oceans. This

suggests that the composition and distribution of temperature are the same for depths greater than about 50 km under continents and oceans. The low velocity zone may be the source of the primary basaltic magma and could account for the long-period nature of *S* waves. It may also represent a zone of decoupling for relative movements between crust and mantle.

Love waves with long propagation paths recorded with long period seismographs are used to infer that the mean value of continental crustal thickness lies in the range of 32 to 37 km.—*Author's abstract*

177–241. Nishitake, Teruo. On the materials in the earth's mantle: Kyōto Univ. College Sci. Mem., ser. A, v. 29, no. 1, p. 37–46, 1958.

In this paper the elasticity of stony meteorites and its variation with metallic content is compared with that of the mantle as determined from seismic waves, density studies, and moment of inertia, to test the theory that the stony portion of stony meteorites is very similar to the materials of the earth's mantle. The density, bulk modulus, and ratio of bulk modulus to density of the stony portion are calculated for three models of stony meteorites: model *A*—average of chemical analyses of 94 chondrite meterorites (Urey, 1953), model *B*—feldspars of stony portion transformed by high pressures to jadeites and garnets (Griggs and Kennedy, 1956), and model *C*—stony meteorite showing transition from original metallic composition to oxidized form (Wahl, 1950).

The rations of bulk modulus to density and the longitudinal wave velocities for the stony meteorites obtained from the models are smaller than those obtained for the mantle from seismic observations, therefore there is no ground for assuming that the earth's mantle consists of minerals similar to those in meteorites. The variation of elasticity of the stony portion with metallic content is also very small and there is no correlation with layers in the mantle. It is concluded that the physical properties of dunite are more consistent with those of the mantle, therefore the mantle must consist mainly of dunite.—*V. S. N.*

177–242. Nishitake, Teruo. Elasticity of solids at high pressure and the earth's mantle: Kyōto Univ. College Sci. Mem., ser. A, v. 29, no. 1, p. 47–56, 1958.

The elasticity of solids under high pressure is calculated on both theoretical and experimental grounds. Two cases are considered, one based upon the assumption that the earth's mantle consists of dunite and the other that the mantle consists of periclase (MgO). The calculated elasticities of dunite and periclase are in good agreement with those obtained from seismic data in the upper and lower mantle respectively. Taking into account the effect of temperature, the existence of a low-velocity or constant-velocity layer just below the Mohorovičić discontinuity is presumed. Below the depth of 2,000 km in the lower mantle an admixture of metallic iron is probable.—*V. S. N.*

177–243. Rittman, A[lfred]. Physico-chemical interpretation of the terms magma, migma, crust and substratum: Bull. volcanol., v. 19, p. 85–102, 1958.

An interpretation of the earth's crust and substratum is given, based on the physico-chemical behavior of oceanitic (olivine-basaltic) and granitic matter. Above the Mohorovičić discontinuity, the continents consist of a grantitic upper and noritic lower layer with intermediate quartz-dioritic material, locally overlain by sediments. Below the M-discontinuity is the sima, crystalline oceanite

in piezo-facies; this is underlain by the substratum of highly viscous, seismically solid magma of oceanitic composition. Between the sima and the substratum is the "base of the crystalline crust" within the transitional zone $M + X$ (M= molten magma, X=floating phenocrysts).—*D. B. V.*

177–244. Pospelov, G. L. Ob "ochagovoy zone" zemnoy kory, "magmatogennoy korone Zemli," "arealakh magmatizma" i "strukturnykh assotsiatsiyakh intruzivov" [On the "hearth zone" of the earth's crust, the "magmatogene corona" of the earth, "areas of magmatism" and "structural associations of intrusives"]: Akad. Nauk SSSR Izv. ser. geol., no. 3, p. 19–35, 1959.

Pointing out the difficulty of accurately defining and delimiting the geological concept known as the crust of the earth, Pospelov suggests that a zone at a depth of 60 to 80 km, where near-critical energy and physicochemical conditions exist, serves as a "hearth" where tectonic and magmatic activity in the crust originate. The drop in the apparent resistivity at a depth of several tens of kilometers found by Krayev (see Geophys. Abs. 174–106) by electrical depth profiling with electrodes 50 to 75 km apart, is taken as indicating the upper boundary of the "hearth zone", whose thickness varies with time, oscillating radially. An aureole formed by magmatogenetically active masses protruding from the interior into the crust flashes into an active state at certain periods of magmatic history; by an analogy with the solar corona it is called the magmatogene corona of the earth.

The regional groups of intrusive and metamorphosed igneous bodies which appear on the face of the earth in spots and magmatically active strips are basic regional structural elements of this magmatogene corona. Such spots and strips are called "areas of magmatism" and appear as definite aggregations and associations of magmatogene formations in and on the crust and follow definite structural patterns. These regular associations of intrusives are called "structural associations", subdivided into "swarm" and "linear" associations.

After these definitions, Pospelov discusses the correlation between degree and differentiation of geotectonic movements, and the petrographic types within specific "areas". The distribution of intrusives and the morphological scheme of structural associations are analyzed for the Altay-Sayan region and for the traps of the Siberian Platform, with a view of opening up new possibilities for interpreting complex regional structural-petrographic-metallogenetic relationships by means of an analysis of regional units of magmatism.—*A. J. S.*

177–245. Birch, Francis. Interpretation of the seismic structure of the crust in the light of experimental studies of wave velocities in rocks, *in* Contributions in Geophysics (Gutenberg volume): Internat. Ser. Mon. Earth Sci., v. 1, p. 158–170, 1958.

The experimental data on the velocities of elastic waves in granites and gabbros at high pressures are summarized, corrected for temperature, and compared with several recent studies of the variation of seismic velocity within the continental crust. The seismic velocities fall in most cases between the values for average granite and average gabbro. Distributions showing a gradual increase of velocity with depth are easily interpreted in terms of an increasing gabbroic component; difficulties arise in attempting to account for low-velocity layers within the crust. Solutions in terms of granite and gabbro are not

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unique, since the same velocities are exhibited by rocks, especially metamorphic rocks, of different composition.—*Author's abstract*

177–246. Richards T. C., and Walker, D. J. Measurement of the thickness of the earth's crust in the Albertan plains of western Canada; Geophysics, v. 24, no. 2, p. 262–284, 1959.

This is the complete paper, of which two preliminary versions have been published elsewhere (see Geophys. Abs. 174–235 and 176–232).—*D. B. V.*

177–247. Hersey, J. B., Bunce, Elizabeth T., Wyrick, B. F., and Dietz, F. T. Geophysical investigations of the continental margin between Cape Henry, Virginia, and Jacksonville, Florida: Geol. Soc. America Bull., v. 70, no. 4, p. 437–466, 1959.

Forty seismic refraction and reflection profiles on the eastern continental shelf and adjacent deep-water areas of the Atlantic Ocean, from lat 29°39′ to 36°30′ N., long 73°30′ to 81°10′ W., trace the transition from deep-oceanic to continental-type structures. The transitional area divides naturally into three parts: the continental shelf, the Blake Plateau, and the adjoining deepwater area.

The deepest horizon traced on the shelf is interpreted as the granitic basement, with longitudinal velocities of 5.82 to 6.1 kmps; at the southern end it is 6 km deep, near Cape Fear only 0.86 km, and north of Cape Hatteras over 3 km. On the Blake Plateau several layers with velocities ranging from 1.83 to 4.5 kmps are interpreted as sedimentary; a 5.5-kmps layer, found only south of a line from lat 30°30′ N., long 78° W. to Cape Canaveral, and a 6.2-kmps layer appear to form a positive feature to the south of this line; higher velocities (8.0 kmps and 7.28 and 7.3 kmps) found at markedly different depths are not the same horizon, but possibly represent the M layer and ultrabasic material.

The deepwater area is a continental slope and rise modified by the Blake Plateau and by a ridge trending southeastward from Cape Fear and deepening from 1,500 to more than 2,000 fathoms (3,657 m). The ridge is underlain by thick sediments (1.83 to 2.96 kmps) and higher velocity layers having the same linear trend as the ridge. At its northwest end this trend terminates against a thick lower velocity section interpreted as a sediment-filled trough. South of the ridge the profiles are similar to those of ocean basins. Evidence of faulting indicates subsidence of the ridge relative to its surroundings.

Attention is drawn to similarities to the structural pattern of the Japanese Archipelago-Ryukus-Bonin Ridge and of Exuma Sound and the Tongue of the Ocean in the Bahamas.—*D. B. V.*

177–248. International Geophysical Year Bulletin (No. 21). Seismic studies in the Western Caribbean: Am. Geophys. Union Trans., v. 40, no. 1, p. 73–75, 1959.

Seismic-refraction measurements were made in the Caribbean area before and during the IGY to study the crustal structure of an island-arc province in order to determine its relationship to ocean-basin and continental structure. Thirty-eight profiles represent the first submarine structural data in the western Caribbean. In general the crustal thickness varies with water depth, a thin crust being associated with deep water and a thicker, more complicated crustal section with shallower waters. Minimum thickness is in the Cayman Trough (0.5 km sediment and 3.2 km of crustal rocks) whereas in some of the shallower areas the thickness was greater than could be penetrated by the equipment used.

It is not certain whether the Caribbean area is rising or subsiding. Structure resembling an ocean basin (Canyon Trough) and structure resembling a continental mass (Nicaraguan Rise) are both found along the cross section within 80 miles of each other. Depth to the mantle under the latter has been estimated as at least 20 to 25 km, almost within the range of continental structure.—*D. B. V.*

177–249. Hales, A. L., and Sacks, I. S. Evidence for an intermediate layer from crustal studies in the Eastern Transvaal: Royal Astron. Soc. Geophys. Jour., v. 2, no. 1, p. 15–33, 1959.

Observations of the traveltimes of waves from Witwatersrand earth tremors along a route in the eastern Transvaal are reported in this paper. It is considered that the most satisfactory interpretation is that the crust is two-layered. The velocities in the granitic layer are 6.0 and 3.6 kmps for *P* and *S* waves respectively. In the intermediate layer the *P* velocity lies between 6.7 and 7.2 kmps, and the *S* velocity between 3.95 and 4.15 kmps. The P_n velocity was found to be 7.96 kmps and the crustal thickness 36.6 km.

It was found that P_n arrivals at stations close to sea level were early with respect to the traveltime found for the plateau at a height of about 1,750 m.—*Authors' summary.*

177–250. Rothé, J[ean] P[ierre]. Quelques expériences sur la structure de la croûte terrestre en Europe occidentale [Some experiments on crustal structure in western Europe] *in* Contributions in Geophysics (Gutenberg volume): Internat. Ser. Mon. Earth Sci., v. 1, p. 135–151, 1958.

Some explosion seismology results for Germany and France are compiled and compared. These include the explosions at Haslach in 1948, Camargue in 1949, Champagne and Blaubeuren in 1952, and French Alps in 1956 (see Geophys. Abs. 138–11294, 144–12548, 147–13141, 173–136, –137, –138, –139, and 177–102). Results obtained from observations of natural earthquakes can be reinterpreted in the light of the explosion data; precise traveltime tables can be calculated from the latter.—*D. B. V.*

177–251. Caloi, Pietro. La crosta terrestre, dagli Appennini all' Atlantico, ricostruita sulla base dei rilievi sismici [The earth's crust, from the Apennines to the Atlantic, reconstructed on the basis of seismic surveys]: Annali Geofisica, v. 11, no. 3–4, p. 249–264, 1958.

The first part of this paper is mainly an outline of the methods used to calculate crustal structure from seismic data. Then some results are quoted, particularly from the central and southern Alps, Apennines, Po valley, and much of Württemberg (Germany). *Pg* wave velocities are greatest under the Alps (5.7 or 5.8 kmps), least under the Po valley and northern Germany (5.1 kmps). The thickness of the granitic layer is 6 km in northern Germany, 10 km in the Po valley, 13 km in the southern Alps, 18 km in Württemberg, and 25 in the north-central Apennines.

Longitudinal wave velocities have not been accurately determined for the succeeding crustal layer (*P**). In general they average 6.45 kmps, vary from 6.1 to 7 kmps. The variations probably reflect the existence of at least two layers beneath the granite, an intermediate (basalt) layer with velocity of 6.1 kmps and a gabbro layer with a velocity of 7 kmps; all European seismic stations show three discontinuities, the base of the crust and two higher boundaries.

Total thickness of the crust is greater under mountains (50 to 55 km under the central Apennines and 40 to 45 km under the southern Alps). The root of the southern Alps (Cansiglio) seems to be formed of the intermediate layer. The crust in the Po valley and Württemberg is not much more than 30 km thick, and in the Atlantic Basin it is about 17 km. The granitic layer diminishes considerably beneath the large seas and is probably absent beneath the Tyrrhenian Sea as in the North Atlantic. The Po valley is filled with 3 to 7 km of sediments.

In the upper mantle, P_n velocity tends to increase decidely at about 120 km; this depth constitutes the axis of the asthenosphere.—*D. B. V.*

Press, Frank. Seismic exploration of the earth's crust. See Geophys. Abs. 177–101.

ISOTOPE GEOLOGY

177–252. Johansson, Sven A. E. On the influence of cosmic radiation on the isotopic composition of the elements: Tellus, v. 11, no. 1, p. 101–105, 1959.

A great number of stable as well as radioactive isotopes are produced by cosmic ray reactions with atmospheric atomic nuclei. The former can be detected only by changes they might cause in the isotopic composition of the elements. The changes in the isotopic abundance of lithium–6, neon–21, and argon–36 that are produced in this way are calculated to be 0.03, 0.02, and 0.02 percent of their total abundances, respectively; these changes are small but not negligible.

If mean cosmic ray intensity in the past has been the same as at present, the changes in isotopic composition are barely detectable, and would probably be masked by other effects. If cosmic ray intensity during the earlier stages of the earth's evolution was higher than at present, easily detectable changes in isotopic composition are to be expected. In this connection it is important to note that the magnetic field of the earth reduces average cosmic ray intensity by almost a factor of 10; if the magnetic field of the past was weaker, it would imply higher cosmic ray intensity at that time.—*D. B. V.*

177–253. Gerling, E. K., Levskiy, L. K., and Afanas'yeva, L. I. O nakhozhdenii Ar^{38} v mineralakh, soderzhashchikh kaliy [On the discovery of A^{38} in minerals containing potassium]: Akad. Nauk SSSR Doklady, v. 109, no. 4, p. 813–815, 1956.

From data on 11 samples (8 micas, 2 granites, 1 sylvite) it is concluded that the accumulation of argon–38 in potassium minerals is best explained as the result of disintegration of the long lived isomer potassium–38. The relationship of argon–38 to potassium is exponential: $Ar^{38}/K=1\times10^{-10}(e^{0.9\times10^{-9}t}-1)$, where t=time in years, $0.9\times10^{-9}=\lambda$ K^{38}, $K^{38}=1\times10^{10}$ g per g K.—*D. B. V.*

177–254. Broecker, W[allace] S., and Walton, A. The geochemistry of C^{14} in fresh-water systems: Geochim. et Cosmochim. Acta, v. 16, no. 1/3, p. 15–38, 1959.

The processes controlling the carbon–14 concentration in dissolved bicarbonate of fresh water systems have been investigated in order to allow more precise estimation of the initial C^{14}/C^{12} ratio in materials formed in such systems in the past. This ratio is controlled by two factors, the relative amounts of silicate

and carbonate minerals dissolved by the system and the rate of exchange of carbon dioxide across the water-air interface.

Measurements were made on samples from the Great Basin. As expected, the initial C^{14}/C^{12} ratio of the bicarbonate in streams flowing over igneous rocks is close to that of atmospheric carbon dioxide. The carbon dioxide exchange rates across the surfaces of Mono, Walker, Pyramid, and Great Salt Lakes are similar. An exchange rate for lakes within the range of 2 to 15 moles per m^2 per yr is suggested; these values are consistent with published estimates for the average exchange rate for the oceans.

Accuracy of data on the C^{14}/C^{12} ratio in samples formed in ancient Lake Lahontan is ±5 percent, whereas error for random fresh water samples is probably as great as ±20 percent. It is concluded that the considerable uncertainty that must be attached to carbon–14 ages on random fresh water materials can be reduced to the level of laboratory error by detailed studies such as this.—*D. B. V.*

177–255. Clayton, Robert N., and Degens, Egon T. Use of carbon isotope analyses of carbonates for differentiating fresh-water and marine sediments: Am. Assoc. Petroleum Geologists Bull., v. 43, no. 4, p. 890–897, 1959.

In order to investigate the application of stable isotopic abundance measurements as possible environmental indicators, carbon and oxygen isotope analyses of the carbonate fraction were made on samples of limestone, sandstone, shale, and some fossil shells. As there is evidence that the isotopic exchange processes which destroy the original record are less extensive for carbon than for oxygen isotopes, the problem was to determine first, the differences in oxygen and carbon isotope abundances between modern fresh-water and marine carbonates and second, the preservation during geologic time.

The difference between modern marine and nonmarine carbonate shells was found to be considerable, fresh-water specimens having less oxygen–18 than marine. The δ carbon-13 of nonmarine carbonates is also markedly lower. All investigated Paleozoic limestones showed lower oxygen–18 values than recent carbonates. In Paleozoic fresh-water limestones the oxygen isotope composition is very similar to the marine range. The C^{13}/C^{12} ratio in all fresh-water samples is consistently lower than in the marine group; unlike oxygen, a large part of the original differences in carbon isotope ratios are preserved back to Paleozoic time.

More sandstone analyses are needed to establish unambiguous criteria, as the number of analyses was small; many marine sandstones contained too little carbonate to provide a big enough carbon dioxide sample for analyses. Among sandstones with >1 percent calcium carbonate the difference in δ carbon–13 between marine and fresh-water samples is more pronounced than in limestones. There also appears to be a slight depletion of oxygen–18 in fresh-water samples. In shales, marine rocks average slightly higher in oxygen–18 than fresh-water or brackish, but there is considerable overlap. No consistent difference in C^{13}/C^{12} ratios was found for various environments. Several reasons why the carbon isotope ratios in shales do not reflect the geologic environment are discussed.—*D. B. V.*

177–256. Fonselius, Stig, and Östlund, Göte. Natural radiocarbon measurements on surface water from the North Atlantic and the Arctic Sea: Tellus, v. 11, no. 1, p. 77–82, 1959.

An apparatus for extracting carbon dioxide from 100 liters of sea water using carbon-free sodium hydroxide solution as absorbent liquid, and its performance, are described. Then the results of test determinations of the carbon–14 and carbon–13 contents and age of 6 samples of surface water from the North Atlantic and Arctic Oceans are tabulated. The carbon–13 values are practically constant (fractionation factor Δr=2.4 to 2.5 percent). Carbon–14 values are more variable. There appears to be a slight correlation between salinity and relative activity. Comparison of these results with those obtained by the Lamont and New Zealand dating laboratories (correcting for differences in standards) shows that there are no significant differences in the carbon–14 age of open sea surface waters from the South Pacific and North Atlantic, except for a sample at the ice border, which is Arctic water. Shallow water at Makara, New Zealand, shows an excess of carbon–14 in comparison with open sea water.—*D. B. V.*

177–257. Singer, S. F. Crucial experiment concerning the origin of meteorites: Phys. Rev., v. 105, no. 3, p. 765–766, 1957.

It is suggested that the He^3/He^4 ratio of iron meteorites be measured after the samples have been heated. It is anticipated that the ratio will be greater than in corresponding unheated samples. Results of such experiments are of importance in dating the breakup of the meteorite's parent planet as well as for estimating the value of the prehistoric cosmic-ray flux.—*Author's abstract*

177–258. Craig, Harmon. Distribution, production rate, and possible solar origin of natural tritium: Phys. Rev., v. 105, no. 3, p. 1125–1127, 1957.

The production rate of tritium is calculated to be about 1±0.5 atom per cm^2_c per sec (cm^2_c=cm^2 of earth's surface). This cannot be accounted for by present estimates of the contribution from cosmic rays; the discrepancy is about one order of magnitude. The cross section for production of protons in N_2 and O_2 has been found to be the same, within experimental error, at 450 mev and 2.2 bev; thus it appears unlikely that cosmic ray production can account for the tritium flux into the atmosphere. A possible solar contribution is suggested.—*D. B. V.*

177–259. Begemann, F[riedrich]. Neubestimmung der natürlichen irdischer Tritiumzerfallsrate und die Frage der Herkunft des "natürlichen" Tritium [New determination of the natural terrestrial decay rate of tritium and the question of the origin of "natural" tritium]: Zeitschr. Naturforschung, v. 14, no. 4, p. 334–342, 1959.

The lower limit of the terrestrial decay rate of "natural" tritium is determined, from measurements of the tritium content of snow samples from Greenland, as 1 tritium atom per cm^3 per sec; this is about 10 times higher than earlier calculations, and thus confirms the findings of Craig (see Geophys. Abs. 177–258) and Begemann and Libby (see Geophys. Abs. 171–222) that the decay rate is substantially higher than has been assumed. Two mechanisms to explain the discrepancy are discussed: production by low energy cosmic radiation, and accretion of solar tritium by the earth. In the first case the tropospheric production rate should vary in antiphase with the sunspot cycle, in the second it should vary in phase. In both cases there will be a phase shift depending on the residence time of tritium in the atmosphere; measurement of this shift will give the residence time. Preliminary results favor the first mechanism, but more measurements are needed before definite conclusions can be drawn.—*D. B. V.*

177–260. Ehrenberg, H., Horlitz, G., and Geiss, J[ohannes]. Beziehungen zwischen dem Modellalter des Bleis, dem Gehalt an Spurenelementen des Bleiglanzes und der geologischen Geschichte einiger Bleierzlagerstätten Westdeutschlands [Relationships between the model age of the lead, the trace element content of the galena, and the geologic history of some lead ore deposits of West Germany]: Deutsch. Geol. Gesell. Zeitschr., v. 110, pt. 3, p. 474–490, 1958.

The model ages of lead from 61 samples of lead ores from 7 districts in West Germany have been newly and more accurately calculated, and are compared with the silver, bismuth, antimony, and copper contents (determined spectrochemically) for 35 samples. The silver content is shown to be fairly representative of the total trace element content. In contrast to the relationships found in the lead ores of North Africa and the Alps (see Geophys. Abs. 175–261), it was not possible to find a critical value or interval which could distinguish regenerated lead from unregenerated, probably because there are three ore epochs to be considered (Calendonian, Variscan, and Tertiary), rather than the simple case of later Tertiary regeneration of Paleocene mineralization as in the earlier study. Comparison of the silver content with model age by individual districts shows that the silver content is generally lower in anomalous leads than in ordinary leads, but the difference is not as marked as in the North African and Alpine ores; there are several exceptions to the rule.—*D. B. V.*

177–261. Clayton, Robert N. Oxygen isotope fractionation in the system calcium carbonate-water: Jour. Chem. Physics, v. 30, no. 5, p. 1246–1250, 1959.

The oxygen isotope exchange reaction between water and calcium carbonate has been studied over the temperature range 190°C to 750°C. Equilibrium constants for the reaction have been measured and fit the equation $ln\ K=2725\ T^{-2}$ (T is absolute temperature). Isotopic data on the system calcite-water alone are of use in determination of geologic temperatures only if both phases are available for analysis. In nature this is likely to be true only for recent samples of sediments, hot spring deposits, and the like. It may prove applicable to hydrothermal rocks if it can be demonstrated that some fluid inclusions represent trapped samples of hydrothermal fluid without subsequent alteration of the oxygen isotopic composition. The sensitivity of this system as a geological thermometer at high temperatures can be estimated, assuming that the isotopic fractionation between the two phases can be determined with sufficient accuracy; error is found to range from ±0.8° at 0°C to ±76° at 1,000°C. This is an indication of what to expect in other systems where the isotopic fractionation is of similar magnitude, as in calcite-magnetite and quartz-magnetite.—*D. B. V.*

177–262. Degens, Egon T. Das O^{18}/O^{16}-Verhältnis im Urozean und der geochemische Stoffumsatz [The O^{18}/O^{16} ratio in the primordial ocean and the geochemical exchange of matter]: Neues Jahrb. Geologie und Paläontologie Monatsh., no. 4, p. 180–186, 1959.

The primordial δ oxygen-18 composition of the seas is +2 to +3 relative to present ocean water. The lower $O^{18}/^{16}$ ratio of today is the result of sedimentation during earth history. A change of 1 per mil is equivalent to the formation of about 50 kg per cm^{-2} of clays and carbonates; the products of chemically unaltered residues of weathering (sandstones, conglomerates, and breccias) have no effect on the oxygen isotope ratio in the oceans.—*D. B. V.*

177–263. International Geophysical Year Bulletin (No. 21). Oxygen isotope studies: Am. Geophys. Union Trans., v. 40, no. 1, p. 81–84, 1959.

Oxygen isotope ratios provide a means for identifying annual accumulation layers in Antarctic ice bodies where other methods fail. A study of the O^{18}/O^{16} ratio in ice cores from deep drill holes at Byrd and Little America IGY stations is expected to provide a record of relative climatic change during the past 500 to 1,000 years.

The ratios in firn and in ice from Greenland, Blue Glacier (Washington), and the IGY South Pole station are also being studied. Preliminary results confirm the basic premise of temperature control and show differences between firn and ice and between clear blue ice and bubbly blue ice.—*D. B. V.*

177–264. Goel, P. S., Narasappaya, N., Prabhakara, C., Thor, Rama, and Zutshi, P. K. Study of cosmic ray produced shortlived P^{32}, P^{33}, Be^{7}, and S^{35} in tropical latitudes: Tellus, v. 11, no. 1, p. 91–100, 1959.

The fallout rate from short-lived isotopes phosphorus-32 and phosphorus-33, beryllium-7, and sulfur-35, produced in collisions of cosmic ray particles with air nuclei, has been measured at a number of stations in India and compared with the calculated rate of production. In the case of beryllium-7 the agreement between the calculated and measured values is good. The fallout rates of phosphorus-32 and phosphorus-33 are not inconsistent with the calculated values, but that of sulfur-35 is about five times higher than expected.

Absolute concentrations of an individual isotope in various rainfalls varied by more than a factor of 40, but relative concentrations of the different isotopes stayed within narrow limits. The periods of irradiation of various air masses between two successive rainfalls were calculated from the ratio of the concentration of beryllium-7 to phosphorus-32 in individual samples; the mean period of irradiation was found to be about 35 days. The results of this study are consistent with the view that in tropical latitudes intrusions of stratospheric air into the troposphere are rare or weak. The method seems capable of further development into a tool for studying meteorological problems.—*D. B. V.*

177–265. Voshage, H., and Hinterberger, H. Die Kalium-Isotope als Reaktionsprodukte der kosmischen Strahlung in Eisenmeteoriten Carbo [The potassium isotopes as reaction products of cosmic radiation in the Carbo iron meteorite]: Zeitschr. Naturforschung, v. 14a, no. 2, p. 194–195, 1959.

The potassium–39, –40, and –41 contents of the Carbo iron meteorite are determined as 79.5, 4.8, and 15.7 percent, respectively. The first is entirely of common origin, the second is almost completely cosmogene, and the third is 5.9 percent common and 9.8 percent cosmogene.

Gerling, Levsky, and Afanas'yeva (see Geophys. Abs. 177–253) have postulated a long-lived potassium–38, produced by spallation in proportion to potassium–40. The results obtained by Voshage and Hinterberger would require a K^{38}/K^{40} production ratio of $<3.5\times10^{-3}$, calculated on the basis of the assumptions used by Gerling and his colleagues; as this ratio is completely unlikely according to our knowledge of spallation, the existence of potassium–38 is questionable.—*D. B. V.*

177–266. Amstutz, G. C. New sulfur isotope ratios from South American volcanoes: Tschermaks mineralog. petrog. Mitt., v. 7, no. 1–2, p. 130–133, 1959.

Four new sulfur isotope ratios are given for native sulfur from Peru (interstitial between crystals, Cerro de Pasco Mine, $S^{32}/S^{34}=22.9\pm0.04$: Yucumani volcano, 22.33 ± 0.04; Huancane volcano, 22.47 ± 0.04; Achacolla volcano, 22.54 ± 0.04). It is shown that isotope distributions are best presented by means of histograms. Such histograms add probability to the distribution field and allow more reliable comparisons, and the shape of the histograms is itself significant and points to tendencies of differentiation or fractionation.

Comparison of isotope abundance from various areas and various petrographic provinces suggests that isotope ratios may vary with geographic location and (or) rock type. It is perhaps significant that in general the spread shown in the histogram corresponds to a spread over the earth's crust, but many more values are needed before any firm conclusion can be drawn.—*D. B. V.*

177–267. Petrovskaya, N. V., Grinenko, L. N., and Chupakhin, M. S. Opyt primeneniya isotopnogo analiza sery pri izuchenii mednokolchedannogo mestorozhdeniya uchaly (yuzhnyy Ural) [Attempt at the use of sulfur isotope analysis in studying the Uchala copper-pyrite deposit (southern Urals)]: Geokhimiya, no. 8, p. 727–734, 1958.

Sulfur isotope analysis of minerals from the Uchala copper-pyrite deposit in the southern Urals shows that the pyrite and copper-zinc ores belong to different stages of mineralization. Similarity of the isotopic composition of the pyrite of both massive and disseminated ores suggests a common source of the solutions which formed them.—*D. B. V.*

MAGNETIC FIELD OF THE EARTH

177–268. Tamao, Tsutomu. Hydromagnetic disturbances in the earth's core: Tōhoku Univ. Sci. Repts., ser. 5, v. 10, no. 3, p. 137–145, 1959.

Small hydromagnetic disturbances in a semi-infinite conducting layer are discussed mathematically in connection with the time-dependent parts of the internal geomagnetic field—the nondipole fields, secular variation, and westward drift. In view of the strongly stabilizing effect of the Coriolis force and of the large toroidal field in the core, it is concluded that these time-dependent phenomena originate directly in the upper boundary layer of the core, even if the core is fluid.—*D. B. V.*

177–269. Warwick, James W. Some remarks on the interaction of solar plasma and the geomagnetic field: Jour. Geophys. Research, v. 64, no. 4, p. 389–396, 1959.

A brief review of the magnetohydrodynamic and ion-cloud theories of magnetic storms and auroras suggests some difficulties, principally connected with the small scale of magnetic disturbances from point to point on the earth's surface. Currents flowing in ion clouds closer than one earth's radius from the surface of the earth appear to be necessary to explain the difficulties. The principal conclusion of this paper is that such currents will flow in plasma sheets moving along the curved magnetic lines of force as a condition of dynamic balance of centripetal forces. Furthermore, these currents produce perturbation fields of the size and direction required to explain storm-time geomagnetic variations.

The plasma involved is assumed to enter the region near the earth through "horns" in incident ion clouds. The material flowing into the horns follows the lines of force to the auroral zone. Finally, these horns are supposed to develop into sheets, mathematically generated by the rotation of a line of force to the

auroral zone about the earth's magnetic dipole axis. Plasma flowing along such sheets performs trajectories that concentrate in the midnight hemisphere. The high energies of auroral particles follows from the headlong collisions of such clouds in the night sky.—*Author's abstract*

177–270. Whitham, K[enneth], Loomer, E. I., and Dawson, E. Recent studies of the north magnetic dip pole: Arctic, v. 12, no. 1, p. 28–39, 1959.

Available scientific data are reexamined to provide the best possible estimate of the secular motion of the north magnetic dip pole and to determine its position for the world declination charts, epoch 1960.0. Data from an extended series of continuous three-component magnetic records from the observatory at Resolute, from a series of isomagnetic charts for Canada for epoch 1955.0 made by Loomer during the northwest passage cruise in 1954, and from observations by Serson and Whitham during arctic flights in 1953 and 1954, provide a basis for estimating the present secular drift of the dip pole and, hence, with the known position for one epoch, for estimating that for a later one. The position 74°±0.3°N., 100°±1.2°W. has been adopted for the epoch 1950.0 as the base dip pole position for such a calculation. The mean of secular drift values calculated by using charts for epoch 1955.0 from the Resolute and Dawson observatories and estimated by using potential theory with essentially the same data but with different approximations indicates a drift of 5.5 miles per yr to the north and (0.7) miles per yr to the east. The predicted movement in this decade is 0.8° in lat and 0.4° in long. Assuming the 1950.0 position, the predicted position for epoch 1960.0 becomes 74.8°±0.3°N., 99.6°±1.2°W.

Since the position of the pole depends entirely on the magnitude of the higher harmonic terms in a spherical harmonic expansion of the main field, its motion is apparently not related in any simple way to the broad-scale core motions deduced by an analysis of the eccentric dipole at different epochs. Thus, the secular motion is a consequence of secular variation and not its cause. The future motion of the pole cannot be reliably predicted at this stage because the secular variation of the earth's field cannot be predicted. Present knowledge suggests that the northward motion is likely to persist within a factor of two in magnitude for the order of 100 years. The significance of the dip pole and of the elongated shape of the isomagnetic contours in studies of magnetic disturbance is still obscure. Synoptic studies show that the axis of the dipole at the earth's center, which can be thought of as intersecting the surface of the earth at the geomagnetic poles, is of more importance in the study of aeronomy. The northern geomagnetic pole is slowly changing position; it was located at 78.3°N., 69°W., at epoch 1955.0, some 600 miles northeast of the magnetic dip pole. The possible penetration of charged particles into the ionosphere along magnetic lines of force and the interaction of the magnetic field with streams of charged particles from the sun may be partially explained by the deviation of the earth's field from that of a dipole. The position and motion of the dip pole are convenient indicators of this deviation from a dipole field.—*V. S. N.*

177–271. Elsasser, Walter [M.], and Munk, Walter. Geomagnetic drift and the rotation of the earth, *in* Contributions in Geophysics (Gutenberg volume): Internat. Ser. Mon. Earth Sci., v. 1, p. 228–236, 1958.

The question is investigated whether changes in the direction of the earth's axis of rotation relative to the crust (changes in pole position) can be explained by a mechanism of variable coupling with the core, similar to the variable magnetic coupling demonstrated between the mantle and fluid core (see Geophys.

Abs. 163–32). It is concluded that displacement of the pole of rotation due to motion in the core is negligible.—*D. B. V.*

177–272. Grenet, Gaston. Sur l'influence de la self-induction des bobinages à noyau magnétique utilizés pour l'enregistrement des variations rapides du champ magnétique terrestre [On the effect of self-induction coils with magnetic core used for recording of the rapid variations of the earth's magnetic field]: Annales Géophysique, v. 13, no. 3, p. 249–251, 1957.

In an apparatus using a coil for which self-induction is not negligible, and a more or less coupled galvanometer, the number of constants characterizing the apparatus can be reduced to four. One of these constants ($F \times l$) characterizes the amplification, another (v) the mean pulsation of the apparatus, finally only two constants (D and E) determine the form of the characteristics. It is shown how the consideration of equivalent devices without reaction or of equivalent electric circuits facilitates understanding of the observed phenomena.—*Author's summary, D. B. V.*

177–273. Thiesen, K. About the influence of magnetic disturbances on geomagnetic variometers: Geophysica [Helsinki], v. 5, no. 4, p. 177–192, no date.

Equations are established for movements of a magnetic needle in two types of magnetic disturbance, the first being a regular harmonic pulsation, the second a force given by $F=F_0t$ where F_0 is a constant and t is time. The constants of these equations are computed for variometers of La Cour type, also the ratio BC between the sensitivities in disturbed and quiet fields. It is seen from the oscillations that when damping of the needle is varied, the ratio BC has its optimum value when the logarithmic decrement $\delta=3.63$. For the field $F=F_0t$, sensitivity is the same as for a quiet field. Several quick-run records on disturbed days show small oscillations having the same period as the variometers used; these are shown to be caused by the first term in the formula for the movement of the needle, not by the last term which gives the variation of the geomagnetic field.—*D. B. V.*

177–274. Frøshaug, J. Two experimental investigations on the reliability of the QHM magnetometer for measuring the geomagnetic horizontal force: Geophysica [Helsinki], v. 5, no. 3, p. 147–149, no date.

The results are reported of two series of experiments made at the Rude Skov observatory in Denmark in order to determine the validity of the logarithmic formula of the QHM horizontal magnetometer, particularly the possible dependency of the constant C on torsion angle. It is concluded that C is independent of the torsion angle within the limits of 1γ at the geomagnetic latitude of Rude Skov, and that generally the thermometer of the instrument will show the true temperature of the magnet provided that the instrument is shielded from sudden changes in outer air temperature and from sunlight.—*D. B. V.*

177–275. Berkman, R. Ya. Pro pīdvyshchennya tochnostī heomahnītnykh vymīryuvan yakī vykonuyut'sya z dopomohoyu zalīzonashychenykh zondīv [On increasing the precision of geomagnetic measurements by means of saturated core probes (in Ukrainian with Russian and English summaries)]: Akad. Nauk Ukrayin. RSR Dopovīdī, no. 4, p. 350–353, 1957.

The variation of the earth's magnetic field is often measured differentially, the original field being compensated by means of a permanent magnet. Berkman has studied the effect of compensation produced by a permanent magnet on the zero-point stability of saturated ferromagnetic sensing elements under varying conditions of excitation. An expression is derived for the conditions of minimum error introduced by changes in excitation conditions, by means of which it is possible to calculate approximately the coordinate points indicating the center of the compensating magnet which corresponds to the minimum error. The compensating magnet should be placed asymmetrically with respect to the ferromagnetic sensing element. It is essential to keep the sensing element, especially its extremities, highly saturated; this results in a more stable magnetic field. Experimental checking of the theory showed that the zero-point drift of the instrument can be reduced by as much as 20 times.—*S. T. V.*

177–276. Fanselau, G[erhard] and Kautzleben, H. Die analytische Darstellung des geomagnetischen Feldes [The analytical representation of the geomagnetic field]: Geofisica Pura e Appl., v. 41, p. 33–72, 1959.

The geomagnetic field for epoch 1945 has been analyzed in a series of spherical harmonics to the 15th degree. It is concluded that with the observational material and analytical methods available at present it is not important to extend the development of geomagnetic potential beyond the sixth order, otherwise the coefficients computed are smaller than the limits of error. With the precision obtainable at present the permanent geomagnetic field originating in the interior can be derived fully. As in developments by others for the same epoch, the analysis tells little about the magnitude of the external part of the geomagnetic field and of a nonpotential part.

Discussion of the mean values on different spherical surfaces suggests that a plausible upper limit for the location of the sources producing the main geomagnetic field is the core boundary. The so-called structure-elements of the geomagnetic potential are considered in relation to different diameters of the earth; it is shown that in components of all magnitudes the geomagnetic field has a maximum tendency toward zonal distribution with respect to the axis of rotation. There is no recognizable connection with the major topographic relationships of the earth's surface.—*D. B. V.*

177–277. Constantinescu, Liviu. Comparabilité des valeurs normales des éléments géomagnétiques fournies pour le Bassin Carpathique par les formules hongroises et roumaines [Comparability of the normal values of the geomagnetic elements furnished for the Carpathian Basin by the Hungarian and Rumanian formulas]: Geofiz Közlemények, v. 7, no. 3–4, p. 181–194, 1958.

Analogous formulas for normal distribution of the geomagnetic field, established by Barta for Hungary and by Constantinescu for Rumania, should furnish comparable results for the Carpathian Basin. Comparison of the normal values of D, I, and H for the two countries shows good general agreement, but there are some discrepancies. These are due partly to differences in methods of analyzing the observational data, but mostly to the fact that the points of reference chosen for the two sets of formulas are too far apart and are far from centrally located within their respective countries.

Recalculation of the normal formulas is recommended, to be based on material as homogenous as possible, and with reference points as central as possible within each country. Ultimately the normal geomagnetic field can be calculated for the

entire Carpathian Basin, using the present data for Hungary and Rumania and a reference point in the center of the whole basin.—*D. B. V.*

177–278. Orlov, V. P. Magnitnyye anomalii vekovogo khoda v Sredney Azii [Magnetic anomalies of secular variation in Central Asia]: Akad. Nauk SSSR Izv. ser. geofiz., no. 10, p. 1245–1247, 1958.

High-precision magnetic surveys were made in 1947–48 and 1955 along several profiles and along two loops in Central Asia, together with precise geodetic measurements for the purpose of determining horizontal or vertical displacements of the ground. The results of these measurements show a secular variation of the vertical geomagnetic component averaging 470γ. In two sections of the Stalinobad–Kolay Khumb profile, abrupt departures from the average values of Z were noted, 500 and 445γ respectively. The comparison of magnetic data with the structural features shows that these two extreme values of Z coincide with intersections of very deep tectonic fractures showing signs of recent displacements. It is probable that a seismological study of those anomalies and their variation can establish a relationship between geomagnetic secular-variation anomalies and geologic movements; if so, magnetic observations could serve as forewarning of earthquakes.—*S. T. V.*

177–279. Gerard, V.B. The propagation of world-wide sudden commencements of magnetic storms: Jour. Geophys. Research, v. 64, no. 6, p. 593–596, 1959.

A study of the times of three sudden commencements, recorded on August 3, September 21, and November 6, 1957, respectively, at ten widely separated magnetic observatories, indicates that when main and preliminary impulses are both recorded at one place (as in the typical *SC*★) they really begin approximately simultaneously. Therefore, it would appear that in nontropical regions the rate of growth of the so-called preliminary impulse is usually greater than that of the main impulse, so that the latter is obscured until the former begins to decay.

Differences around the earth between recorded times of the first impulse, whether the sudden commencement is an *SC* or *SC*★ type, are only a few seconds, and the evidence suggests that the position of the sun controls the hemisphere in which the sudden commencement first occurs. This finding is interpreted in terms of the Singer shock-wave theory to mean that, as would be expected, the shock wave enters the auroral zone nearest the sun first and produces the sudden commencement a few seconds earlier in that hemisphere. At the equinox the sudden commencement times are roughly symmetrically distributed with respect to the geomagnetic equator.—*Author's abstract*

177–280. Zevakina, R. A. Bukhtoobraznyye vozmushcheniya geomagnitnogo polya i svyzannyye s nimi izmeneniya v ionosfere po nablyudeniyam v Murmanske [Bay disturbances of the geomagnetic field and changes in the ionosphere related to them according to observations in Murmansk]: Akad. Nauk SSSR Izv. ser. geofiz., no. 2, p. 304–310, 1959.

The geomagnetic bays observed at Murmansk have a pronounced diurnal period. During the years 1954–56 positive bay disturbances were observed mainly during the second half of the day, the negative during the first half. Most frequently the negative bays were observed during summer months, the positive during the winter. The currents producing the bay disturbances re-

corded at Murmansk change direction at about 20:00 hours (local time); before that time they flow from west to east causing positive bays; afterwards from east to west producing negative bays. The center of the currents in most cases (86 percent) is located somewhat north of Murmansk. With increasing solar activity the center of the currents is displaced southward. Most of the bays are accompanied by anomalous changes in the ionosphere. In about 50 percent of the cases the cut-off frequency of the Es layer increased to over 3 megacycles per sec. In about 25 percent of such disturbances, they were accompanied by complete absorption of radio waves.—*S. T. V.*

177–281. Herrinck, P. Sur les perturbations du champ magnétique terrestre considérés comme variations de relaxation [On perturbations of the earth's magnetic field considered as variations of relaxation]: Annales Géophysique, v. 13, no. 3, p. 211–221, 1957.

Analysis of records of the horizontal geomagnetic component at Elisabethville, Belgian Congo, for 1938–54 reveals a systematic succession of exponential phenomena: an abrupt diminution of the field, frequently of more than 100 γ, is followed by a progressive but less rapid increase up to the next abrupt diminution. The phenomenon is here called a relaxation oscillation or variation. These variations are analogous to and include the after-perturbations of magnetic storms, but they are more frequent and are subject to the 27-day recurrence tendency. Consideration of magnetic perturbations as relaxation variations permits quantitative study of these phenomena individually. Use of this method of analysis in observatory routine might help clarify the cause of the perturbations.—*D. B. V.*

177–282. Maeda, Hiroshi. On the geomagnetic S_d field: Jour. Geomagnetism and Geoelectricity [Kyōto], v. 10, no. 2, p. 66–68, 1959.

The electric field necessary to produce average disturbed-day daily magnetic variation $S_d = S_q + S_D$ is discussed, based on data from the Second Polar Year.—*D. B. V.*

177–283. Parkinson, W. D. Directions of rapid geomagnetic fluctuations: Royal Astron. Soc. Geophys. Jour., v. 2, no. 1, p. 1–14, 1959.

The vectors representing the change experienced by the geomagnetic field during short (about 20 min) intervals have a strong tendency to lie on a plane at nonpolar stations. At some places this plane is inclined to the horizontal by as much as 40°. This phenomenon is almost certainly due to some form of electromagnetic damping which inhibits rapid changes in the field in a certain direction (normal to the preferred plane).

The eddy currents causing this damping must flow either in the oceans or quite deep in the earth, probably in the upper part of the mantle. If the latter is the case, a study of the directions of geomagnetic vectors could become a powerful method of exploring the upper part of the mantle, which in turn may throw some light on the large scale tectonic systems of the earth. At present not enough is known of the regional distribution of the effect, nor of the theoretical interpretation. With modern geomagnetic recording instruments the collection of data should not be difficult. The theory, however, is complicated. It may be necessary to use model experiments to solve certain problems associated with irregularly shaped conductors.—*Author's conclusion*

177–284. Kalashnikov, A. G. Nablyudeniye bystrykh pul'satsiy geomagnitnogo polya i zemnykh tokov [Observation of rapid pulsation of the geomagnetic field and earth currents]: Priroda, no. 4, p. 59–62, 1959.

Kalashnikov discusses micropulsations of the geomagnetic field and earth currents. He describes the operations of several stations (see Geophys. Abs. 175–288) in the U.S.S.R. Variations in intensity of the geomagnetic field are recorded on a phototape, a 1-mm run of which corresponds to a variation of 0.001 gamma. It has been established from the records that the total vector of micropulsations rotates at different rates at different times. Sometimes it rotates with a period of a few tens of minutes, but more often it oscillates within a certain directed angle. *Z*-component gradients vary in both shape and amplitude even within a 1-km distance when the variations are rapid and intense.—*A. J. S.*

177–285. Duffus, H. J., Shand, J. A., and Wright, Charles [S.] Possible causes of geomagnetic fluctuations having a 6-sec. period: Nature, v. 183, no. 4673, p. 1479–1480, 1959.

Geomagnetic fluctuations in the range of 1 to 7 sec period have been observed in records of $\delta X/\delta t$, $\delta Y/\delta t$, and $\delta Z/\delta t$ nearly simultaneously at two sites some hundreds of miles apart (near Victoria, British Columbia, and Borrego, Calif.). Fluctuations of this type have been observed during the magnetically quiet time of night, associated with a characteristically damped fluctuation of about 1 to 3 min period and maximum amplitude of 0.5 to 2γ; rarely, they precede the main phenomenon by a minute or so, but more often they accompany it and may continue for some time if the general magnetic activity is maintained. Both the short and long periods are believed to be of electromagnetic origin, probably associated with the "oscillatory bursts" in earth current records examined by Troitskaya (see Geophys. Abs. 168–220).—*D. B. V.*

177–286. Duffus, H. J., Shand, J. A., Wright, C[harles] S., and Nasmyth, P. W. Geographical variations in geomagnetic micropulsations: Jour. Geophys. Research, v. 64, no. 5, p. 581–583, 1959.

Simultaneous observations of geomagnetic micropulsations made with identical equipment at two stations some 25 miles apart on Vancouver Island, British Columbia, show that significant differences consistently occur. These will have to be reconciled before any detailed comparison can safely me made bewteen the records of widely separated observatories. At the same time, the general similarity of the records suggests that the origin of the normal-daytime micropulsations (Pc's) must be either a point source more than 25 miles away or an extended source coherent over that distance.—*D. B. V.*

Kebuladze, V. V., and Lashkhi, A. S. On diurnal variations of telluric currents according to data of the Dusheti geophysical station. See Geophys. Abs. 177–30.

Kebuladze, V. V. Some data on the interrelation between telluric currents and the geomagnetic field. See Geophys. Abs. 177–30.

Kebuladze, V. V. On the relationship between regional telluric currents and the geomagnetic field. See Geophys. Abs. 177–30.

MAGNETIC PROPERTIES AND PALEOMAGNETISM

177–287. Stacey, F. D. A domain theory of magnetic grains in rocks: Philos. Mag., v. 4, no. 41, p. 594–605, 1959.

The activation theory of domain wall movements cannot explain the observed coercive forces of magnetite powders if the individual grains are considered to be divided into lamellar domains with alternately opposite directions of magnetization. Experimental data are shown to be consistent with a "rod model" in which the grains are divided into domains of square cross section extending right across the grains. This model leads to a coercive force proportional to the $-\frac{3}{4}$ power of grain diameter, in agreement with observations on powdered magnetite. An approximate calculation of the energies of the two models indicates that the rod model has the lower energy if magnetostrictive strain is more important than magnetic anisotropy in determining domain structure. It appears probable that this is the case in magnetite, and therefore that the rod model gives a better picture of the domain structure of magnetic grains in rocks.—*Author's abstract*

177–288. Collinson, D. W. Rock magnetism: Royal Astron. Soc. Occ. Notes, v. 3, no. 20, p. 203–210, 1958.

This paper is concerned chiefly with the description and interpretation of paleomagnetic directions. Methods of collection and measurement and of interpretation are discussed. Paleomagnetic data agree with geologic and paleontologic data on climatic conditions under which rocks were laid down. The mechanisms causing instability and changes of polarity are not fully understood.—*D. B. V.*

177–289. Runcorn, S. K. Rock magnetism: Science, v. 129, no. 3355, p. 1002–1012, 1959.

A review of the question of rock magnetism, discussing the physical process of magnetization of lavas and of sediments, other sources of secondary magnetization, results of paleomagnetic surveys, use of statistical methods in measuring rock magnetism, corroborative evidence from paleoclimatology including wind directions, and the hypotheses of polar wandering and continental drift.

The evidence suggests that dispersion of the continents occurred at the end of the Mesozoic, rather late in the history of the earth; if this is so it must reflect a change in the convection patterns in the mantle at that time. Such change could be the result of a gradually growing core, an idea recently postulated by Urey.—*D. B. V.*

177–290. Irving, E. Palaeomagnetic pole positions: a survey and analysis: Royal Astron. Soc. Geophys. Jour., v. 2, no. 1, p. 51–79, 1959.

The positions of the pole during different geological periods obtained from studies of the magnetism of rocks are reviewed. For the past 20 million years the results from different continents are in good agreement. For periods prior to this, the results from the same continent are still in broad agreement with one another but not with those from different continents. The meaning of this disagreement is discussed and it is concluded that explanations other than relative movements between continents (continental drift) are not promising.—*Author's summary*

177–291. DuBois, P. M. Late Tertiary geomagnetic field in northwestern Canada: Nature, v. 183, no. 4675, p. 1617–1618, 1959.

The results of paleomagnetic study of 48 samples collected in the summer of 1955 from flat-lying undisturbed vesicular basalts from four different places in northwestern Canada are shown in stereographic projection. The mean direction of these samples has been computed by reversing all the reversely polarized rocks and adding them to the normal ones; two horizontally polarized samples are considered to be anomalous, possibly owing to lightning, and are not included in the statistical analysis. The results support the basic assumption of most geophysical interpretations of paleomagnetism, namely that the average magnetic field of the earth is due to a geocentric axial dipole.—*D. B. V.*

177–292. Kawai, Naoto, and Kume, Shoichi. Observations of magnetic chronic drag over geologic time: Jour. Physique et Radium, v. 20, no. 2–3, p. 258–261, 1959.

To study the magnetic aftereffect in low fields and at room temperatures, several sedimentary rocks with unstable remanent magnetization were stored for several years at constant temperature in a fixed position with their magnetic vectors making a large angle with the geomagnetic field. Each rock was taken out from time to time and its magnetism tested by a sensitive astatic magnetometer. It was found that the direction and intensity of magnetization changed slowly and steadily with time. In the first 2 or 3 years the change took place at a rate nearly proportional to the logarithm of the time, but became slower and after 8 years appears to be frozen.

The measurements were extended back in time by study of natural samples which have long been kept under similar conditions, such as pebbles in strata or stones in old buildings or statues. It was found that in the most recently reoriented rocks, the vectors of remanent magnetization were still scattered at random, whereas in rocks reoriented earlier the vectors were all nearly parallel to the earth's field; those of intermediate date of reorientation show an intermediate distribution of vectors. The aftereffect apparently does not reach zero even in the oldest samples.

The test specimens have been found to contain a number of ferromagnetic phases with different Curie points. Plotting the line along the top of the vectors with the initial and final vectors of remanence makes an isosceles triangle model of the time change, from analysis of which it is concluded that the part of the initial vector which first alters its orientation toward the geomagnetic field is due to the domains whose Curie points are lowest; next comes the part of the vector due to those domains of next lowest Curie points, and so on in order of increasing Curie points.—*D. B. V.*

177–293. Daly, Lucien. Sur l'anisotropie magnétique dans les roches déformées, et la nature de leur aimantation rémanente naturelle [On magnetic anisotropy in deformed rocks, and the nature of their natural remanent magnetization]: Acad. Sci. [Paris] Comptes Rendus, v. 248, no. 18, p. 2614–2616, 1959.

The nature of the natural remanent magnetization of metamorphic rocks was studied using phyllites, high and low stage mica schists, and gneisses, from the Maures massif and from the Hyères islands, France, in all of which the structure is visible to the naked eye. Intensity, direction, and sign of

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magnetization were measured. The majority of specimens had total magnetic moments ranging between 1×10^{-3} and 10×10^{-3} emu. In general the natural remanent magnetization was found to lie in the plane of schistosity.

As the magnetization is very weak, it was thought it might be entirely of viscous origin, but most of it was eliminated by rotating the specimen in the earth's field, and extrapolation through geologic time gave distinctly lower values for viscous remanent magnetization than those observed. Progressive heating and demagnetization in alternating fields were then used to determine whether the magnetization was isothermal or thermoremanent; the resulting curves, though regular, did not resemble those of either. Marked anisotropy was noted.

As the natural magnetization thus has been shown to be none of these three known types, the explanation for the tendency toward the plane of schistosity must be sought in the metamorphic phenomena themselves. Recrystallization in the geomagnetic field, as has been proposed, hardly explains the tendency toward the plane of schistosity. It might be due to pressure, with or without the help of temperature; or to magnetostrictive effects due to decompression upon uplift of the rock, as suggested by Graham. This does not exclude the possibility of rearrangement by gliding within the crystal lattices.—*D. B. V.*

177–294. Graham, John W., Buddington, A. F., and Balsley, J[ames] R. Magnetostriction and paleomagnetism of igneous rocks: Nature, v. 183, no. 4671, p. 1318, 1959.

Reasons are given why the experiment reported by Stott and Stacey (see Geophys. Abs. 176–268) was not crucial; consequently, their conclusion that errors owing to magnetostriction are negligible in paleomagnetic work is not justified. The magnetic fraction of natural igneous rocks almost without exception consists of mixtures of two or more crystalline phases; distinguished magnetically by a number of parameters that are dependent on structure, composition, and particle size; the magnetic properties of the bulk samples are determined by the properties of the individual phases and by the nature of the magnetic interactions among them. The degree to which the phases have become segregated and the size scale on which the intergrowth textures have developed depend on composition, thermal history, and other factors.

The rate of unmixing, as a result of which magnetic properties of rocks change conspicuously, is easily affected by heat treatment (see Geophys. Abs 160–36, 161–41). Stott and Stacey's assumption that their experiments give realistic replicas of typical conditions in nature is not safe, except possibly for the case of some young rocks which were cooled quickly; it does not permit generalizations about the possible effect of magnetostriction in the case of samples of a dolerite sill which cooled over hundreds of years under load, remained under a load that decreased over millions of years while magnetic phases were segregating from original simpler phases, and finally were brought to the laboratory for measurement.—*D. B. V.*

177–295. Carmichael, Charles M. Remanent magnetism of the Allard Lake ilmenites: Nature, v. 183, no. 4670, p. 1239–1241, 1959.

The Allard Lake (Quebec) hemoilmenite consists of about 70 percent ilmenite and 25 percent hematite, the rest consisting largely of feldspar, pyroxene, and pyrite. The hematite has exsolved in lamellae of two distinct size ranges, most simply explained by two plateaus in the cooling curve of the deposits. It is not known whether the lamellae were exsolved before or after they passed through their Curie point (about 580°C).

Directions of remanent magnetization of samples from the deposits show a wide scatter, both in angle of declination and in magnitude of the angle of inclination, but the angles of inclination are all negative. This accounts for the strong negative anomalies in the aeromagnetic survey of the region. There is high correlation between direction of remanent magnetization of a specimen and average direction of the long axes of the hematite lamellae. This relationship was tested by dissolving the hematite lamellae out of thin sections of ore; in sections 0.2 mm thick this decreased the intensity of remanent magnetization by more than 99.6 percent.

As the present remanent magnetization of the deposits is due to the exsolved hematite lamellae and is directed in the average direction of the long axes of these lamellae, the direction of magnetization is not necessarily that of the earth's field which existed when the deposits were being magnetized. If the crystal axes were in random orientation, the geomagnetic field at the time of cooling could be determined by averaging the directions of a large number of samples; unfortunately the specimens show a marked alinement owing to stress or other geological factors. The results are probably applicable to other ilmenite deposits, and perhaps indicate that these rocks should not be used for paleomagnetic work.—*D. B. V.*

177–296. Nairn, A. E. M., Frost, D. V., and Light, B. G. Paleomagnetism of certain rocks from Newfoundland: Nature, v. 183, no. 4661, p. 596–597, 1959.

Paleomagnetic measurements have been made on samples of Precambrian and Mississippian rocks from Newfoundland. Results (tabulated) show a marked difference between mean directions of the two Precambrian collections. The pole position obtained from the Mississippian rocks lies considerably to the east of those quoted by other authors (see Geophys. Abs. 173–296, 166–284). This difference disappears if it is assumed that since the Carboniferous time, Newfoundland has been rotated about 20° counterclockwise with respect to the rest of North America; the effect of such rotation also improves the agreement of the Precambrian pole position obtained for the rest of North America (see Geophys. Abs. 173–296, 170–247).—*D. B. V.*

177–297. Roche, A[lexandre], and Cattala, L[ouis]. Remanent magnetism of the Cretaceous basalts of Madagascar: Nature, v. 183, no. 4667, p. 1049–1050, 1959.

A general study of the remanent magnetism of volcanic rocks from Madagascar has been in progress since the beginning of 1958. Of the more than a hundred oriented samples collected, 40 belong to flows or dikes (basalts, dolerites, or sakalavites) well dated as Upper Cretaceous (Cenomanian to Santonian). In some places, directions of magnetization and intensities are highly variable; it is believed that lightning is responsible for the high magnetizations. For other places directions and intensities showed good consistency. Mean values of intensity vary from 0.8×10^{-3} to 9×10^{-3} cgs units per gram. All samples are magnetized in the sense of the present geomagnetic field in Madagascar. Inclinations are systematically steeper by 2° to 10° on the east cost but generally lower (by less than 7°) in the west. Magnetic inclination increases with latitude. The pole position calculated from the values obtained is in the vicinity of Bering Strait. This is less than 1,500 miles from the American pole calculated by Runcorn. It is more likely that the discrepancy means that the

samples from America and Madagascar do not belong to exactly the same period, rather than that continental drift has occurred.—*D. B. V.*

177–298. Blundell, D. J., and Read, H. H. Palaeomagnetism of the Younger Gabbros of Aberdeenshire and its bearing on their deformation: Geologists Assoc. [London] Proc., v. 69, pt. 4, p. 191–204, 1958.

Banding and other structures in some of the basic gabbro masses intruding the Dalradian metamorphic rocks of Aberdeenshire in northeastern Scotland have been interpreted by several workers in the area as evidence that the gabbro masses have been overturned since their consolidation. Determination of remanent magnetism on 21 samples from six of the larger intrusions has shown that the direction of magnetization of all the gabbro masses is essentially the same and therefore any postconsolidation folding in unlikely to have occurred. Precautions to be observed in collecting samples of basic igneous rocks for paleomagnetic determinations and the experimental procedures used in making the determinations are discussed in detail.—*V. S. N.*

177–299. Reich, Hermann. Magnetische Geheimnisse deutscher Basaltkuppen [Magnetic secrets of German basalt summits]: Umschau, v. 59, no. 4, p. 110–112, 1959.

This is essentially a review of paleomagnetic research in Germany (see Geophys. Abs. 168–240, 170–251, 172–166, and 177–309) and of the paleogeographic implications of worldwide paleomagnetic results (see Geophys. Abs. 173–290, 175–297).—*D. B. V.*

177–300. Hargraves, Robert B., and Fischer, Alfred G. Remanent magnetism in Jurassic red limestones and radiolarites from the Alps: Royal Astron. Soc. Geophys. Jour., v. 2, no. 1, p. 34–41, 1959.

Red Jurassic limestones and radiolarites from the Kammerköhr range on the Austrian-German frontier show rather consistent remanent magnetic vectors. The average North Pole position for Lower Jurassic rocks (red limestones) is lat 53° N., long 112° E. and for Middle Jurassic rocks (red radiolarites) lat 58°.5 N., long 128° E.—*Authors' summary*

177–301. Akopyan, Ts. G. O magnitnykh svoystvakh gornykh porod Armenii [On the magnetic properties of rocks of Armenia]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy, v. 14, p. 61–75, 1955.

As a result of field work during 1950–53, data on magnetic properties have been compiled for rocks of almost all ages in the Armenian S.S.R.: Precambrian, Paleozoic, Jurassic, Upper Cretaceous, Tertiary, and Quaternary. The magnetic susceptibility of the late Tertiary and Quaternary volcanics varies between 200×10^{-6} cgs μ and 10,000 cgs μ; these basalts, andesite-basalts, volcanic tuffs, and other effusives are comparatively strongly magnetized with a high ratio of remanent to induced magnetization, $J_r/J_i=11$. As a rule the direction of magnetization of J_r does not coincide with that of J_i, often making an angle of more than 90°; sometimes these directions are exactly opposite one another. The effect of the terrain and of the character of magnetization of the volcanic rocks on the vertical component of the magnetic field is discussed. See also Geophys. Abs. 177–302.—*A. J. S.*

177–302. Akopyan, Ts. G. O paleomagnetizme izverzhennykh gornykh porod Armenii [On the paleomagnetism of igneous rocks of Armenia]: Akad. Nauk SSSR Izv. ser. geofiz., no. 8, p. 1033–1039, 1958.

During the Tertiary and Quaternary periods, intense volcanic eruptions covered almost two thirds of the area of the Armenian S.S.R. with lavas and volcanic tuffs. The magnetic properties of over 500 oriented specimens of these rocks were investigated in the laboratory. It was found that the Tertiary and Quaternary volcanic rocks are characterized by high magnetic susceptibility, averaging $3{,}740\times10^{-6}$ cgs μ and by high remanent magnetization $I_r=14{,}930\times10^{-6}$ cgs μ, 10 to 15 times greater than the intensity of induced magnetization I_i. The Armenian volcanic rocks can be divided, magnetically, into three groups: normally (obliquely) magnetized, with the vector I_r of remanent magnetization directed downward (Quaternary volcanics); inversely magnetized, with vector I_r directed upward (Upper and post-Pliocene); normally (obliquely) magnetized rocks (Paleocene–Middle Eocene and Miocene–Middle Pliocene) with vector I_r directed downward.

As a rule the vector of remanent magnetization does not coincide with the direction of induced magnetization, and may differ by as much as 90°; therefore in spite of the great intensity of the magnetization, no very strong magnetic anomalies should be observed. (Ten samples of intrusive rocks were also studied.) In these the ratio I_r/I_i averages 1.2 and the angle of inclination of the vector of I_r with the plane xOy averages 53°; reasonably intense magnetic anomalies can thus be produced.) The ratio I_r/I_i shows some correlation with age (see Geophys. Abs. 168–234 and 169–226). Some correlation was also found between direction of flow of lavas and azimuth of the vector of remanent magnetization. The results of this study confirm earlier conclusions that during the Cenozoic era the magnetic field of the earth suffered some sharp reversals keeping the same axis of magnetization. See also Geophys. Abs. 177–301.—*S. T. V.*

177–303. Deutsch, E. R., Radakrishnamurty, C., and Sahasrabudhe, P. W. Paleomagnetism of the Deccan Traps: Annales Géophysique, v. 15, no. 1, p. 1–21, 1959.

Paleomagnetic measurements on more than 400 specimens of basalt from the Deccan Traps of India suggest that India has drifted northward through 50° of latitude and rotated 25° counterclockwise within the last 70 million years. Ancient pole positions corresponding to these results differ considerably from those obtained by other workers for contemporaneous European and North American rocks, suggesting that part of the postulated movement of India has been in relation to other continents. In all localities poles corresponding to the upper rocks are nearer the present geographic poles than those from the lower flows; the discrepancy may represent a northward drift during formation of the traps, but further data are necessary.

The investigation is being extended to older rocks, starting with the Rajmahal Traps (Jurassic?) in Bengal Province. The possibility of dating rocks by comparison of their direction of magnetization with a "standard" direction is also suggested.—*D. B. V.*

177–304. Wen-you, Chang, and Nairn, A. E. M. Some paleomagnetic investigations on Chinese rocks: Nature, v. 183, no. 4656, p. 254, 1959.

Paleomagnetic measurements have been made on 8 samples from the Tertiary Kansu series from 3 sites and on 3 Middle Silurian siltstones from southern Yumen, in Kansu province, China. The Tertiary rocks proved to be magnetically unstable, with low magnetization and scattered results. The measurements on the Silurian rocks were more consistent, giving a mean declination of N. 66.4° W., mean inclination +55.3°, with a circle of confidence of 8.5° calculated from 17

measured disks. Mean intensity of magnetization was $8.8 \pm 3.8 \times 10^{-6}$ emu per cm^3. The pole position was long 168° W., lat 49° S. or long 12° E., lat 49° N., compared to the Silurian pole for North America of long 138° E., lat 19° N. and for Europe (by extrapolation) of long 165° E., lat 22° N. Differential movement is implied; when Gondwanaland was a single unit, China at least was not part of the Laurasian continent.—*D. B. V.*

MAGNETIC SURVEYS

177–305. Smith, R. A. Some depth formulae for local magnetic and gravity anomalies: Geophys. Prosp., v. 7, no. 1, p. 55–63, 1959.

This paper discusses formulas for magnetic anomalies, analogous in some respects to that of Bullard and Cooper (1948), that can be applied to the readings of either a vertical magnetometer or a total-field magnetometer (or a gravimeter) to yield a maximum possible value for the depth below the earth's surface of the top of the body producing the anomaly. Some new formulas for gravity anomalies are given as a special case. A negligible amount of calculation is required.—*D. B. V.*

177–306. Price, Charles E. Magnetic dipole nomograms: Geophysics, v. 24, no. 2, p. 330–334, 1959.

Two nomograms or alignment charts are presented for the solution of the magnetic-dipole equations for magnetic intensity over a dipping dipole $\Delta z = -m(d_1/r_1^3 - d_2/r_2^3)$ and $\Delta h = -m(e_1/r_1^3 - e_2/r_2^3)$. The two charts are used in conjunction with each other and are as accurate as is needed for fieldwork. One of these charts will be found useful also in other calculations involving d/r^3.—*Author's abstract*

177–307. Strakhov, V. N. K teorii dvumernoy zadachi magnitorazvedki [On the theory of the two-dimensional problem of magnetic exploration]: Akad. Nauk SSSR Izv. ser. geofiz., no. 2, p. 244–253, 1959.

Theoretical magnetometry deals with two classes of problems, the direct and the inverse. The most convenient mathematical method for the interpretation of two-dimensional magnetic anomalies (the inverse problem) is the theory of functions of complex variables. Strakhov develops the fundamental relations of the theory of the magnetic field, introducing the concept of the complex potential of the magnetized body, the effective complex field intensity, and the components of the vector of the effective field strength.—*S. T. V.*

177–308. Stupak, M. [N.] K., and Tyapkin, K. F. Interpretatsīya deyakykh mahnītnykh ī hravītatsīynykh anomalīy Kryvorīz'-koho typu [The interpretation of certain magnetic and gravitational anomalies of the Krivoy Rog type (in Ukrainian with English and Russian summaries)]: Akad. Nauk Ukrayin. RSR Dopovīdī, no. 7, p. 768–771, 1958.

An analytical method is given for determining the depth of the upper boundary and the horizontal thickness of an inclined layer from magnetic measurements, where direction of magnetization is arbitrary. The method can also be used for the interpretation of gravitational anomalies produced by bodies of similar geometric configuration. In combined magnetic and gravitational surveys the method may be used to determine the dip of the stratum and the direction of

the vector of magnetization. This eliminates the very expensive electric procedure ordinarily used in determining the depth of disturbing bodies.—*S. T. V.*

Zidarov, D. Experimental solution of the inverse gravimetric and magnetometric problem. See Geophys. Abs. 177–196.

Hope, E. R. Geotectonics of the Arctic Ocean and the Great Arctic Magnetic Anomaly. See Geophys. Abs. 177–378.

177–309. Kutscher, Fritz. Angewandte erdmagnetische Messungen in Hessen. 5. Verfolgung einer Basaltspalte bei Dietges i.d. Rhön (Blatt Kleinassen Nr. 5425) [Applied geomagnetic measurements in Hesse. 5. Tracing a basalt dike near Dietges-in-the-Rhön (Kleinassen quadrangle, no. 5425)]: Hesse Landesamt für Bodenforschung, v. 85, p. 420–424, 1957.

A magnetic survey showed a striking long narrow anomaly in the Buntsandstein area east of Dietges in the Rhön mountains of Germany. This is interpreted as a buried basalt-filled fissure zone. Magnetic investigation of the numerous isolated basalt occurrences in the less immediate vicinity of Dietges should throw light on the age relations and origin of the basalt volcanism.—*D. B. V.*

Scheffer, Viktor. The problem of the ancient Transylvanian massif. See Geophys. Abs. 177–214.

177–310. Jančić, Toplica, and Jovanović, Vlastimir. Geomagnetno ispitivanje titanomagnetitskih pojava jugozapadno od sela Mitrašinci u Makedoniji [Geomagnetic exploration of titanomagnetite occurrences southwest of the village of Mitrašinci in Macedonia (with English summary)]: [Serbia] Zarod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 411–420, 1957.

A magnetic survey was made in 1956 of the titanomagnetite ore southwest of Mitrašinci in Macedonia province of Yugoslavia. The ore occurs as an impregnation of iron and titanium minerals in amphibolites and amphibolitic schists, or as massive concentrations of titanomagnetite. From the shape, extent, and intensity of the anomalies it is concluded that the ore bodies are thin and shallow, and can easily be explored by trenching. The survey further shows that the bodies are not continuous but are frequently interrupted by granite intrusions or faults. The Konjičke Rid and Dlga Poljana ore deposits, most promising so far, were not visible at the surface but were discovered by the survey. A possible extension of the mineralized area toward the southwest is also suggested.—*D. B. V.*

177–311. Jančić, Toplica, and Jovanović, Vlastimir. Rezultati geofizičkog rekognosciranja na pojavama oolitske rude gvozđa sa Ni i Co kod sela Ržanovo (Makedonija) [Results of geophysical reconnaissance on the occurrence of oolitic iron ore with Ni and Co near the village of Ržanovo (Macedonia) (with English summary)]: [Serbia] Zavod Geol. i Geofiz. Istrazhivanja Vesnik, v. 14, p. 391–400, 1957.

Magnetic, self potential, and apparent resistivity surveys were made on the nickel- and cobalt-bearing oolitic iron ores near Ržanovo in Macedonia province of Yugoslavia. Only the magnetic survey gave useful results. The ore was easily distinguished from the underlying limestone and argillaceous schist, owing

to the great contrast in magnetic susceptibility. The only difficulty in interpretation was encountered when serpentine masses were present over the ore-bearing strata, giving anomalies comparable to those produced by the ore.—*D. B. V.*

Milanović, Božidar, and Damnjanovíc, Konstantin. Use of geophysical investigations on silicate iron ore deposits in southwestern Macedonia. See Geophys. Abs. 177–125.

177–312. Andryeyev, R. Y. Mahnītnī anomalīyi Dnīprovs'ko-Donets'koyi zapadyny ta yikh heolohīchne tlumachennya [Magnetic anomalies of the Dnepr-Donets basin and their geologic interpretation (in Ukrainian with Russian summary)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 18, no. 4, p. 61–71, 1958.

The precambrian basement in the marginal areas of the Dnepr-Donets basin in the Ukrainian S.S.R., contoured on the basis of magnetic survey data, appears deeply eroded along structural lines. Linear anomalies reflect the trends (predominantly north-south, also east-west) of an ancient fold system; mosaic anomalies represent metamorphosed Archean sediments and, less often, basic intrusives. In the boundary fault zones of the Dnepr graben three types of magnetic anomalies are distinguished. The first type coincides with a zone of steep gravity gradients and corresponds to intrusions along regional fractures in the basement; magnetic anomalies between zones of gravity minimums indicate shallower parts of the basement; and finally, magnetic anomalies within zones of regional gravity lows are produced by diabase intrusions associated with salt domes. The last are important in connection with exploration for salt dome structures. Within the Dnepr graben the anomalies reflect basement relief, which in turn is influenced by thick sheets of Upper Devonian effusives; the northwest trend is characteristic of Hercynian diastrophism. Effusives are also presumably associated with subsidence of blocks in the graben; these are probably of a different age, possibly the same as the diabases of the salt domes.—*D. B. V.*

177–313. Matsaberidze, V. S. Magnitnoye pole Kolkhidskoy nizmennosti [Magnetic field of the Kolkhida depression]: Akad. Nauk Gruzin. SSR Inst. Geofiziki Trudy v. 15, p. 7–25, 1956.

After an historical review of a systematic geophysical exploration of the Kolkhida depression during the period 1931 to 1951, Mataberidze surveys the magnetic methods used there in surveys made in 1948, 1949, and 1951. A map of vertical component anomalies over an area of about 10,000 km^2 shows absolute and relative maximums and minimums, ranging from +600 to −900 gammas. Eleven pages of the paper are devoted to geological interpretations of the magnetometric data.—*A. J. S.*

177–314. Wellman, H. W. Geological interpretation of airborne magnetometer observations from Nelson to Waikato River, New Zealand: Geol. Mag. [Great Britain], v. 96, no. 2, p. 118–124, 1959.

A map is presented showing a series of airborne magnetometer profiles from the north end of the South Island of New Zealand to the mouth of the Waikato River. The two southern profiles are related to the exposed Upper Paleozoic igneous rocks which are considered to extend north across Cook Strait and along the west coast of the North Island to cause the anomalies in the north-

ern profiles. The North Island profiles are considered to reflect the Kawhia syncline and a major anticline to the east. The eastward displacement of the magnetic low relative to the synclinal axis at the surface is considered due to the eastward dip of the axial plane of the syncline.—*Author's abstract*

RADIOACTIVITY

177–315. Evans, P. Rice, and Freeman, N. J. The branching ratio of thorium C: Phys. Soc. [London] Proc., v. 72, pt. 2, p. 300–301, 1959.

The branching ratio of thorium C (bismuth–212) was determined from the intensities of the two α-particle groups, measured with a scintillation counter, and found to be $\alpha/\alpha+\beta=0.359\pm0.002$, which is in agreement with the recent value of Senftle, Farley, and Lazar (see Geophys. Abs. 168–258).—*D. B. V.*

177–316. Iokhel'son, S. V. O vydelenii gornymi porodami radona pri vysokikh temperaturakh [On the liberation of radon from rocks at high temperatures]: Akad. Nauk SSSR Izv. ser. geofiz., no. 12, p. 1451–1457, 1958.

All rocks emanate a certain amount of radon, which as an inert gas occupies voids and capillaries in rocks and spaces in crystal lattices of minerals. The coefficient of radon emanation of a rock, defined by the formula $K_{Rn}=\frac{q_n-q}{q_n}\cdot 100\%$ (where q_n and q=amounts of radon before and after heating, respectively), was investigated experimentally by measuring the gamma radiation of various samples before and after heating at different temperatures with time constant, or at constant temperature for different periods of time. The rock types investigated were silicates, hematite-magnetite rocks, carbonates, and caustobioliths.

The curves of radon emanation as a function of temperature show that K_{Rn} depends on the composition of the rock and on the thermal properties of the essential rock-forming minerals. Crystalline rocks composed of minerals which do not disintegrate upon heating show a sharp increase in K_{Rn} at a temperature corresponding to the beginning of destruction of the crystal lattice (about 700°C). The intense liberation of radon by carbonates is caused by their dissociation. Caustobioliths give up the largest part of their radon at low heats. Complete liberation of radon takes place at temperatures exceeding the melting temperature (1,700°C to 1,800°C), after 5 minutes. If the duration of heating (constant temperature) is increased, the coefficient K_{Rn} increases to a certain limiting value characteristic for each temperature; with increased temperature the time necessary for complete liberation of radon decreases. With repeated heating of heat-resistant rocks, the emanation coefficient remains practically unchanged.

These results should be of interest in explaining the kinetics of processes in the earth's crust, in age determinations, in interpreting emanation survey results, and in radiometric analysis of rocks.—*S. T. V.*

177–317. Iokhel'son, S. V., and Shitov, Ye. V. Radiometricheskiy analiz gornykh porod po spektru gamma-izlucheniya [Radiometric analysis of rocks using the spectrum of gamma-radiation]: Akad. Nauk SSSR Izv. ser. geofiz., no. 1, p. 96–104, 1959.

The isotopic composition of a mixture of elements emitting gamma rays can be determined by the distribution of the pulse amplitudes on the exit end of a differential gamma-ray spectrometer provided with an oscillograph. Examples

of the use of the suggested arrangement, called radiometric analysis, are given, illustrating the determination of uranium, radium, and thorium content in rocks and ores. The wiring diagram and the basic scheme of the entire installation are given. The results of the radiometric analysis of specimens of rocks are in good agreement with the chemical analyses. The possibilities of application of radiometric analysis are wide, as the method is free of errors that are due to the absorption of external radiation by the specimens.—*S. T. V.*

177–318. Roubault, Marcel, and Coppens, Réné. Étude de la radioactivité du massif granitique de Carnac (Morbihan) [Study of the radioactivity of the Carnac granitic massif (Morbihan)]: Cong. Soc. Savantes Comptes Rendus, Bordeaux and Libourne, p. 31–43, 1957.

The radioactivity of samples from various parts of the Carnac massif in Morbihan, France, was studied by means of nuclear emulsion plates and a counting tube. The activity is due to tiny inclusions of more or less strongly radioactive minerals rather than to the presence of uranium or thorium in the essential minerals or in the interstices or fractures. In the interior of the massif these inclusions are zircon; near the margins monazite, apatite, sphene, and allanite are also present. Although the overall radioactivity is fairly uniform (min 26 counts per sec, max 40), the abundance, nature, and degree of radioactivity of the inclusions are highly variable, particularly in the border rocks.—*D. B. V.*

177–319. Leible, Otto. Die Verteilung de Radioaktivität, der Thorium und Urangehalte im Malsburggranit (Südschwarzwald) [The distribution of radioactivity, thorium and uranium contents in the Malsburg granite (Southern Black Forest)]: Zeitschr. Erzbergbau und Metallhüttenwesen, v. 12, no. 5, p. 234–237, 1959.

The radioactivity of the Malsburg granite pluton in the Schwarzwald of Germany was investigated by the coincidence method developed by Gentner and Husmann (1952) for distinguishing between thorium and uranium content of a rock in the field. Results of 73 measurements are presented in a table which gives total (Th+U) intensity in curies per gram of rock$\times 10^{-12}$ for all samples, and for 20 samples, the thorium and uranium contents in grams per ton of rock and the Th/U ratio. The geographic distribution of total intensity is shown on a map; it varies from 2.1 to 7.8×10^{-12} curie per g, is clearly higher in the marginal and roof zones of the pluton. The distribution of thorium closely parallels that of total intensity, with particularly high values on the northern and eastern margins; it varies from 17 to 64 g per ton, with an average value of 29 g per ton. Uranium content on the other hand varies sharply from point to point (0.4 to 9.3 g per ton, average 5 g per ton); there is no enrichment in uranium at the borders, in fact the highest values are in the thorium-poor central part. Average Th/U ratio is 5.85.—*D. B. V.*

177–320. Polak, L. S. Nekotoryye zakonomernosti yestestvennoy radioaktivnosti mezozoyskikh i tretichnykh otlozheniy Prikaspiyskoy vpadiny [Certain regularities in the natural radioactivity of the Mesozoic and Tertiary deposits of the Pri-Caspian depression]: Prikladnaya Geofizika, no. 17, p. 274–283, 1957.

After an analysis of the phenomena of natural radioactivity of various deposits of the Caspian depression, as established by field measurements and

studies, Polak concludes that the natural radioactivity can be used to distinguish the Mesozoic and Tertiary argillaceous sandstones in this area stratigraphically and lithologically. Pure clays have the same intensity of natural radioactivity, independent of age and depth of the deposit. Similarly the natural radioactivity of individual rocks appears to be independent of age or depth. Correlation of radioactivity with carbonate content of sandstones is lacking, with porosity is very slight, and with average specific area in granular rocks is slight. The natural radioactivity of sandstones appears to correlate closely, almost in a functional (logarithmic) relationship, with their clay fraction. In the Mesozoic and Tertiary deposits of the Caspian depression the content of the argillaceous fraction of standstones can be determined from the gamma-ray log with an accuracy of about 25 to 35 percent.—*S. T. V.*

177–321. Belin, R. E., and Steiner, A. Some observations on the radioactivity of Ngauruhoe and White Island lavas: New Zealand Jour. Geology and Geophysics, v. 2, no. 1, p. 177–182, 1959.

Measurements of α and β radioactivity were made on 15 samples of lava of various ages from Ngauruhoe and Tongariro volcanoes in New Zealand and on gneissic xenoliths found in the Ngauruhoe flow of September 1954. The α activity ranges from 0.6 to 2.9 counts per min, β activity from 20 to 87 counts per min. Variation observed in α count rates of lavas and ash erupted from Ngauruhoe in 1954 is attributed to the presence or absence of a varying amount of small feldspathic xenoliths. The radioactivity is roughly proportional to potash content.

A Geiger-tube survey on the White Island volcano showed that the recent lavas are more radioactive than the older.—*D. B. V.*

177–322. Belin, R. E. Radon in the New Zealand geothermal regions: Geochim. et Cosmochim. Acta, v. 16, no. 1/3, p. 181–191, 1959.

Measurements have been made on radon and thoron associated with gas and condensate samples from fumaroles and pools along the Rotorua-Taupo graben, New Zealand. Methods of collection and measurements are described briefly. The values of radon to gas (R_g) range from 0.8×10^{-9} to 320×10^{-9} curies per liter for pools and 0.32×10^{-9} to 340×10^{-9} curies per liter for fumaroles; values of radon to condensate (R_c) for fumaroles range from 7×10^{-9} to 340×10^{-9} curies per liter.

Radioactive discharge is found to be greater from acid igneous regions than from intermediate igneous regions. The ratio of the average R_c values for fumaroles in the acid igneous regions to the average for those in intermediate regions is equal, within experimental error, to the ratio of gamma-ray counting rates of the surface rocks in the two regions. It is, therefore, suggested that steam or water brings the radioactive gases to the surface.—*D. B. V.*

177–323. Jurain, Georges. Signification géochimique des anomalies de teneur en radon des eaux des massifs cristallins et cristallophylliens [Geochemical significance of anomalies in radon content of the waters of granitoid and foliated massifs]: Soc. géol. France Comptes Rendus, no. 14, p. 348–350, 1958.

Observations of the anomalous radon content of waters in crystalline massifs, illustrated by examples from the southern Vosges and the Vendée in France, lead to the conclusion that there is a more or less direct relationship between the content of radioactive elements of the uranium-radium family and the radon

content of the waters of granitoid or foliated massifs. These particularly high radon contents correspond to the amounts of radiogenic lead (10^{-6} curies of radon correspond to 0.91×10^{-6} g Pb^{206}). Such loss through the waters introduces an error that cannot be neglected in age determinations by the lead-alpha method and in the Pb^{206}/U^{238} as well as in the Pb^{207}/Pb^{206} ratios.—*D. B. V.*

177–324. Wilkening, Marvin H. Daily and annual courses of natural atmospheric radioactivity: Jour. Geophys. Research, v. 64, no. 5, p. 521–526, 1959.

Measurements of the radon-decay products in the atmosphere over a 6 year period have been made with a monitor which precipitates fine airborne particulate matter onto a moving metallic tape. A calibration of the apparatus showed that the mean value for radon content at Socorro, New Mexico, is 2.4×10^{-13} curie per liter, with an average diurnal fluctuation of a factor of 3.1 between maximum and minimum values. The diurnal variation is attributed to the amount of vertical mixing due to eddy diffusion in the lower atmosphere. The gustiness in air motion near the ground is taken as a measure of the mixing that occurs, and it is measured with a hot-wire anemometer. An annual variation in the atmospheric radioactivity is found which gives values during the fall months that are about twice those during the spring. This variation can also be explained in terms of the mixing that occurs at low levels as judged from mean wind-speed data. Values for the coefficient of vertical diffusion are calculated from measurements of the exhalation rate of radon from the ground and the concentration of radon near ground level as determined from the monitor data. The mean value of the height-independent diffusion coefficient is 6.7×10^{4} cm^2 per sec. Maximum values of as high as 55×10^{4} cm^2 per sec are found in the late afternoon of the month of April. Minimum values of the order of 2.0×10^{4} cm^2 per sec are found in the early morning hours in the fall months.—*Author's abstract*

177–325. Cantone, B., Pappalardo, G., and Ricamo, R. Air radioactivity in Catania: Nuovo Cimento, v. 11, no. 1, p. 84–88, 1959.

Measurements of air radioactivity have been made at Catania, Sicily, by measuring the beta activity of air filter deposits. A marked correlation was noted between maximum radioactivity and minimum wind speed. For the summer months the observed air radioactivity was $(2–50)\times10^{-13}$ curies per liter, close to mean values at Leghorn and for central Europe. The artificial radioactivity concentration is $(1.2–2)\times10^{-15}$ curies per liter.—*D. B. V.*

177–326. Kawano, M., and Nakatani, S. The absolute measurement of the concentrations of radioactive substances in the atmosphere, in Tokyo: Jour. Geomagnetism and Geoelectricity, v. 10, no. 2, p. 56–63, 1959.

Concentrations of radioactive substances in the air were measured continuously at Tokyo by the ionization chamber method and compared with those of radon emanated from a radium standard solution to give absolute values. On fine days these concentrations were $2.3–12\times10^{-16}$ curies per cm^3. The ratio of beta plus gamma radiation to total radiation was found to be 5–25 percent; in radon in equilibrium with its decay products this ratio is 2–3 percent; therefore, the radon in the atmosphere is apparently not in equilibrium.—*D. B. V.*

RADIOACTIVITY SURVEYING AND LOGGING

177–327. Vaughn, W.[illiam] W., Rhoden, V.[asco] C., Wilson, E. E., and Faul, Henry. Scintillation counters for geologic use: U.S. Geol. Survey Bull., no. 1052–F, p. 213–240, 1959.

A small light hand-portable scintillation counter, an airborne-carborne scintillation counter, and a portable scintillation gamma-ray well-logging instrument have been designed, constructed, and tested, and are now commercially manufactured. The amplifier circuits take full advantage of the high counting rate that can be obtained from photomultipliers and phosphors. Relaxation-oscillator-type high-voltage supplies provide regulated voltages for the photomultiplier tubes.

The hand-portable scintillation counter was designed for prospecting on foot. The airborne-carborne unit is intended primarily for broad-area reconnaissance from automobiles or light aircraft at altitudes of 500 feet or less; it uses a sodium iodide crystal 3 inches in diameter and 1½ inches thick and a photomultiplier tube with a cathode diameter of 3 inches. Larger crystals may be adapted. The instrument cannot be calibrated directly in terms of uranium content, but can be calibrated in milliroentgens per hour if the type of radiation is specified.

The well-logging instrument has a manually operated reel and is capable of logging holes 1,000 feet deep. The probe contains only the photomultiplier tube and matching circuit. The energy resolution using a cesium source is approximately 10 percent, measured through the 1,000 ft of coaxial cable. The instrument was designed both as an aid in stratigraphic studies and to log ore-grade material. The wide range of sensitivity is accomplished by adjustments made at the surface. A sample calibration chart for determining the grade of material in a drill hole is given.—*V. S. N.*

177–328. Kim, Chong Su, and Chang, Yun Hwan. On the atomic energy mineral resources and its prospecting method [in Korean with English abstract]: Korea Geol. Survey Bull., no. 2, p. 145–158, 1958.

This summarizes for the layman the geological occurrence of radioactive minerals and the most effective geophysical prospecting methods (scintillation and Geiger counters) for use in locating such deposits. The probability of occurrence of such minerals in Korea is discussed.—*V. S. N.*

177–329. Kim Chong Su; Hwang, In Jon; and Sang, Ki Nam. Report on prospecting of atomic energy mineral resources (II) [in Korean with English abstract]: Korea Geol. Survey Bull., no. 2, p. 159–171, 1958.

The radioactivity of 2 pegmatite veins, 1 cobalt, 1 graphite [and] 1 gold mine, and 7 monazite placer deposits was investigated with scintillation and Geiger counters. Several of the monazite placers were found to be rich in thorium and zirconium; Korean reserves were thus substantially increased by the investigation.—*V. S. N.*

177–330. Kim, Chong Whan, and Yun, Sang Kyu. Uranium-bearing crystalline graphite deposit, south-eastern area of Kongju-up, Chungchongnamdo [in Korean with English abstract]: Korea Geol. Survey Bull., no. 2, p. 219–232, 1958.

A report on a geological investigation and radioactivity measurements of a radioactive anomaly in graphite deposits in southeastern Kongju-gun, Chungchong-namdo, Korea. Uraninite in intimate asociation with graphite was found to be the source of radioactivity.—*V. S. N.*

177–331. Bunker, C.[arl] M., and Hamontre, H. C. A comparison among caliper-log, gamma-ray-log, and other diamond-drill-hole data: U.S. Geol. Survey Bull., no. 1052–G, p. 241–255, 1959.

To obtain comparative data on the variation in gamma-ray intensity accompanying possible variation in the diameter of small-diameter diamond-drill holes, six drill holes in the Joe Dandy area, Montrose County, Colo., were caliper logged using a well-bore caliper developed by the U.S. Bureau of Mines. The caliper logs show that within radioactive-ore zones the variation in drill-hole diameter is insufficient to cause significant variation in the gamma-ray logging measurement, that with increasing particle size in the ore-bearing sandstone the drill-hole diameter tends to increase slightly, and that with increase in hole diameter the core recovery tends to decrease slightly.—*Authors' abstract*

177–332. Filippov, Ye. M. K teorii gamma-gamma-karottazha (GGK) [On the theory of gamma-gamma logging (GGK)]: Prikladnaya Geofizika, no. 17, p. 231–264, 1957.

A simplified theory of the processes taking place in a drill hole during gamma-gamma-logging is presented by Filippov in order to provide the backbround necessary for the application of this phenomenon in investigations of formations pierced by a drill hole. The article has a brief introductory chapter containing fundamental concepts of atomic physics, followed by a discussion of the photo-effect, the Compton effect, and the formation of electron pairs. This is followed by a discussion of the dependence of the intensity of scattered γ radiation on the density of the substance emitting the radiation, and on the length of the probe lowered into the hole, so that in a general form it is possible to represent the intensity as a function of density and probe length. The intensity of γ radiation is dependent on the kind of the primary radiating source. It was found advantageous to use sources of high relative energy E and with long half-life T, such as cobalt-60, (E=1.25 Mev, T=5.3 yr).—*S. T. V.*

177–333. Verbovenko, P. K., and Fakidov, I. G. K voprosu o gamma-gamma-karotazhe [Contribution to the question of gamma-gamma-well logging]: Atomnaya Energiya, v. 4, no. 4, p. 210–211, 1958.

In this article the functional relationship between intensity of radiation (I) and density (ρ) in gamma-gamma logging is analyzed. Several theoretically computed curves of $I(\rho)$ were tested. The densities which are of interest to geophysicists range from about unity (water, oil) to hardly more than seven. For this range a semiempirical formula suggested by Verbovenko and Fakidov gives the best results. Also tested were the formulas of Dyad'kin (see Geophys. Abs. 163–154) and Bulashevich and Voskoboynikov (see Geophys. Abs. 169–271). The effect of the sonde length on the value of I is pointed out.—*S. T. V.*

177–334. Mihailović, Milorad A. Sonda za radioaktivnu karotažu istražnih bušotina [Sonde for radioactivity logging of exploratory boreholes (with English summary)]: [Serbia] Zavod Geol. i Geofiz Istrazhivanja Vesnik, v. 14, p. 307–310, 1957.

A transistorized apparatus for radioactivity logging is described and illustrated with photograph and wiring diagram. Dimensions are only 25 cm by 3 cm. Results are accurate to 800 m depth. The apparatus is used in conjunction with electrical logging equipment.—*D. B. V.*

177–335. Nikiforov, N. N., and Manoilov, A. G. Pervaya Bolgarskaya avtomatischeskaya stantsiya dlya radiometrii skvazhin [First Bulgarian automatic station for radioactivity logging] : Ministerstvo Vysshego Obrazovaniya SSSR Izv. Vyssh. Ucheb. Zavedeniy, Neft i gaz, no. 10, p. 9–14, 1958.

The principal units of the BARS–1 gamma-ray logging apparatus are described. This apparatus includes no outstanding new features.—*J. W. C.*

177–336. Harkalenko [Garkalenko], I. O. Do vykorystannya hamma-hammakarotazhu v zakhīdnomu sektorī Donets'koho baseynu [On the use of gamma-gamma logging in the western sector of the Donets basin (in Ukrainian with English and Russian summaries)] : Akad. Nauk Ukrayin. RSR Dopovīdī, no. 8, p. 874–878, 1958.

The separation of coal layers by electric logging in drill holes becomes difficult or even impossible when the resistivity of the coal stratum is equal to that of the enclosing formations, as is the case, for instance, when the coal lies beneath limestone. The gamma-gamma well logging has been used very effectively since 1956 for distinguishing coals of all grades. In wells of 86 to 92 mm the best results were obtained with a sonde 50 to 60 mm in diameter and a gamma ray source (cobalt–60) of 3 to 10 millicuries. Recording rate should be 150 to 200 m per hr for a scale of 1:200, 50 to 70 m per hr for a 1:50 scale. Garkalenko disagrees with Voskoboynikov in his recommendation of a more intense gamma ray source; the increase is of no aid in cases of caverns. This difficulty should be eliminated through use of other methods of well logging in combination with the gamma-gamma log.—*S. T. V.*

177–337. Bayembitov, F. G., Gulin, Yu. A., and Dyad'kin, I. G. Opyt primeneniya gamma-gamma-karottazha v Bashkirii [Test of the application of gamma-gamma logging in Bashkiria] : Prikladnaya Geofizika, no. 17, p. 284–292, 1957.

Several formulas are given for approximate determination of density of formations pierced by the drill hole on the basis of data obtained from gamma-gamma logging. An improvement is suggested in the construction of the sonde which is very valuable, especially in the case of holes inclined more than 1°30′ from the vertical. The article contains reproductions of several gamma-gamma logs obtained in the Bashkir A.S.S.R., and their interpretations.—*S. T. V.*

SEISMIC EXPLORATION

177–338. Tatel, Howard E., and Tuve, Merle A. Seismic observations at one kilometer depth, *in* Contributions to Geophysics (Gutenberg volume) : Internat. Ser. Mon. Earth Sci., v. 1, p. 152–157, 1958.

Earth motions at depths of 3,000 ft have been observed. The ground motion is considerably less than the surface motion, which indicates that the surface waves are surface bound either as Rayleigh waves or upwardly refracted secondary *P* waves. A shot at depth was also observed and the seismogram indicates considerable interior wave interaction in the form of scattering.

The lesser ground motion in the interior holds promise for better signal to background ratio for observation of distant shots.—*Authors' conclusion*

177–339. Chereau, J[ean] Y[ves], and Ledoux, Y. Aspects théoriques et pratiques de la détermination des vitessee d'intervalle en sismique réflexion [Theoretical and practical aspects of the determination of interval velocities in seismic reflection]: Geophys. Prosp., v. 7, no. 1, p. 24–37, 1959.

The physical meaning of interval velocities is reviewed. Velocity distribution obeys certain general laws; the principal factors determining the velocity are degree of saturation and nature of the fluid, porosity, depth, age of the formation, and lithology. The variation of interval velocity with depth observed in sedimentary basins of different ages is analyzed statistically and compared with Faust's law (see Geophys. Abs. 145–12825). It is concluded that Faust's work furnishes a frame of reference to which all results can be compared. If the law is applicable, medium argilosandy or slightly calcareous formations are indicated; too low a value suggests formations that were either very rapidly deposited, are argillaceous, thoroughly invaded, or abnormally porous; too high a value suggests either limestones or evaporites, or strongly cemented or deformed or eroded formations. Values obtained at the surface can also give information on a given bed by serving to eliminate certain types of lithology from consideration. The paper concludes with discussion of examples from Madagascar, the Aquitaine Basin, and Gabon.—*D. B. V.*

Sumi, Franc. Electrical and elastic anisotropy. See Geophys. Abs. 177–105.

177–340. Radzhabov, M. M. Nekotoryye zadachi interpretatsii odinochnykh prodol'nykh godografov prelomlennykh voln [Certain problems of interpretations of single longitudinal traveltime curves of refracted waves]: Akad. Nauk Turkmen. SSR Izv., no. 4, p. 3–12, 1958.

Gamburtsev's method of interpretation of a single refracted P-wave traveltime curve (see Geophys. Abs. 122–8091) is described briefly, then applied to examples of the case of an inclined refracting boundary plane.—*A. J. S.*

177–341. Radzhabov, M. M. Opredeleniye granichnykh skorostey po poperechnym godografam prelomlennykh voln. I. [The determination of the boundary velocities from transverse traveltime curves of refracted waves, part 1]: Akad. Nauk SSSR Izv. ser. geofiz., no. 12, p. 1491–1503, 1958.

In this study a graphic method of determining boundary velocity is suggested, namely, a determination from two traveltime curves of transverse waves corresponding to the same refracting boundary and traveling in the same direction. The procedure of observations along the transverse profile is discussed. The analysis of the accuracy of the suggested method shows that the relative error in the determination of boundary velocity from the profile across the contact does not exceed 5 percent where the dip is less than 15°. Several examples of the application of the method are given. Comparison of the results with those obtained by the longitudinal profile method shows good agreement. The method also makes it possible in certain cases to take into account discontinuous variations in the boundary velocity along the refracting layer if these variations are not smaller than about 250 m per sec.—*S. T. V.*

177–342. Soske, Joshua L. The blind zone problem in engineering geophysics: Geophysics, v. 24, no. 2, p. 359–365, 1959.

Consideration of the "blind zone" in specific cases definitely improves the correlations between the interpretations of seismic refraction work and the engineering data obtained by core drilling. The blind zone is here defined narrowly as that portion of the underground which lies between the surface layer and a high speed marker in the three-layer problem and is not represented in the graph of "first breaks"; this volume of material is not suggested by the first breaks because of the relative thicknesses of the layers and the effect of the excess of the velocity of the third layer over that of the second. Two actual examples are given: in one, about 45 percent by volume of material lying between the ground surface and a granite could not be detected by normal study of first breaks; in the other, a water table was not detected.

Two methods of investigating the blind zone are suggested. The first is a graphic solution in which Huygens wave-front diagrams are fitted to measured traveltime data and known geology; this method is indirect and in some cases laborious. A direct and preferable solution may be accomplished by burying the explosive charges sufficiently deep so that all the shallow velocity discontinuities are represented on the graph of first breaks.—*D. B. V.*

177–343. Werth, G. C., Liu, D. T., and Trorey, A. W. Offshore singing—field experiments and theoretical interpretation: Geophysics, v. 24, no. 2, p. 220–232, 1959.

At some locations offshore, seismic records degenerate into nearly sinusoidal waves or simple combinations of nearly sinusoidal waves despite the fact that the recording may be made with little or no seismic filtering. Results from field experiments indicate that this "singing" phenomenon is caused by the reflections themselves exciting an acoustic resonant layer formed by the ocean surface and bottom. A simple theoretical model predicts the mode of excitation and the frequency, depth, and range dependence which are verified by controlled field experiments.—*Authors' abstract*

177–344. Backus, Milo M. Water reverberations—their nature and elimination: Geophysics, v. 24, no. 2, p. 233–261, 1959.

In offshore shooting the validity of previously recorded seismic data has been severely limited by multiple reflections within the water layer. The magnitude of this problem is dependent on the thickness and the nature of the boundaries of the water layer.

The effect of the water layer is treated as a linear filtering mechanism, and it is suggested that most apparent water reverberation records probably contain some approximate subsurface structural information, even in their present form.

The use of inverse filtering techniques for the removal or attenuation of the water reverberation effect is discussed. Examples show the application of the technique to conventional magnetically recorded offshore data. It has been found that the effectiveness of the method is strongly dependent on the instrumental parameters used in the recording of the original data.—*Authors' abstract*

177–345. Martner, S. T., and Sparks, N. R. The electroseismic effect: Geophysics, v. 24, no. 2, p. 297–308, 1959.

The electroseismic effect manifests itself as an electrical potential generated in the subsurface by the passage of seismic waves. It can be detected at the surface of the ground with electrode pairs. The time of occurrence of the voltage

clearly distinguishes the effect from either the ionization potential produced at the time of explosion or the seismic electric effect produced coincident with the arrival of seismic waves at the surface of the ground.

Evidence is presented which associates the electroseismic effect with the base of the weathered layer and demonstrates its characteristics in several areas and at various distances from the shotpoint. Its immediate utility appears to be that of determining the travel time through the weathered layer at the shotpoint.—*Authors' abstract*

177–346. Antsyferov, M. S. Laboratornoye vosproizvedeniye seysmoelektricheskogo effecta vtorogo roda [Laboratory reproduction of the electro seismic effect of the second type] : Akad. Nauk SSSR Doklady, v. 121, no. 5, p. 827–829, 1958.

Under the electroseismic effect of the second type is the appearance of a potential difference between two adjacent points of a rock, owing to elastic wave propagation, without any previous polarization of the rock. If a polarization by an external voltage is already present, and if the elastic wave produces a new potential difference in two adjacent points, then this phenomenon is called the electroseismic effect of the first type.

The electroseismic effect has been produced artificially by Antsyferov. The main difficulty to be overcome was the necessity of producing powerful enough seismic effects, owing to the transient nature of this phenomenon.

A bar of moistened slate of 235 mm length was used, placed upright on a vibrator, which supplied vibrations of acoustic frequency. The vibrator was a piezoelectric hydrophone activated by an acoustic generator. In the middle and at one end of the bar, copper rings serving as electrodes were attached. The alternating electromotive force was amplified and observed in an oscillograph. Two resonance peaks were discovered, one at 2,800 cycles per sec, the other at more than 5,000 cycles per sec.

It was found that the sharpness of the resonances is very much dependent upon the mositure content of the rock. The sharpest resonant peaks had absolute widths of 10 to 20 cycles per sec. The voltage observed at these resonant frequencies was equal to 10^{-4} volts. Outside of the resonances the electromotive force was too small to be measured. It was not possible to establish the electroseismic effect in dry rocks.—*S. T. V.*

177–347. Kisslinger, Carl. Observations of the development of Rayleigh-type waves in the vicinity of small explosions: Jour. Geophys. Research, v. 64, no. 4, p. 429–436, 1959.

Study of the particle motion and dispersive properties of waves generated by small explosions has led to the identification of the fundamental M_2 mode and possibly a higher mode of this branch of the solution of the Rayleigh wave equation. In the particular field models, consisting of loess and clay over limestone, variations in near-surface conditions at the source have a greater effect on the recorded motion than do similar variations at the recording sites.

The features within the complex motion close to the source can be identified with specific wave types, which are well separated at the larger distances.—*Author's abstract*

177–348. Konstantinova, A. G. O dinamike vnezapnykh vybrosov uglya i gaze v shakhtakh po dannym seysmoakusticheskikh nablyudeniy [On the dynamics of sudden bursts of coal and gas in mines, according to

the results of seismoacoustic observations] : Akad. Nauk SSSR Izv. ser. geofiz., no. 2, p. 229–241, 1959.

This study is based mainly on material collected during seismoacoustic observations during the rockburst of April 7, 1954, in the Yunkom coal mine in the central Donets Basin. The material analyzed included oscillograms, spectrograms, and phonograms recorded in the mine during the rockburst. The total duration of the rockburst was about 23 sec. The oscillograms indicate that the rockburst can be divided into three cycles. Each cycle lasted about 8 sec and can be divided into two parts. The first part lasted about 5 sec and is characterized by low frequencies (largely 150 to 300 cycles per sec). The second part is characterized by higher frequencies and also a greater range of frequencies (600 to 1,600 cycles per sec). The overlap of the low and high frequency intervals is only a few tenths of seconds.

An analysis of the data makes it possible to establish certain characteristics of the rockburst process. The greatest destruction was produced by the splitting off of a mass of coal and of the walls of the mine gallery; these were pulverized. This splitting was caused by the pressure of the overburden to which the mine gallery is exposed from all sides except from the face of the workings. The pressure of the gas contained in the coal can be a contributing factor. The article reproduces many oscillograms, showing the process at different stages.—*S. T. V.*

177–349. Berzon, I. S., Vasil'yev, Yu. P., and Starodubrovskaya, S. P. O prelomlennykh volnakh, sootvetstvuyushchich vodonosnym peskam [On refracted waves corresponding to water-bearing sands] : Akad. Nauk SSSR Izv. ser. geofiz., no. 1, p. 32–48 (part 1), and no. 2, p. 177–183 (part 2), 1959.

Experimental study of the kinematic and dynamic characteristics of waves refracted on a layer of water-bearing sand shows that the longitudinal (head) waves are characterized by a higher frequency spectrum than the same waves refracted on argillaceous strata ordinarily having comparable seismic velocities. This makes it necessary to use high frequency instruments. Boundary velocities in sand range from 1,500 to 1,800 m per sec. The damping coefficients of seismic waves in sands vary from 0.002 to 0.004 m^{-1}. Dipping refracting planes usually are related to higher values of damping. The experiments show the importance of the observation of dynamic characteristics of the wave in broadening the possibilities of interpretation of seismic data. It is possible to distinguish water-bearing formations from others with similar velocity and a slightly different frequency. Studies of amplitudes and of damping coefficients represent an approach to the study of the physical properties of sands.

In the second part of the study, the causes of marked changes of the absorption coefficient in a sand layer are discussed. These changes, which occur simultaneously with relatively unimportant changes in boundary velocities (from 1,500 to 1,800 m sec^{-1}), are found to be related to a reduction of the relief of the surface in question. They have been explained to be a result of incomplete saturation of the sand in some places, a portion of the pores remaining filled with air. The sand at these places must then be regarded as a three-component medium. A theoretical analysis of the behavior of the velocity of such waves in a three-component medium shows that this factor does not explain the observed velocity variations. The cause probably lies in variation of porosity and physical composition of the sands; this hypothesis will be investigated in subsequent studies.—*S. T. V.*

177–350. Puzyrev, N. N. Izmereniye seysmicheskikh skorostey v skvazhinakh [The measurement of seismic velocities in drill holes]: Vses. nauchno-issled. inst. geofiz. metodov razvedki Trudy, no. 3, p. 1–81, 1957.

This book on well shooting, intended for use by petroleum geophysicists, discusses in some detail the necessary theory, methods of observation with the usual instrumentation, analysis of the seismograms obtained, and accuracy of results. Numerical tables and a set of curves are given to facilitate the analysis of the data.—*S. T. V.*

177–351. Manchee, E. B. Direct integration of continuous velocity logs: Geophysics, v. 24, no. 2, p. 335–343, 1959.

The number of conventional check shots associated with a continuous velocity log (CVL) well survey may be reduced to one or perhaps to zero if the integration of CVL travel times can be made at least as accurate as check-shot times. This should be possible if mud lag and instrumental lag can be taken into account. By the use of a centralizer on the CVL sonde and a caliper log, mud lag may be calculated. A digital computer may be used to simplify reduction of the data. Results to date are encouraging but further testing of the method will be necessary.—*Author's abstract*

177–352. Tixier, M. P., Alger, R. P., and Doh, C. A. Sonic logging: Jour. Petroleum Technology, v. 11, no. 5, p. 106–114, 1959.

The principle, equipment, and field operation of a sonic logger are described. The logger consists of a sound transmitter and three receivers mounted 3, 4, and 6 ft from the transmitter. Sound pulses are transmitted at 10 per sec. The logs are independent of hole size and mud. The sonic log records transit time, the time required for the sound wave to travel 1 ft through the formation: the transit time, Δt (in microsec per ft) is related to velocity V (in ft per sec) by the formula $\Delta t = 10^6/V$. An *SP* curve is run along with the sonic curve to give a more interpretable log and to establish absolute depth control for comparison with other logs run for the same well, and if desired a gamma-ray curve may be recorded simultaneously.

The porosity of limestones and sandstones can be determined from the sonic log with the aid of a simple chart. The sonic log can also detect vugular zones and horizontal fissures. In unconsolidated formations the sonic log can be used as an approach to porosity values if correction is made for degree of compaction, shaliness, and fluid content. The paper is illustrated with field examples.—*J. W. C.*

177–353. Tarasov, Yu. A. K vyboru parametrov gruppy pri gruppirovanii seysmopriyemnikov [On the selection of parameters of the group in connection with grouping of seismic receivers]: Ministertstvo Vysshego Obrazovaniya SSSR Izv. Vyssh. Ucheb. Zavedeniy, Neft i gaz, no. 9, p. 23–29, 1958.

The problem of the optimum geophone array is discussed. The base line of the array is regarded as the principal parameter determining the precision for direction, and a small number of geophones is best for this particular purpose. Graphs are presented for selection of the optimum parameters of arrays.—*J. W. C*

177–354. Radzīyevs'kyy, V. A. Chastota y zatukhannya vlasnykh kolyvan' u līnīynykh vībrodatchykakh inertsīynoho typu z rīdynnym zaspokoyennyam [The frequency and the damping of natural oscillations in linear vibrometers of inertia type with fluid damping (in Ukrainian with English and Russian summaries)]: Akad. Nauk Ukrayin. RSR Dopovīdī, no. 7, p. 716–720, 1958.

Experience with inertia-type vibration pickups with fluid damping has shown that these instruments often have a frequency of natural oscillations lower than the value computed in designing. The phenomenon is here explained by the fact that a certain portion of the damping fluid does not remain passive but is caused to oscillate by the vibrating system of the instrument, increasing the vibrating mass. The amount of the fluid involved in this oscillation increases with the amplitude of vibrations, producing corresponding lowering of the natural frequency. The changes in natural frequencies and in damping of the instrument affect other characteristics of the vibration pickup such as degree of amplification and sensitivity, especially in the vicinity of the natural frequency of the instrument. Several characteristic curves describing the observed phenomena are given.—*S. T. V.*

177–355. Radzīyevs'kyy, V. A. Deyakī rezonansnī yavyshcha u vībrodatchykakh seysmīchnoho typu z rīdynnym zaspokoyennyam [Some resonance phenomena observed in vibrometers of seismic type with fluid damping (in Ukrainian with English and Russian summaries)]: Akad. Nauk Ukrayin. RSR Dopovīdī, no. 8, p. 552–557, 1957.

The results of the experiments made on several vibration pickups with fluid damping are presented. These vibrometers are of inertia type. They were tested on a shaking table at frequencies of 80 to 1,000 cycles per sec. It was found that for various amounts of the damping fluid, resonance peaks have been observed on the frequency curve of the instruments. These phenomena appeared when the pickup was not completely full of the damping fluid. The observed phenomena are explained by the appearance of a second vibrating mass, with the elastic element formed by the air replacing the missing fraction of the damping fluid. Thus the vibrating system of the vibrometer having one degree of freedom is transformed into a system with two degrees. The computations made for various amounts of the damping fluid confirm the hypothesis. The article gives the frequency curves corresponding to various amounts of fillings with the damping fluid (see also Geophys. Abs. 177–354).—*S. T. V.*

177–356. Melamud, A. Ya, Khudzinskiy, L. L., and Deynega, S. A. Stantsiya promezhutochinoy magnitnoy zapisi seysmicheskikh kolebaniy [A station for intermediate magnetic recording of seismic vibrations]: Akad. Nauk SSSR Izv. ser. geofiz., no. 2, p. 197–209, 1959.

This is a description of Russian apparatus designed for intermediate recording of seismic vibrations, using the method of frequency modulation. The instruments are designed for frequencies ranging from 20 to 500 cycles per sec and can be combined with equipment designed for low, middle, and high frequencies. The range of the useful frequency can be increased by a simple modification of the preamplifier wiring. Thus, the frequency spectrum of the station could be adapted for use as an intermediate recording station in deep seismic exploration. A great advantage of the station described is the precise reproduction of the records for detailed analysis in the laboratory. The instal-

lation does not produce any additional distortion of recorded vibrations and thus can be used in studies of the dynamic characteristics of seismic waves. The apparatus can easily be built as a portable station.—*S. T. V.*

177–357. Hall, T[homas] O., and Martin, J[ack]. Ammonium nitrate: economy blasting agent for oil exploration: Geophys. Prosp., v. 7, no. 1, p. 18–23, 1959.

This is the same as the paper published in Geophysics, v. 24, no. 1, 1959 (see Geophys. Abs. 176–334).—*D. B. V.*

177–358. Andres, Jakob, and Schad, Albert. Seismische Kartierung von Bruchzonen im mittleren und nördlichen Teil des Oberrheintalgraben und deren Bedeutung für die Ölansammlung [Seismic mapping of fault zones in the central and northern part of the Upper Rhine Valley graben and their importance for oil accumulation]: Erdöl und Kohle, v. 12, no. 5, p. 323–334, 1959.

Systematic seismic investigation of the fault zones of the northern and central part of the Upper Rhine graben began in 1950. The first borehole checks showed broad agreement with the seismic results but also revealed the necessity of more detailed seismic surveys; the faults were far more numerous than reconnaissance measurements had indicated. A second phase, of more detailed surveys, was then initiated and is still in progress. The most significant results of both phases are summarized. Since 1950, 14 oil and 7 gas fields have been discovered, most of them small in comparison to other German deposits; most important of these are the Landau (oil) and Stockstadt (oil and gas) fields. Production is mainly from the Tertiary, a little from the Keuper.—*D. B. V*

177–359. Popović, Špiro, and Petrović, Jovan N. Primejena reflektivne seizmičke metode na terenu Boka [Application of the seismic reflection method in the Boka region (with English summary)]: [Serbia] Zavod Geol. i Geofiz. Istrazivanja Vesnik, v. 14, p. 401–409, 1957.

Seismic reflection measurements were made over the north-south-trending gravimetric high established by earlier surveys near Boka in Banat province, Yugoslavia. Three reflection profiles are shown, two across the strike of the gravity anomaly and one along it. Numerous reflecting horizons are indicated; the shallow ones are all approximately horizontal, but the Miocene-Pliocene contact is folded. A fault zone is revealed in the eastern part of the area; the east side is downdropped. In the western part a small fault is encountered in only one of the profiles.—*D. B. V.*

177–360. Sollogub, V. B. Fizicheskiye svoystva gornykh porod yugo-zapadnogo i yuzhnogo rayonov Evropeyskoy chasti SSSR [The physical properties of rocks of the southwestern and southern regions of the European part of the USSR]: Akad. Nauk Ukrain. ŚSR Inst. geol. nauk Trudy, ser. geotektoniki i geofiziki, no. 4, 100 p., 1958.

This is a review and critical analysis of seismic investigations made at different points in the southwestern and southern regions of the European part of U.S.S.R., in which several hundred exploratory drill holes were used. An introductory chapter gives the fundamental data on the geology of the area. This is followed by a discussion of data on density and seismic velocities in the

Pri-Carpathian depression; the Cis-Dobrudzha depression; Crimea with the exception of its mountainous portion; the Azov-Kuban depression; the southwest end of the Russian platform; and the Dnepr-Donets Basin.

Numerous data are presented on seismic velocities in the different regions and on their variation with depth. The curves of seismic velocities are plotted on an accompanying map. Many of the data on density and velocity have been taken from studies by Sollogub (see Geophys. Abs. 171–338, 174–91, –150, –349). In the concluding section of the book, laboratory methods of investigating the elastic properties of rocks and of determinating longitudinal wave velocities are described. An extensive bibliography is appended.—*S. T. V.*

177–361. Yunusov, N. K. O vvode popravok za verkhnyuyu tolshchu v godografy otrazhennykh voln na vostochnoy okraine Russkoy platformy [On the introduction of corrections for the upper layer into the traveltime curves of reflected waves at the eastern border of the Russian Platform]: Prikladnaya Geofizika, no. 17, p. 115–129, 1957.

Experiences during seismic exploration for oil in the eastern part of the Russian Platform showed the necessity of introducing much more precise methods of seismic investigations to obtain better results. The main source of error is considered to be the usual assumption that velocity is constant in the upper layer. In reality this velocity varies (from 1,500 to 2,900 m per sec) not only with depth but also horizontally. The complex geologic structure of the upper layer (post-Kungur deposits) must be thoroughly surveyed by other methods and exploratory drilling in order to give a firm basis for the interpretation of the seismic data in this region. Examples are given of the relationship of refracting horizon to stratigraphy; the indirect method is applied to determination of the average velocity in three areas; and it is shown that the error in determining depth of a reflecting horizon depends on the method by which corrections are introduced for the upper layer.—*S. T. V.*

177–362. Hurevīch [Gurevich], B. L., Andr[y]eyeva, P. Y. [I], and Hdalevs'ka [Gdalevskaya], Ts. M. Do pytannya pro shvydkīsnu kharakterystyku osadochnykh vīdkladīv Kryms'koho pībostrova [On the question of the velocity characteristics of the sedimentary deposits of the Crimean peninsula (in Ukrainian with English and Russian summaries)]: Akad. Nauk Ukrayin. RSR Dopovīdī, no. 6, p. 654–657, 1958.

From the results of well-shooting in ten drill holes in various parts of the Crimean Peninsula, the seismic velocity has been determined as a function of depth. The depth of the investigated drill holes ranged from 1,500 to more than 2,600 m. It was found that the velocity is affected not only by depth but also by geologic age of the formations traversed by the hole. This makes it necessary to take into account the depths of the reflecting horizons, especially those between the upper and middle Eocene formations.—*S. T. V.*

177–363. Neprochonov, Yu P. Rezul'taty seysmicheskikh issledovaniy na Chernom more v rayone g. Anapy [The results of seismic explorations in the Black Sea in the region of the city of Anapa]: Akad. Nauk SSSR Doklady, v. 121, no. 6, p. 1001–1004, 1958.

The results of seismic refraction exploration of the bottom of the northern part of the Black Sea are presented. Two mutually perpendicular profiles with a combined length of 70 km were investigated. Intervals between shots ranged

from 2 to 5 km. On the north-south profile, 30-km long, two refracted waves were recorded, t_1 with an apparent velocity of 3,500 m per sec and t_2 with a velocity of about 2,400 m per sec (±10 percent). The t_2 wave was clearer on the east-west profile, but even on the other an explosion of a 2.5 kg-charge was accurately recorded at 30 km from the shot point. Two tentative geologic profiles are constructed, showing a lower layer with a velocity of 5,000 m per sec and an upper layer with a velocity of 2,400 m per sec. The boundary between these layers dips south and west.—*S. T. V.*

177–364. International Geophysical Year Bulletin (No. 19). Trans-Antarctic trough: Am. Geophys. Union Trans., v. 40, no. 1, p. 48–50, 1959.

New evidence that east and west Antarctica may be separated by a deep ice-filled trough has been provided by the recent discovery, by seismic soundings, of the greatest bottom depth yet found (4,400 ft) beneath the Ross Ice Shelf. The existence of such a transcontinental trough, first postulated by Griffith Taylor, geologist with the Scott expedition of 1901–04, is suggested by the difference in geologic character of east and west Antarctica and by the deep penetration of the Ross Sea on the Pacific side and the Weddell Sea on the Atlantic side.—*D. B. V.*

177–365. Robin, G. de Q. Seismic shooting and related investigations: Glaciology III, Norwegian-British-Swedish Antarctic Expedition, 1949–52, Sci. Results, v. 5, pt. 3, 134 p., 1958.

A seismic profile about 425 miles long was made from the coast to the plateau in Queen Maud Land, Antarctica, in order to determine the thickness of the ice. Some 950 shots were fired at 178 stations with partial or complete success at 134 points. Portable equipment with six recording channels adapted for operation at low temperature was used. Both refraction and reflection techniques were employed.

Travel times, surface heights of seismic stations, and ice thicknesses are shown in tables. Contours of the surface, location of nunataks, areas in which bedrock rises above sea level, and the route of the profile are shown on a map.—*J. W. C.*

177–366. Yamashita, Shirō, and Noritomi, Kazuo. On the survey of underground structure by using E. T. L. seismic equipment [in Japanese with English abstract]: Akita Univ. Mining College Research Inst. Underground Resources Rept., no. 17, p. 18–23, 1957.

Results of a seismic refraction survey of a terrace at Ochiai, Higashitagawa district, Yamagata Prefecture, Japan, show that the terrace is composed of four horizontal layers. The basement, shown by a geological survey to be composed of agglomerates, could not be located exactly from the time-distance curves.—*V. S. N.*

SELENOLOGY

177–367. Urey, H[arold] C., Elsasser, W. M., and Rochester, M. G. Note on the internal structure of the moon: Astrophys. Jour., v. 129, no. 3, p. 842–848, 1959.

The irregular shape of the moon can be explained by assuming that its density varies with angular position and possibly also with the radius, and it is shown that great strength in the deep interior is not required in this model. The outer parts must have great strength in order to account for certain surface irregulari-

ties. It is suggested that the external parts are now, and have been since the surface features were established, colder and, hence, more rigid than those of the earth. The irregularities in density indicate that some 10^4 to 10^5 masses of matter of variable density were required in the moon's formation. The variable density is inconsistent with its accumulation from small objects only or with a generally high temperature state at any time.—*D. B. V.*

177–368. Kozyrev, N. A. Vulkanicheskaya deyatel'nost'na lune [Volcanic activity on the moon]: Priroda, no. 3, p. 84–87, 1959.

Kozyrev is convinced that the morphology of the moon's surface demonstrates conclusively that its relief developed gradually as a result of repeated uplift and subsidence and that such tectonic processes must be associated with volcanic activity. The surficial rocks of the moon are porous and, therefore, poor conductors of heat; this should promote mountain building processes, which may even now be more intense than those on earth.

There have been previous reports of a haze veiling the crater floors, but these have been visual and not substantiated. The first breakthrough came in October 1956 when a photograph obtained at Mount Wilson Observatory, Calif., showed an obliteration of the detail of the floor of Alphonsus crater. On the morning of November 3, 1958, three photographs were made of the spectrum across Alphonsus crater. The first of these was normal, the second exhibited anomalous absorptions in the carbon spectrum, and the third was again normal. The second and third spectrograms are reproduced, together with a photograph of the crater. Kozyrev also observed the activity visually; he reports that the central peak was bright and that it then returned suddenly to normal as he watched. The luminescence detected in the spectrograms is similar to that of comets but ten thousand times more intense.

On November 19, 1958, two English observers also noted a blur in Alphonsus crater that did not exist until then.—*J. W. C.*

177–369. Fremlin, J. H. Volcanoes on the moon: Nature, v. 183, no. 4656, p. 239, 1959.

Kozyrev's phenomenon (see Geophys. Abs. 177–368) can be explained without recourse to a volcanic origin for the moon's craters. Assuming that the effective conductivity of the dust accumulated in the craters, whatever their origin, is about $7\times10^{-7}h$ (h=depth), that radioactivity accounts for a temperature rise of 8°C per million years, and that the heat flux reaching the surface is the whole of that produced in the interior (about 8.4×10^{-6} cal per cm^2 per sec), it is calculated that the temperature at a depth of 1 m would be 240°C and at 25 m would reach the softening point of basalt. Therefore, dust could not lie indefinitely over large areas to depths of more than 25 m. The mere filling of the larger craters with dust would provide in time for volcanic activity at their centers. This activity would consist of periodic liberation of puffs of hot gas and dust, more analogous to boiling with bumping than to volcanic action on the earth's surface, and would produce just the kind of phenomenon observed.—*D. B. V.*

177–370. Jaeger, J. C. Sub-surface temperatures on the moon: Nature, v. 183, no. 4671, p. 1316–1317, 1959.

Fremlin, J. H. Sub-surface temperatures on the moon: Nature, v. 183, no. 4671, p. 1317–1318, 1959.

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Jaeger points out that the extreme values for temperatures on the moon predicted by Fremlin (see Geophys. Abs. 177–369) are obtained by using a value for thermal conductivity that is probably much too low, together with a value of heat flux that is probably much too high. It is pointed out that the triaxial figure of the moon requires substantial strength in the interior for a considerable time in the past.

An average heat production in the moon at the chondritic rate would give a lunar surface heat flux of the order of 2.3×10^{-7} cal per cm^2 per sec, and this is the value which should be assumed in the absence of evidence to the contrary. Using this value and a conductivity of 2×10^{-4} deduced for the substratum from eclipse observations, the temperature value is reduced to 3°C. This value is just within the range of experiment; the mean temperature as shown by microwaves, which originate from a region some meters thick, should be greater than that derived from optical observations if there is any general increase of temperature with depth owing to lunar heat flux.

Fremlin in reply admits that he used a high figure for the radioactivity of the moon and a low conductivity value but claims these are not necessarily wrong; on the other hand Jaeger's more conservative figures must almost necessarily be wrong, as they show that Kozyrev's phenomenon (see Geophys. Abs. 177–368) could not have occurred.—*D. B. V.*

177–371. Dolezal, Erich. Ein tätiger Mondvulkan? [An active moon volcano?]: Universum, v. 14, no. 6, p. 167–170, 1959.

The evidence of possible volcanic activity on the moon is reviewed. The reddish cloud observed by Kozyrev in Alphonsus crater and attributed by him to a volcanic eruption was also seen in England but not in the United States or in the Pyrenees; possibly its visibility depended on the angle of the sun's rays. Up to mid-December, 1958, seven observers had seen the spot in question. The existence in the moon of isolated heat pockets, at least, is not impossible. The disappearance of the deep Linné crater, 10 km in diameter, between 1843 and 1866, and the appearance in 1877 of Hyginus N, a rimless crater 5 km in diameter in a well-observed region, are other signs of possible volcanic activity. A yellow-orange flash of light observed in 1948 in Plato crater, too brief for a volcanic eruption, was attributed to a meteor fall, and a glow lasting a half hour observed in 1951 in Lichtenberg crater, was attributed at the time to reflection of sunlight.—*D. B. V.*

177–372. Die Umschau. Vulkanausbrüche auf dem Mond [Volcanic eruptions on the moon]: Umschau, v. 59, no. 5, p. 147, 1959.

Kozyrev's observation of a bright gas cloud in Alphonsus crater indicates the existence of at least isolated hot areas beneath the surface of the moon, and is a strong argument in favor of the volcanic origin of the moon's surface features.—*D. B. V.*

177–373. Kopal, Zdeněk. Origin of the lunar craters and maria: Nature, v. 183, no. 4655, p. 169–170, 1959.

Impact theories of the origin of lunar craters and extensive plains such as the Mare Imbrium so far have been limited to considering the effects of solid bodies such as meteors or small asteroids. It is pointed out that the kinetic energies of the order of 10^{26} to 10^{28} ergs that are necessary to produce impact craters 20, 40, and 80 miles in diameter would excite seismic waves so strong

that the steep mountains and ridges of the moon could not have survived a long series of such impacts.

If the effect of collision with cometary heads is taken into account, the objections are removed. Cometary heads are loose conglomerations of frozen hydrocarbons with admixed unstable compounds, which behave on impact like high explosives, releasing chemical energy as well as kinetic. Having no tensile strength their impact would not indent the surface, but if their kinetic energy alone (which may be as much as 10^{31} ergs) could be converted into heat it could melt 10^{20} g of lava, or enough to cover the 400,000 km^2 area of the Mare Imbrium to a uniform depth of 100 m. Comets with kinetic energies of this order are scarce, but the number of maria on the moon is small; furthermore there is no indication of deformation in their central regions. Smaller comets could produce the smaller craters.

In conclusion it is suggested that the gas discharge recently observed by Kozyrev from the peak of Alphonsus crater might represent accidental discharge of gas deposited by a cometary impact long ago.—*D. B. V.*

177–374. van Dorn, William G. Origin of the lunar craters and maria: Nature, v. 183, no. 4663, p. 737, 1959.

Kopal, Zdeněk. Origin of the lunar craters and maria: Nature, v. 183, no. 4663, p. 737–738, 1959.

In reference to Kopal's suggestion concerning the origin of lunar craters and maria by comet impacts, van Dorn is of the opinion that although the kinetic energy of an impacting mass is probably much larger than previously thought, analogy with underground nuclear explosions suggests that the seismic energies produced are spent preferentially in the P-waves, and widespread damage visible from the earth would not result. Furthermore the molten material produced would not be so large in amount, and it would be thrown out of the crater along with other debris and not collected as a molten pool on the bottom.

Kopal replies that the analogy is invalid, as the lunar meteor explosions would be at least a few thousand yards deep; that the lower gravity on the moon would allow S-waves to attain greater amplitudes than on the earth; and that the real point of his earlier communication was to draw attention to the damage caused by the cumulative effects of hundreds of thousands of such occurrences, not to that caused in the immediate neighborhood of the impact.—*D. B. V.*

177–375. Worzel, J. Lamar. Extensive deep sea sub-bottom reflections identified as white ash: [U.S.] Natl. Acad. Sci. Proc., v. 45, no. 3, p. 349–355, 1959.

SUBMARINE GEOLOGY

The great extent of a subbottom echo at depths of 0 to 40 m below bottom in the tropical eastern Pacific is demonstrated. Occasionally there are two, and rarely three, of these echoes. The first, is well correlated by cores throughout the area with a white ash layer; as this layer is fairly near the surface, is not discolored, and contains nothing but glassy ash material, it must have been laid down fairly quickly. The layer rises to the ocean floor toward the higher parts of the topography and deepens in the lower parts; it disappears on the shelves. If the white ash can be identified with the same time of occurence in all of the cores, much can be learned of sedimentation rates in this part of the Pacific and particularly about the variability of these rates.

The great extent of the ash and its shallow cover imply such a great amount of recent activity for a short time that it may be difficult to ascribe it to Andean

volcanism. If it can be correlated with subbottom echoes from other areas, a worldwide or perhaps cosmic source must be sought. It will be possible to measure the acoustic properties above and below the layer and of the layer itself; this area can then become an excellent testing ground for theories of reflectivity for various layer thicknesses and depth of burial, and for the effectiveness of various sounding equipment.—*D. B. V.*

177–376. Ewing, Maurice, Heezen, Bruce C., and Ericson, David B. Significance of the Worzel deep sea ash: [U.S.] Natl. Acad. Sci. Proc., v. 45, no. 3, p. 355–361, 1959.

Reexamination of echograms obtained by the Lamont group from other areas shows that subbottom echoes similar to those found in the eastern Pacific (see Geophys. Abs. 177–375) have also been recorded in the South Atlantic and Indian Oceans. In general, the layer responsible was too deep to be reached by cores, but in the Gulf of Mexico it has been correlated with a white ash layer in some cases and with a carbonate layer in others. Extensive ash layers are now recognized in continental areas throughout the geologic record, and ash has been found in ocean bottom cores obtained by other expeditions in the North Atlantic, Pacific, and Mediterranean.

The ash consists of colorless shards of volcanic glass; it is entirely unlike material described as meteoritic dust, and only the wide geographic extent suggests any source other than volcanic eruptions. The three possible sources are Galapagos, eastern Ecuador, and Central America. The outstanding difficulties are the wide extent and uniqueness of the ash layer, difficulties which are also encountered in the explanation of beds of bentonite. Either a single very large volcanic explosion or the simultaneous explosion of many volcanoes is required, or conceivably a cometary collision occured similar to that suggested by Urey as a "last resort type explanation" for the origin of tektites.—*D. B. V.*

177–377. Scheidegger, A[drian] E[ugen]. Physics of marine orogenesis: Alberta Soc. Petroleum Geologists Jour., v. 6, no. 11, p. 266–291, 1958.

The contraction, continental drift, convection, and other standard theories of orogenesis are discussed and evaluated as to their adequacy in producing the recently discovered structures of the sea bottom that lie seaward from the andesite line, that is, midocean ridges, abyssal plains, and sea mounts which in the Pacific are often concentrated within fracture zones characterized by deep narrow troughs, asymmetrical ridges, and escarpments. In general, physiographic evidence on the earth's surface indicates that the crust has been subjected to forces of compression, tension, and shear; therefore any theory of orogenesis must be flexible enough to allow for production of all three forces in sufficient magnitude in the earth's crust. The acceptable theories at present are the continental-drift and the convection-current hypotheses. The convection-current hypothesis alone is unsatisfactory, but in conjunction with the continental-drift hypothesis, particularly with the assumption that the drift is somewhat random, a more satisfactory theory is obtained; but since the forces causing this drift are not yet understood, the problem of the origin of marine orogenic features must be regarded as unsolved (see also Geophys. Abs. 176–164).—*V. S. N.*

177–378. Hope, E. R. Geotectonics of the Arctic Ocean and the Great Arctic Magnetic Anomaly: Jour. Geophys. Research, v. 64, no. 4, p. 407–427, 1959.

A tentative description of the structure of the Arctic Ocean floor is presented, based mainly on recent Soviet literature. The most prominent feature is the Lomonosov Range, an abrupt ridge folded in the Mesozoic, whose peaks rise to within 1,000 m of the surface. This range divides the deep part of the Arctic Ocean into two basins, here called the European Arctic Basin and the Hyperborean Basin. The Alpha Range, an elevation—possibly a horst—extending completely across the deep part of the ocean, was reported by the United States drifting station Alpha; it lies on the Alaska side of the Lomonosov Range and roughly parallel to it. Recent volcanic activity (see Geophys. Abs. 176–362) is believed to mark a deep fault or crustal dislocation extending across the entire Arctic Ocean from within Eurasia. On the Greenland side the Lomonosov Range folding is interrupted by a series of enormous gullies and ridges, the extension of the Hercynian folding on the floor of the European Arctic Basin. At the other end of the Lomonosov Range is the Sadko Trough, bordered on the east by a wall 150 miles long and as much as 2 miles high in places. This may be a subsidence feature.

The Great Arctic magnetic anomaly is unique on the face of the earth. Before the discovery of the Lomonosov Range an elevation of the ocean floor was postulated to account for the anomaly; but the anomaly does not coincide with the Lomonosov Range. Discovery of the Alpha Range simplifies the problem. Two theories are compared: Hope's own, that the anomaly may be related to the interplatform geosynclinal corridor of Mesozoic folding extending across the ocean floor, and the Russian view that the anomaly is related to two primeval centers of consolidation in the earth's crust, located in the Greenland-Canadian Shield and in the Central Siberian Platform (Anabar Shield). Present data are insufficient to decide between these points of view.—*D. B. V.*

177–379. Elmendorf, C. H., and Heezen, Bruce C. L'océanographic et les réseaux de cables sous-marins [Oceanography and submarine cable networks]: Rev. Géographie phys. et Géologie dynam., v. 2, no. 1, p. 2–28, 1959.

Present knowledge of the topography, nature of the bottom, temperatures near the bottom, and possibility of catastrophic changes in the Atlantic Ocean are outlined and discussed in relation to the planning, laying, and repairing of submarine cables. Most information on the topography has been obtained by echo sounding; on the nature of the bottom, by visual observations and photographs, sampling, sounding, and study of the magnetic and gravity fields and heat flow. Catastrophic changes may result from earthquakes, turbidity currents, and submarine slumping. Earthquakes are concentrated in a belt along the Mid-Atlantic Ridge. Turbidity currents and submarine slumping may be a result of earthquakes or their aftershocks. A map shows regions of the world oceans that are believed to be inaccessible to turbidity currents by virtue of their elevation or protective barriers. Many turbidity currents have been detected because of their damage to cables.—*D. B. V.*

Hersey, J. B., Bunce, Elizabeth T., Wyrick, B. F., and Dietz, F. T. Geophysical investigations of the continental margin between Cape Henry, Virginia, and Jacksonville, Florida. See Geophys. Abs. 177–247.

VOLCANOLOGY

177–380. Gorshkov, G. S. On some theoretical problems of volcanology: Bull. volcanol., v. 19, p. 103–113, 1958.

This is an English version of the paper published in the Izvestiya, ser. geol., no. 11, p. 21–27, 1958, of the Akad. Nauk SSSR. (See Geophys. Abs. 176–359.)—*D. B. V.*

177–381. Rittmann, A.[lfred] Su l'origine dei magmi [On the origin of magmas]: Accad. Gioenia Boll., ser. 4, v. 4, no. 6, p. 381–401, 1958 (reprinted by the Istituto di Vulcanologia dell'Universita di Catania).

On the basis of geophysical, physiochemical, and volcanological considerations it is concluded that basaltic magmas and their differentiates originate in a true substratum of molten magma of oceanitic composition, which under high pressure behaves seismically as a solid body. The differences between geosynclinal proto-ophiolites and continental basalts are due to mechanism of ascent. Rhyolitic and dacitic magmas are formed by anatexis, mainly during the phase of engulfment of sial in orogenies. More rarely, magmatic types can be formed as a result of processes of assimilation, when favorable geological conditions permit the formation of shallower magmatic chambers filled with primary magma, not magma derived by differentiation.—*D. B. V.*

177–382. Matschinski, M[atthias]. Caractéristiques chimiques des arcs volcaniques, "densités" de Sapper et pressions moyennes correspondentes [Chemical characteristics of volcanic arcs, Sapper "densities" and corresponding mean pressures]: Soc. géol., France Comptes Rendus, no. 3, p. 67–69, 1959.

The average probable correlation between Sapper "density" (d) and concentration of the fundamental oxides in the products of volcanic arcs is given by the formula $d \cdot const = const + 1.08/SiO_2/ + 0.92/Al_2O_3/ - 0.32/CaO/ - 1.20/MgO/ - 0.25/Na_2O/ - 0.51/K_2O/ + 0.28/Fe$ oxides. Comparison of this with a simplified version of the formula correlating chemical composition with pressure (see Geophys. Abs. 167–276, 168–307) leads to the conclusions that the "density" of the volcanoes in a chain is a function of the pressure (or better still, of the excess pressure) in the zone of origin of the eruptive products, and that the purely chemical constants of the primary mixture can be obtained—almost by means of a common multiplier—by "geographic" measurements.—*D. B. V.*

177–383. Rittmann, A[lfred]. Sul meccanismo dell'attività vulcanica persistente [On the mechanism of persistent volcanic activity]: Accad. Gioenia Boll., ser. 4, v. 4, no. 6, p. 352–360, 1958 (reprinted by Istituto di Vulcanologia dell'Universita di Catania).

Persistent volcanic activity takes place if the conduit is open and the viscosity of the magma is sufficiently low that degasification can take place freely. The mechanism consists of a rhythmic degasification combined with two-phase convection. The great variability of visible phenomena depends essentially on the depth level of magma within the vent.—*D. B. V.*

177–384. Roux, Jean. Particularités du volcanisme: les trous-cratères [Details of volcanism: pit craters]: Soc. géol. France Comptes Rendus, no. 13, p. 318–319, 1958.

Pit craters, similar to those observed in Hawaii, are associated with the ancient volcanoes of Auvergne, France. Some are large and well known (the Pavin, the Chauvet), others became lake basins and now for the most part are swamps. Their depth ranges from a few to almost a hundred meters (the Pavin, 92 m); their form may be circular, ellipsoidal, or sometimes star shaped. They appear to be phenomena that occur at the end of volcanic activity, resulting from a very localized explosion like a bomb crater. Some degree of subsidence of the crater bottom after the explosion is very likely but only due to settling of the shattered material. Exactly how the gases reach the point of explosion is not clear; perhaps a last gasp of the dying volcano, a final spark, could touch off the explosion.—*D. B. V.*

177–385. Gèze, Bernard. Excursion géologique à la Martinque et à la Guadeloupe [Geologic excursion to Martinique and Guadeloupe]: Soc. géol. France Comptes Rendus, no. 3, p. 55–56, 1959.

Volcanic phases on Martinique and Guadeloupe have been numerous and varied in dynamics, but the occurrence of spines, domes, pelean breccias, and glowing-cloud deposits has been one of their outstanding characteristics. Present activity of Mount Pelée consists of 80°C fumaroles at the base of the dome and hot springs (about 70°C) near Prêcheur; at the Soufrière the fumaroles, hot springs, and steam jets at the base of the dome and the thermal springs at Galion, Bains jaunes, and elsewhere apparently have not been affected by the eruption of 1956. On Guadeloupe an old volcanic alinement of N. 10° W. is distinguished from a more recent trend of N. 20° W., which includes the Soufrière and parallels the zone of negative-gravity anomalies outside the Lesser Antilles according to the classic design of island arc evolution. A submarine eruption reported in 1943 between Basse-Terre and Marie Galante Island also appears to confirm this tendency toward eastward migration.—*D. B. V.*

177–386. Barrabé, L[ouis], and Jolivet, J. Les récentes manifestations d'activité de la Guadeloupe (Petites Antilles) [The recent manifestations of activity on Guadeloupe (Lesser Antilles)]: Bull. volcanol., v. 19, p. 143–157, 1959.

The history of the Soufrière de Guadeloupe is outlined briefly. Between 1837 and 1956 the only activity was fumarolic. A new eruption began suddenly on the night of October 19–20, 1956, with little or no preliminary signs in the form of fumarolic or seismic manifestations. Clouds of gas and cinders were erupted from a new fissure trending southeast from the center of the plateau, and for a brief time from another new fissure trending north-northwest. Activity lessened progressively from October 20 to November 20, then revived slightly. A rumbling noise was heard on November 27, but no external phenomena were connected with it. On December 17 two earthquakes were recorded in southwestern Guadeloupe, of intensity 2 and 2–3, respectively. In general the eruption was of the same character as those of 1797 and 1836.—*D. B. V.*

177–387. Berg, E. Volcanic eruption in the Belgian Congo: Jour. Geophys. Research, v. 64, no. 5, p. 580, 1959.

This is a brief report on an eruption that occurred on the north side of Nyamuragira in the eastern Belgian Congo, beginning on August 7, 1958. Activity was preceded by a swarm of small earthquakes. The main eruption occurred on August 10 at Kitsimbanyi. The laval outflow measured about 20 km

when it stopped, on November 21. Maximum outflows from the very spectacular cinder cone were reported to be about 50 m^3 per sec.—*D. B. V.*

177–388. Neumann van Padang, M. Changes in the top of Mount Ruang (Indonesia): Geologie en Mijnbouw, v. 21, no. 4, p. 113–118, 1959.

Mount Ruang, in the Sangihe Archipelago of Indonesia, is comparable to Merapi in activity; catastrophic eruptions occur repeatedly. This paper describes briefly various outbursts that have occurred since 1808 and consequent changes of shape of the crater. Of special interest is the repeated development of a lava dome in the crater and the occurrence of glowing avalanches.—*D. B. V.*

177–389. Corwin, Gilbert, and Foster, Helen L. The 1957 explosive eruption on Iwo Jima, Volcano Islands: Am. Jour. Sci., v. 257, no. 3, p. 161–171, 1959.

A sudden explosive eruption occurred near the center of Iwo Jima on March 28, 1957, and continued for 65 minutes, ending abruptly. No juvenile material was ejected. The eruption resulted from the sudden release of an underground accumulation of steam under high pressure beneath artificial fill adjacent to an abandoned airfield. The eruption does not seem to indicate an increase in volcanic activity on Iwo Jima.—*V. S. N.*

177–390. Namba, Munetoshi, and Sugimoto, Yasuhiro. Some studies on Volcano Aso and Kuju (Part 14). On volcanic sounding: Kumamoto Jour. Sci., ser. A, v. 3, no. 3, p. 201–211, 1958.

Violent explosions of the fumarolic craters of Aso Volcano, Japan, are commonly preceded by a period of roaring sounds not unlike the sound of an organ and varying in intensity with the amount of gas released. The atmosphere in the crater acts as a sounding box and the rim of the crater often vibrates. At its greatest intensity, the sound may be heard at a distance of 10 km. From studies of the crater and from experiments with a water-feed cock with distorted rubber packing, it is concluded that the sound is produced in the volcanic vent tube immediately beneath the crater when volcanic gases flow with great velocity through a narrow path and cause magma in the tube to vibrate like a reed. If the narrow path is closed by magma, all sounds and gas effusion cease; if the channel is not quickly reopened, the gas pressure increases and an explosion in the crater results. Thus activity at Aso follows a cycle of fumarolic activity, sounding, and explosive stages. This phenomenon was also observed in the March 1957 eruption of Sakura-jima. (See also Geophys. Abs. 169–321, 322 and 323.)—*V. S. N.*

177–391. Lloyd, E. F. The hot springs and hydrothermal eruptions of Waiotapu: New Zealand Jour. Geology and Geophysics, v. 2, no. 1, p. 141–176, 1959.

The waters of hot springs of the Waiotapu thermal area of New Zealand are divided into four classes on the basis of chemical composition, and their origin and the relationships of the hot springs to geological features are discussed. Natural heat flow of the Waiotapu area has been estimated as 302,000 kcal per sec above 15°C.

Hydrothermal eruptions of steam-blast type took place throughout the Waiotapu district about 900 years ago. If all the eruptions occurred from a common hydrothermal system, it must have been extensive. For such a large block of

country (8 sq. miles) to heat up, heat losses at the surface must have initially been low compared with rate of heat supply from below. The system would eventually reach equilibrium, with heat gain equal to heat loss by surface thermal activity. After the eruptions, shattered zones beneath the craters would channel the hot water to the surface, resulting in accelerated heat output and allowing cold ground water to flow in from the margins. Permanent shrinkage of the hydrothermal system would result.

Possible mechanisms for triggering such eruptions are: accumulation of pressures within the system until they exceed lithostatic load and disrupt the overlying rocks; intrusion of magma at depth, upsetting equilibrium because of intensified thermal effects (minor gravity highs are the most valuable evidence in favor of this view); and tectonic movements allowing hot water to rise to levels where its temperatures exceeds the boiling point for the depth conditions. The Waiotapu eruptions probably were initiated by the more violent volcanic disturbances at Tarawera; as local earthquake shocks undoubtedly would have accompanied such pumice eruptions, Lloyd favors a tectonic triggering.—*D. B. V.*

177-392. Noi, Alfonso di. Sul significato della presenza di metano nelle manifestazioni esalative e idrotermali [On the significance of the presence of methane in exhalative and hydrothermal manifestations]: Annali Geofiscia, v. 11, no. 3–4, p. 241–247, 1958.

Theoretical physicochemical study of the stability of methane and comparison with known conditions in different igneous environments show that the presence of hydrocarbons need not exclude a juvenile origin, for methane is not completely dissociated under typical plutonic conditions (high pressure, not so high temperature). On the other hand methane is completely dissociated under conditions of plateau volcanism (high temperature, pressure down to atmospheric value as magma is extruded).—*D. B. V.*

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