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

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GEOPHYSICAL ABSTRACTS 173, APRIL-JUNE 1958

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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 unless summaries of substantial length are published. Abstracts of papers in Japanese and Chinese are based on abstracts or summaries in a western language accompanying the paper.

LIST OF JOURNALS

Full titles and abbreviations of journals cited for the first time in this issue (with the sponsoring organization and its address where these do not form part of the title) are given below. This list supplements the List of Journals published in Geophysical Abstracts 160 (January–March 1955, Bulletin 1033–A) and the supplements published in Geophysical Abstracts 161–172.

Československá Akad. Věd Studia Geophys. et Geod.—Studia Geophysica et Geodaetica. Československá Akademie Věd. Praha.

Geotecnica—Geotecnica (Geologic tecnica-Foundazioni-Construzioni di Terra). Associazione Geotecnica Italiana. Milan.

New Zealand Jour. Geology and Geophysics—New Zealand Journal of Geology and Geophysics. Department of Scientific and Industrial Research, Wellington.

Royal Astron. Soc. Geophys. Jour.—The Geophysical Journal of the Royal Astronomical Society, incorporating the Geophysical Supplement to the Monthly Notices of the Royal Astronomical Society, London.

Univ. Zagreb Geofiz. Inst. Radovi—Sveučilište u Zagrebu—Prirodoslovno-matematički Fakultet, Geofizički Institut Radovi. Yugoslavia.

FORM OF CITATION

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

ABSTRACTORS

Abstracts in this issue have been prepared by J. R. Balsley, G. D. Bath, P. E. Byerly, Beryl T. Everett, R. G. Henderson, H. R. Joesting, F. C. Kracek, D. R. Mabey, R. M. Moxham, Virginia S. Neuschel, L. C. Pakiser, and I. Zietz, as well as by the principal authors. The notation "Author's abstract" followed by the initials of an abstractor indicates a translation of the author's abstract.

AGE DETERMINATIONS

173–1. Rubin, Meyer, and Alexander, Corrinne. U. S. Geological Survey radiocarbon dates IV: Science, v. 127, no. 3313, p. 1476–1487, 1958.

The results of 180 new age determinations made by the U. S. Geological Survey radiocarbon laboratory during the period between July 1, 1955 and November 7, 1956 are tabulated. Essentially the same laboratory procedure and same methods of computing ages and errors were used as before (see Geophys. Abs. 158–171, 172; 161–135; 164–14). Some of the problems pursued in this series of dates include the age of sea water; the age of the Mankato substage (found to be pre-Two Creeks); sequence and timing of North American continental glaciations and correlations with those of South America and Australia; climatically induced sea-level changes as related to the postglacial altithermal interval; dating of mountain glaciations; timing of pluvial stages of lakes in the Interior Basin; Alaskan glacial chronology; and the study of modern grass for evidence of nuclear bomb contamination of the atmosphere.—*D. B. V.*

173–2. Crane, H. R., and Griffin, James B. University of Michigan radiocarbon dates II: Science, v. 127, no. 3306, p. 1098–1105, 1958.

A list of 109 radiocarbon dates obtained since the last report (see Geophys. Abs. 167–9) is presented. No essential changes in technique were made in the interval. Samples, mainly of archeological interest, are listed geographically from the upper Mississippi Valley, Great Lakes, northeastern United States, southeastern United States, western and southwestern United States, Mexico and Guatemala, to the Pacific and Far East.—*D. B. V.*

173–3. German, R. Neue C^{14}-Daten [New C^{14} dates]: Naturw. Rundschau, v. 11, no. 4, p. 146, 1958.

Quotes some carbon-14 dates recently published by the Lamont group (see Geophys. Abs. 171–24).—*D. B. V.*

173–4. Te Punga, M. T. Evidence for a low sea-level 9900 years ago: New Zealand Jour. Geology and Geophysics, v. 1, no. 1, p. 92–94, 1958.

It is tentatively submitted that radiocarbon dating of Podocarpus wood from a well at Foxton suggests that sea-level may have risen about 150 ft during the last 9,900 years, but there is no decisive evidence to indicate whether the land at the well site has been stable or tectonically elevated or depressed in recent times.—*Author's summary*

173–5. Suggate, R. P. Late Quaternary deposits of the Christchurch metropolitan area: New Zealand Jour. Geology and Geophysics, v. 1, no. 1, p. 103–122, 1958.

Carbon-14 dates for nine samples of wood, peat, or shells from water wells in Christchurch, New Zealand are presented in this paper on the late Quaternary deposits of that area. Some of these dates record part of the post-glacial rise of sea level during deposition of the youngest of these deposits (the Christchurch Formation, extending down to more than 200 ft below present sea level); 9,400 years ago the sea stood at −73 ft, 6,100 years ago at −12 ft. Other dates, together with topographic and soil evidence, are interpreted as indicating the subsequent development of a gravel fan by the Waimakiriri River, probably completed about 2,000 years ago when sea level stood a little higher than at present.—*D. B. V.*

173–6. Moorbath, S., Taylor, S. R., and Upton, B. G. J. Age of zircon from the Kunait syenite complex, southwest Greenland: Geol. Mag., v. 95, no. 2, p. 149–152, 1958.

The age of zircons from the Kunait syenite pluton in northwestern Greenland has been determined by the lead-alpha method as 497 million years, or Cambrian according to Holmes' time scale. The Kunait complex is probably contemporaneous with the Ilimausak and Igaliko complexes which intrude the Gardar sedimentary series; therefore, an age determination on the Kunait should give a minimum age for the Gardar series. This result agrees well with the geological work of Wegmann, who considers the Gardar formation to be late Precambrian or Paleozoic.—*V. S. N.*

173–7. Long, Leon E., and Kulp, J. Laurence. Age of the metamorphism of the rocks of the Manhattan Prong: Geol Soc. America Bull., v. 69, no. 5, p. 603–606, 1958.

Potassium-argon ages of biotite, phlogopite, and muscovite from several different rock units and locations in the Manhattan Prong are reported. The measured ages of the Manhattan schist, Inwood marble, and pregmatites are in excellent agreement, with an average apparent age of $366 \pm 9 \times 10^6$ yrs. Two samples of biotite from the Fordham gneiss are significantly older. This may be interpreted in two ways: either the gneiss represents an older basement rock which did not lose all its argon during the recrystallization, or else the biotite contained some impurity such as amphibole that may carry excess argon. The small ratio of rubidium: common strontium in the samples investigated makes

it impossible to eliminate one of these hypotheses. It is concluded that the latest major orogenic event that produced the metamorphism of the rocks of the Manhattan Prong and the intrusion of the pegmatites occurred about 365 million years ago and can be correlated with the Taconic orogeny in the upper Ordovician; this result is not inconsistent with a Cambro-Ordovician date for the deposition of the Lowerre, Inwood, and Manhattan formations.—*D. B. V.*

173–8. Geiss, Johannes, and Hess, David C. Argon-potassium ages and the isotopic composition of argon from meteorites: Astrophys. Jour., v. 127, no. 1, p. 224–236, 1958.

The potassium and the argon contents of 13 meteorites were measured by isotopic dilution method. It is proved that the amounts of argon-36 and argon-38 found in these samples are of extra-terrestrial origin, the main source being spallation processes induced by cosmic radiation. Two explanations are suggested for the excess of argon-36 compared to argon-38 found in some chondrites: either a special nuclear process forms argon-36 preferentially to argon-38, or else non-radiogenic argon was trapped during the formation of the crystals of these meteorites. The ages of 4.4 to 4.0×10^9 yrs found for the seven chondrites indicate that formation of the crystals found in these meteorites took place during or shortly after the great phase differentiations of meteoritic material. Great variations in age are observed (4.4 to 0.7×10^9 yrs) in the five achondrites, indicating a more complex history involving reheating, or either argon loss or potassium contamination. The age of the Brenham pallasite was not calculated, as its fall was not observed and, hence, it may be weathered.—*D. B. V.*

173–9. Farquhar, R. M., and Russell, R. D. Dating the Proterozoic of Canada, *in* Gill, James E. and others, The Proterozoic in Canada: Royal Soc. Canada Spec. Pub., no. 2, p. 28–32, 1957.

Methods of dating Precambrian rocks by absolute age determinations on radioactive minerals are reviewed and the present knowledge of absolute ages of Proterozoic and Archean rocks of the Canadian Shield are summarized. The best dated Proterozoic-type rocks of the Canadian Shield are the Athabaska sediments but even these have an age range of 300 million years, based indirectly upon determinations made on pitchblends and monazites of the area. It is only within the last year that basic assumptions underlying age determinations by the absolute dating methods have been extended to direct dating of sedimentary rocks. The work has been confined to fossiliferous strata and ages determined on glauconites by the potassium-argon and rubidium-strontium methods. Results agree fairly well with the "B" time scale of Holmes and the method should be easily extended to Proterozoic-type rocks. Such direct age determinations will provide a much better basis for a Precambrian time scale for Canada than present indirectly obtained data.—*V. S. N.*

173–10. Gast, P[aul] W., Kulp, J. L[aurence], and Long, L. E. Absolute age of early Precambrian rocks in the Bighorn Basin of Wyoming and Montana, and southeastern Manitoba: Am. Geophys. Union Trans., v. 39, no. 2, p. 322–334, 1958.

Age determinations on nine samples from the southeastern part of the Beartooth Range, Montana, indicate that the absolute age of the pegmatites and

granitic gneisses of this area is 2750±150 million years. A single determination from the northern Bighorn Mountains, Wyoming, suggests a similar age for this portion of the Precambrian basement. Several samples from the Winnipeg River-Johnston Lake area of Manitoba indicate an absolute age of 2650± 150 million years for both the pegmatites and gneisses. A similar age was found for a muscovite from the northwestern angle region of Minnesota. Rubidium-strontium ages were found to be more consistent than potassium-argon ages. Argon loss from micas was commonly as great at 15 percent.—*Authors' abstract*

173–11. Schreiner, G. D. L. Age of a Pilansberg dike of paleomagnetic significance: Nature, v. 181, no. 4619, p. 1330–1331, 1958.

The age of one of the Pilansberg dikes of South Africa, determined on a biotite from a coarse feldspathic center facies encountered at two levels in the Robinson Deep Mine by the rubidium-strontium method, is $1{,}290\pm180\times10^6$ yrs. The concordant ages given by two fractions of widely different mineralogic composition from the same hand specimen, and the concordant rubidium-strontium ratios in specimens from both levels indicate that the alteration observed in the rock occurred soon after intrusion; therefore, the measured age is not essentially different from the true age. This dike is the "Dike C" of Gough's paleomagnetic study (see Geophys. Abs. 168–244); it is far older than previously assumed from the stratigraphic evidence.—*D. B. V.*

173–12. Pinson, W. H., Jr., Fairbairn, H[arold] W., and Cormier, R. F. Sr/Rb age measurements on hornblende and feldspar, and the age of syenite at Chicoutimi, Quebec, Canada: Geol. Soc. America Bull., v. 69, no. 5, p. 599–601, 1958.

Strontium ages have been calculated for feldspar and hornblende from the syenite at Chicoutimi, Quebec. The age of the hornblende is found to be $1020\pm100\times10^6$ yrs and of the feldspar to be $600\pm300\times10^6$ yrs on the basis of isotope dilution data; on the basis of isotope ratios the hornblende is $950\pm50\times10^6$ and the feldspar $840\pm40\times10^6$ yrs old. Agreement is close enough to show that hornblende may be used when mica is absent or altered in age measurements on coexisting minerals in igneous rocks. Comparison with determinations on rocks in the Grenville age province shows that the Chicoutimi syenite may be assigned to the same orogeny that produced the Grenville metamorphism. Strontium isotope ratios (87/86, 84/88, 86/88) of both minerals are also given.—*D. B. V.*

173–13. Ewald, H., Felkel, G., Hebeda, E., and Kocher, H. Über Alterbestimmungen von Gesteinen nach der Rubidium-Strontium-Methode [On age determinations of rocks by the rubidium-strontium method]: Zeitschr. Naturforschung, v. 13a, no. 3, p. 235, 1958.

Chemical determination of the strontium-rubidium ratio in rocks for dating purposes is tedious; mass spectrometic-dilution techniques require strong concentrations of both elements; and the more convenient optical-spectroscopic method is not as accurate. This note describes an improvement of this last technique, used on a specimen of microcline from Varuträsk, Sweden. The strontium-rubidium ratio was determined using a Photovolta cell and spectroscope; intensities of strontium and rubidium lines were compared against standard solutions, giving a value of $Sr/Rb=(10.9\pm0.2)\times10^{-3}$. The Sr^{87}/Sr

ratio, measured spectrometrically, was 0.745±0.006. Using a half-life value of 5.0×10^{10} yrs for rubidium–87, an age of $2.08\pm0.04\times10^{9}$ yrs is obtained, which is in good agreement with an age of 2.06×10^{9} yrs obtained by the potassium-argon method for a lepidolite from the same locality (see Geophys. Abs. 165–294).—*D. B. V.*

173–14. Herr, W[ilfrid], and Merz E[rich]. Zur Bestimmung der Halbwertzeit des ^{187}Re. Weitere Datierungen nach der Re/Os-Methode [On the determination of the half-life of Re^{187}. Further datings by the rhenium-osmium method]: Zeitschr. Naturforschung, v. 13a, no. 3, p. 231–233, 1958.

The decay constant of the very weak ($E<7keV$) B-radiation of rhenium–187 has been determined by chemical analysis of mother and daughter substances in molybdenum minerals. Special neutron activation and measuring techniques permitted quantitative determination of the trace elements rhenium and osmium down to 10^{-7} percent. Measurements of the osmium–187 abundance were made by the neutron activation method. The age of the minerals was known, in part, from verified uranium-lead determinations. From these data the half-life of rhenium–187 is calculated to be $5.5\leqq T\leqq6.8\times10^{10}$ yrs. Using the average value of 6.2×10^{10} yrs, the ages of 17 molybdenites and one gadolinite from known localities in Norway, Chile, Canada, and Africa are calculated by the rhenium-osmium method and found to correspond well with determinations by other methods.—*D. B. V.*

Herr, W[ilfrid], Merz, E[rich], Eberhardt, P[eter], and Signer, P. On the determination of the β-half-life of lutetium–176 by the detection of radiogenic hafnium–176. See Geophys. Abs. 173–326.

173–15. Deutsch, S[arah], Picciotto, E[dgard] [E.], and Niggli, E[rnst]. Âge des halos pléochroïques des granits de Baveno et Monte Orfano [Age of the pleochroic halos of the Baveno and Monte Orfano granites]: Experientia, v. 14, no. 4, p. 128, 1958.

The age of the pleochroic halos in the Baveno and Monte Orfano granites in the Alps is determined as 75 million years on the basis of comparison with halos in the Tertiary Elba granite, indicating that they are at least as old as the Cretaceous. It is possible that they are actually older—Hercynian, for instance—the halos having been partly effaced during the Alpine orogeny.—*D. B. V.*

173–16. Deutsch, S[arah], and Picciotto, E[dgard] [E.]. Étude des halos pléochroïques dans le granit de Medel (Massif du St.-Gothard) [Study of the pleochroic halos in the Medel granite (St. Gotthard massif)]: Experientia, v. 14, no. 4, p. 128–129, 1958.

The pleochroic halos in the normal, granodioritic, and mylonitized border facies of the Medel granite of the St. Gotthard massif in the Alps have been compared with those of the Tertiary Elba granite. Because of the much greater sensitivity to coloration of the former, a direct estimate of their relative ages is not possible. A provisional maximum value of 60 million years, corresponding to the Alpine metamorphism, is assigned to the Medel granite.—*D. B. V.*

EARTH CURRENTS

173–17. Yoshimatsu, Takasaburo. The local characteristics of earth currents (III). Chapter II. Universal earth-currents and their local characteristics: Kakioka Magnetic Observatory Mem., v. 7, no. 2, p. 57–117, 1956.

Yoshimatsu analyzes data from 17 stations in various parts of the world, particularly Kakioka, in order to deduce the local characteristics of earth currents as well as the nature of their spatial distribution and time variations (see also Geophys. Abs. 158–85). The annual change of the maximum range of the S_q variation of earth currents shows a nearly linear correlation with sunspot numbers. An exceptionally small east component at Kakioka is attributed to winter characteristics of the mode of S_q. A remarkable long-period variation is found in the time of occurrence of the extreme minimum of the east component in winter at Kakioka (T^E_{min}), having a distinct maximum about two years before the maximum of S and corresponding with the change $\Delta S/\Delta t$ (where S=relative sunspot number, t=time in years), but no such variation appears in T^E_{max}. A similar variation is shown at Kakioka in the geomagnetic S_q field, especially in horizontal intensity. Tucson shows the same tendency to a smaller degree. A shorter 4-year period is superimposed on the long-period variation of T^E_{min} of S_q.

Phase angles ϕ_n of harmonic waves of S_q show no systematic relationship with S. In solar daily variations at most of the stations the magnitude of the resultant is of the order of some millivolts per km. Apparent resistivities are calculated from the ratio of resultant potential gradient to horizontal intensity for various middle latitude stations; these agree fairly closely with observed resistivities for the upper 100 m of the ground. Behavior of the second harmonic curve of S_q near the coast suggests that local earth currents due perhaps to electro-chemical action or capillary fluid motion may be produced near the coast by solar tidal motion of the sea water. Changes in *SSC* and *SI* are generally anticipated by small preliminary changes of some minutes duration. Solar daily variation of amplitude in this preliminary change resembles the S_q variation strikingly though the phase angle of the former lags about three hours behind the latter. *SSC*s* of earth currents are not always accompanied by geomagnetic *SSC*s*, nor are they always observed simultaneously at all five stations in Japan; they seem to be affected by the local electrical structure of the ground.—*D. B. V.*

173–18. Yanagihara, Kazuo. On the correlation between the frequency of the earth-current pulsation and the solar activity: Kakioka Magnetic Observatory Mem., v. 7, no. 2, p. 27–30, 1956.

Analysis of earth-current records at the Kakioka Observatory covering two recent sunspot cycles, particularly of the longer period type of pulsations in the night hours or of those accompanied by bay-type variation, shows an inverse relationship to solar activity. This relationship may be caused indirectly by increased ionospheric conductivity in and near the sunspot maximum years.—*D. B. V.*

173–19. Yanagihara, Kazuo. On the inequalities of the diurnal variations and the short period variations of the earth-currents (in Japanese with English summary) : Kakioka Magnetic Observatory Mem., v. 7, no. 2, p. 143–152, 1956.

Comparison of diurnal variations of earth currents at Toyohara, Memambetsu, Morioka, Haranomachi, Owashi, and Kanoya stations in Japan with Kakioka shows a simple relationship between the observed variations; this relationship is expressed in a formula. Using the constants of this formula it is shown that effective earth resistivities at Kakioka and Haranomachi may have varied in the last few years. The relationship between the short period (5–30 m) variations at Kakioka and Haranomachi can also be expressed by the same formula as the diurnal variations.—*D. B. V.*

173–20. Ádám, Anton, and Verő, Jose. Das Erdstrom-Observatorium bei Nagycenk (Ungarn) [The earth-current observatory near Nagycenk, Hungary] : Geofisica Pura e Appl., v. 39, p. 126–151, 1958.

The first part of this paper is a description of the earth current observatory established during the International Geophysical Year near Nagycenk, Hungary; the second part discusses in some detail the treatment of the data obtained. Periodic variations are grouped into five frequency classes. Correlations with magnetic phenomena such as bay disturbances, or magnetic storms are studied.—*D. B. V.*

Barta, Gy[örgy]. Report on the geomagnetic and telluric researches carried out in Hungary during the period of 1954–57. See Geophys. Abs. 173–272.

EARTHQUAKES AND EARTHQUAKE WAVES

173–21. Charlier, C[harles]. Symposium sur les mouvements récents du sol belge et les enseignements qu'ils apportent. 3.—Synthèse séismologique [Symposium on recent movements of the ground in Belgium and the information they convey. 3.—Seismological synthesis] : Cong. nat. Sci. (Belgium), 3d, Brussels, v. 4, p. 31–34, 1950 (1954).

Twenty-seven earthquakes occurred in Belgium between 1900 and 1950. Hainaut province suffered 19 shallow shocks (<3 km), western Belgium had two, Limbourg one, Liège province four; and the strongest was that of June 11, 1938, with its epicenter near Audenaerde. Except for Hainaut the seismic areas coincide with areas of large magnetic maxima (see Geophys. Abs. 173–310); the foci lie in the granitic layer. In Hainaut the foci appear to be related to faults affecting the Coal Measures. Correlation with gravity anomalies is not as striking. Too few isostatic reductions are available to warrant drawing conclusions as to isostatic compensation.—*D. B. V.*

173–22. Petkov, T. N. Razvitiye i dostizheniya seysmicheskoy sluzhby v Narodnoy Respublike Bolgarii [The development and achievements of the seismic service in the Bulgarian People's Republic] : Akad. Nauk SSSR Sovet po Seysmologii, Byull, no. 6, p. 19–25, 1957.

Bulgaria, in the Mediterranean seismic belt, is a rather interesting country for a seismologist. Several thousand earthquakes occurred during the last century, many of them reaching an intensity of 9, 10, and even 11 (on the

Forel-Mercalli scale). The earthquake centers belong to different systems, many of them lying outside of the country. Bulgaria has one well-equipped seismic station and an extensive system of macroseismic observation, which makes possible the publication of annual bulletins, containing the isoseismic maps and indicating the position of epicenters. The entire country can be divided into six separate blocks; relative displacements of these blocks causes the noticeable earthquakes.—*S. T. V.*

172–23. Banerji, S. K. Earthquakes in the Himalayan region, Calcutta, Indian Assoc. Cultivation Sci., 64 p., 1957.

This monograph covers the subject matter of a series of three lectures delivered in 1953. It includes a general discussion of the evolution of the Himalayas and the nature of the compression forces that are in operation, and their relation to the condition of the materials in the interior of the earth; an analysis of Himalayan earthquakes, both shallow and deep focus, that have occurred during the past 200 years; and a discussion of the origin of Himalayan earthquakes and the expectations for the future. The expectation of occurrence of disastrous earthquakes in this region is one in eight years.—*V. S. N.*

173–24. Tsuboi, Ch[uji]. Earthquake epicenters, volcanoes and gravity anomalies in and near Japan: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 243–247, 1956.

Comparison of the distribution of earthquake epicenters, Quaternary volcanoes, and gravity anomalies in Japan shows a very close correlation between these phenomena. Bouguer anomalies in northeastern Japan are mostly positive, in southeastern both positive and negative; epicenters in northeastern Japan are located chiefly on the Pacific side of the islands, in southwestern Japan along the islands. In mountainous central Hokkaido the anomalies indicate that a certain degree of isostatic equilibrium prevails, and there earthquakes are rare. Earthquakes occur when Bouguer anomalies are strongly positive or negative; in northeastern Japan one strongly seismic area corresponds to abnormally negative Bouguer anomalies, a second to abnormally positive anomalies. It would be worth investigating whether there are any differences in character of the seismograms of earthquakes from these two areas. Volcanoes are located in narrow zones generally running parallel to the isoanomaly lines, especially where they are closely spaced. They are always along the continental side of these zones, at an average distance of 30 km from them. Earthquakes and volcanic areas generally do not overlap. A more quantitative study of these correlations will be published elsewhere.—*D. B. V.*

173–25. Wadati, K[iyoo], and Iwai, Y. The minute investigation of seismicity in Japan (2nd paper): Bur. central séismol. internat. Pubs., sér. *A*, Travaux sci., no. 19, p. 261–265, 1956.

The same paper as that published in Geophysical Magazine (see Geophys. Abs. 166–52).—*D. B. V.*

173–26. Tsuchidaka, S. On the earthquakes in western Japan (in Japanese with English summary): Quart. Jour. Seismology, v. 21, no. 2, p. 37–40, 1956.

The vertical distribution of focal depth (H), radius of focal region (a) defined by Takagi, and depth of focal region ($h=H-a$) are investigated for

earthquakes that occurred in western Japan, especially in the Kii peninsula, in the period 1926–1952. The results are tabulated and plotted on maps and profiles.—*D. B. V.*

173–27. Shalem, N[athan]. Seismicity and Erythrean disturbances in the Levant: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 267–275, 1956.

A macroseismic network of about 400 observers in Palestine has furnished data on nine earthquakes since 1951. From these and from the reliably recorded disastrous earthquake of 1927 it is concluded that most of the earthquakes in the eastern Mediterranean area occur along the northwest-southeast-trending "Erythrean" fracture series that forms an integral part of the East African rift system and results from strain due to Alpo-Himalayan orogenic forces. The dormant volcanoes and hot springs of the area also are alined in this direction. North-south and northeast-southwest trends are also noted.—*D. B. V.*

173–28. Debrach, Jean. Sur quelques alignements séismiques remarquables du Maroc. Essai d'interprétation tectonique [On some remarkable seismic alinements in Morocco. Attempt at structural interpretation]: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 307–313, 1956.

Examination of a map of epicenters for Morocco based on earthquakes since 1932 (reliable records before that date are scarce) shows that epicenters are concentrated in zones of Tertiary folding; two seismic domains are distinguished, the Riff and the folded Atlas proper (Moyen Atlas and Grand Atlas). The Moroccan meseta as a whole is peneseismic with rare earthquakes in the old central massif; eastern Morocco (meseta) is aseismic, and no earthquake has yet been reported from the Anti-Atlas. Epicenters of the principal earthquakes are grouped along two networks of straight lines, each consisting of a principal direction with a secondary direction at right angles to it. One of these principal directions is oriented in the direction of Tertiary fold axes, the other follows Hercynian trends; the latter appears to continue into the Iberian peninsula. Earthquakes in western Morocco are almost never felt in eastern Morocco, and the larger Algerian shocks are not felt west of the meridian of Guercif, suggesting a seismic "screen" between the two areas.—*D. B. V.*

173–29. Silgado, F. E[nrique]. Datos sismológicos del Peru 1952–1955 [Seismological data from Peru, 1952–1955]: Soc. geol. Peru Bol., v. 29, 71 p., 1957.

A compilation of statistics for earthquakes felt in Peru in the years 1952 to 1955. Place, time, and intensity (modified Mercalli scale) are given for all, and epicenters have been located for some on the basis of records from Lima and Huancayo. Distribution of the principal shocks is plotted on a map. The characteristics of the most notable earthquakes (February 20 and 26, March 30, May 3, July 19, and August 3, 1952; February 15, 1953 at Lima; December 12, 1953 in northwestern Peru; June 15, 1954 in northeastern Peru; and February 9 and 26, March 9, May 3 and 22, July 16 and 21, August 19, and October 9 in 1955) are mentioned briefly.—*D. B. V.*

173–30. Petresku, G. Seysmichnost' territorii Rumynskoy Narodnoy Respubliki za 1935–55 gg [The seismicity of the territory of the Rumanian Peoples Republic during the years 1935–55]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 43–47, 1957.

A description is given of the equipment of the six seismic stations of the Rumanian network. With the aid of the records of several stations in adjoining countries these stations were able to determine the epicenters and the depth of the foci of numerous earthquakes occurring within the territory of Rumania during the years 1935 to 1955. It is interesting to note that the depth of the focus of the earthquake of April 28, 1943, about 65 km, indicates a very thick crust under the Carpathian Mountains. Other earthquakes with epicenters near Vrancha, also in the Carpathian Mountains, with focal depth of 70 to 150 km, are related to the sharp bend in the main ridge of the Carpathians. The article contains a map showing the location of most of the earthquakes occurring during the period in question.—*S. T. V.*

173–31. Boletín Sismologico del Servicio Geológico Nacional de El Salvador. Resumen de la actividad sísmica registrada en San Salvador [Summary of seismic activity registered at San Salvadorl: Servicio geol. nac. El Salvador Bol. sismol., v. 1, p. 55–56, 1955 (1956).

Earthquakes registered at San Salvador each week from January 3, 1954 to October 15, 1955 are plotted graphically. In 1954 a very large maximum occurred in April-May, a smaller one in late October; in 1955 one maximum again was in April-May, and a smaller one in September-October. With only two years of observations an attempt to correlate frequency of earthquake occurrences with changes in season is inconclusive.—*D. B. V.*

173–32. Boletin Sismológico del Servicio Geológico Nacional de El Salvador. Actividad sismica registrada durante il año de 1956 [Seismic activity registered during the year 1956]: Servicio geol. nac. El Salvador Bol. sismol., v. 2, p. 42 and 45, 1956 (1957).

Earthquakes originating in Central America, registered by the central seismic station at San Salvador from the time it resumed operations in March 1956 until the end of the year, are summarized in a graph showing distribution by weeks. The number of shocks felt is shown within the total number. No particular seasonal maximum is indicated, suggesting that the concentration observed in March-April both in 1954 and 1955 (see Geophys. Abs. 173–31) was probably coincidental.—*D. B. V.*

173–33. Boletin Sismólogico del Servicio Geológico Nacional de El Salvador. Algunos de los sismogramas caracteristicos de temblores registrados en la estación sismológica de San Salvador por los sismografos Wiechert [Some characteristic seismograms of shocks registered by the Wiechert seismographs at the San Salvador seismological station]: Servicio geol. nac. El Salvador Bol. sismol., v. 2, p. 18–21, 1956 (1957).

Seismograms obtained for horizontal components of six earthquakes registered at San Salvador in 1956, and in three cases of vertical components as well, are reproduced and discussed briefly. The six examples illustrate different combinations of focal depth and distance.—*D. B. V.*

173-34. Schulz, Rudolf. Informe preliminar sobre los epicentros localizados por la estación sismológica en San Salvador [Preliminary report on the epicenters located by the seismological station in San Salvador]: Servicio geol. nac. El Salvador Bol. sismol., v. 1, p. 28–32, 1955 (1956).

Almost all the strong earthquakes affecting El Salvador recently have originated along one of two tectonic lines. One of these is the depression in which the active volcanoes are located, lying about 20–30 km parallel from the coast; epicenters here have been determined accurately with macroseismic data supplementing the instrumental. The second line is a submarine trough paralleling the Pacific coast of Nicaragua, El Salvador, and Guatemala; the oceanic epicenters could not be located as precisely as those on the continent, but are found to lie on the continental shelf along the trough rather than in it or on its margins. Eight continental and ten offshore epicenters are plotted on a map.—*D. B. V.*

173-35. Savarenskiy, Ye. F. Ob izuchenii seysmichnosti SSSR [The study of the seismicity of the USSR]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 16–18, 1957.

A fundamental contribution to the study of seismicity of the U. S. S. R. is the Seismic Atlas of the Soviet Union, now ready for publication, containing among other data the seismic zoning maps of the entire country. For this purpose a new scale of the measurement of the intensity of earthquakes is introduced; five groups are established, the intensity in each being determined from the amplitude and period of oscillations registered at the seismic stations, in relation to the Gutenberg-Richter magnitude scale. The first group of this scale includes catastrophic earthquakes with $M \geqq 7\frac{1}{2}$; group 2 is defined by $7\frac{1}{2} > M \geqq 6\frac{1}{2}$; group 3 by $6\frac{1}{2} > M \geqq 5\frac{1}{4}$; group 4 by $5\frac{1}{2} > M \geqq 4\frac{1}{4}$; and group 5 by $M < 4$. Earthquakes in groups 4 and 5, as a rule, are non-destructive. Group 4 includes those recorded by remote stations (more than 10° epicenter distance). Group 5 includes feeble earthquakes recorded only by stations located in the same seismic zone.

The earthquakes are also classified according to the accuracy of the determination of their epicenters. Class A comprises earthquakes whose epicenters were determined with an error not exceeding 25 km from the seismograms of at least four stations surrounding the epicenter and located not further than 7° angle; in class B, the error does not exceed 50 km. The Atlas shows the following seismic zones: Carpathian, Crimean, Caucasian, Kopet-Dagh, Central Asia, Altay, Baykal, Far Eastern, and the Arctic. About 10,000 epicenters are indicated.—*S. T. V.*

173-36. Vyalov, O. S. Deyakī pytannya seysmotektonīky Sklīdnykh Karpat ī prylehlykh oblastey [Some questions of the seismotectonics of the eastern Carpathians and adjacent regions (in Ukrainian with Russian summary)]: Akad. Nauk Ukraynskoy RSR Geol. Zhur., v. 17, no. 2, p. 16–29, 1957.

The distribution of earthquake epicenters in the eastern Carpathians and vicinity is analyzed, discussing possible relationships to Tertiary volcanism and folding and to deeper major crustal lineaments. Data are still insufficient for definite conclusions to be drawn.—*D. B. V.*

Yevseyev, S. V. On seismic traveltime curves and crustal structure in the region of the Carpathians on the basis of data of two earthquakes. See Geophys. Abs. 173–251.

173–37. Aronovich, Z. I. O pogreshnostyakh pri opredelenii koordinat Krymskikh zemletryasenniy [On errors in the determination of the coordinates of Crimean earthquakes]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 254–259, 1958.

Systematic instrumental observations of earthquakes in the Crimea, a moderately active seismic region of Russia, were initiated in 1927 with the establishment of seismic stations at Yalta, Feodosiya, Simferopol', and Sevastopol'. The interpretation of earthquakes in the Crimea is very dependent upon the accuracy of the determination of the foci. Vvedenskaya (see Geophys. Abs. 165–52) studied the accuracy of the determination of the coordinates of an earthquake from *S–P* arrivals. Here Aronovich analyses the error in the determination of epicenters of near earthquakes by the method of sectors, using the seismograms from Yalta, Feodosia, and Simferopol'. The results are presented in tables. The accuracy of determination of Crimean foci has been greatly increased in the last few years, because more precise instruments have recently been installed in the old stations and a new station has been established at Alushta.—*S. T. V.*

173–38. Tamrazyan, G. P. Zemletryaseniya v Tbilisi i kosmicheskiye usloviya zemli [Earthquakes in Tbilisi and their relations to cosmic conditions of the earth]: Akad. Nauk Gruzinkoy SSR Soobshcheniya, v. 19, no. 2, p. 151–158, 1958.

It is definitely established that earthquakes are produced by processes taking place deep in the earth, but in addition to these causes there are external factors, meteorological or astronomical, that contribute to the occurrence of earthquakes. The earth is under the constant influence of the moon and the sun which produce tides in the fluid, aerial and solid masses of the earth. The amplitudes of these tides vary during the lunar month with maximums during the new moon and the full moon. Another maximum is caused by the position of the moon on its orbit; in perigee the tidal attraction is about 40 percent greater than in apogee. Analyzing the seismologic data available at Tbilisi, embracing the period from 1893 to 1950 during which 387 earthquakes occurred, Tamrazyan concludes that earthquakes are more frequent during the new moon and full moon. Six of the seven strongest earthquakes (intensity 7, 8, and 9) occurred during the new or full moon and only one during the first or last phase of the moon. Similar results were obtained for the entire Transcaucasian region. Thus the liberation of seismic energy in form of earthquakes is clearly affected by cosmic factors. The results of the statistical investigation are presented graphically.—*S. T. V.*

Karapetyan, N. K. Dynamic parameters of the foci of some earthquakes in the Caucasus. See Geophys. Abs. 173–81.

173–39. Rozova, E. A. O seysmichnosti Sredney Azii [On the seismicity of Central Asia]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 36–42, 1957.

Systematic recording of earthquakes in Russian Central Asia was begun in 1930–1931 at several permanent and temporary seismic stations. The results

of determinations of the seismological parameters of the earthquakes recorded and of seismic velocities in various parts of this area were published in 1935 using the P, P^*, $\overline{P}$, S, S^*, and $\overline{S}$ waves. In many cases the data were insufficient and results were published as only approximate. Subsequently the number of seismic stations in this region was increased and the equipment of all stations was improved. The 1935 study is defended from a charge that its results are unreliable. All earthquakes included in the recent edition of the seismic atlas of U. S. S. R. and covered by the study of the author are in sufficient agreement. In view of the high seismicity of Central Asia and important structural differences in its various areas, an expansion of the network of seismic stations is recommended to increase the accuracy and reliability of seismological investigations of this region.—*S. T. V.*

173–40. Vvedenskaya, A. V. Ob ispol'zovanii instrumental'nykh nablyudeniy nad slabymi zemletryaseniyami pri seysmicheskom rayonirovanii [The utilization of instrumental observations on weak earthquakes in seismic zoning]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 210–224, 1958.

Analyzing the records of about 5,800 weak earthquakes obtained by the network of seismic stations of Central Asia during 1950–1955, and taking into account their intensities, accuracy of determination of epicenters, and focal depth, Vvedenskaya has plotted the most probable felt areas for different groups of these earthquakes. Comparison with the distribution of strong earthquakes which occurred in individual areas over a much longer period of time shows that as a rule the epicenters of the strong earthquakes fall within the areas delineated by the epicenters of weak earthquakes. Thus for Central Asia, where over 1,000 earthquakes occur every year, it is possible to obtain valuable information on seismic zoning during a relatively short period of time by means of precise observation of weak earthquakes. Still unanswered is the question of prediction of intensity and timing of earthquakes in a given area.—*S. T. V.*

173–41. Roberts, E. B., and Cloud, W[illiam] K. Seismological activities of the Coast and Geodetic Survey in 1954 and 1955: Seismol. Soc. America Bull., v. 48, no. 1, p. 83–95, 1958.

A review of the seismological work of the U. S. Coast and Geodetic Survey in 1954 and 1955, including a list of earthquakes of intensity 6 or greater in the western United States (with map of epicenters and isoseismal maps of the earthquakes of December 16, 1954 in Nevada and December 21, 1954 in California); list of principal earthquakes in the eastern United States and outlying territories; and summaries of the teleseismic, questionnaire, and strong-motion seismograph programs, vibration and tiltmeter work, instrumental research and development, and geodetic surveys after earthquakes.—*D. B. V.*

173–42. Rothé, J[ean]-P[ierre]. Le tremblement de terre d'Orléansville et la séismicité del' Algérie [The Orleansville earthquake and the seismicity of Algeria]: La Nature (Paris), no. 3237, p. 1–9, 1955.

A more detailed description of the Orleansville earthquake in Algeria in 1954 (see Geophys. Abs. 163–103). Effects on the terrain include large collapses of 2 or 3 m; a network of fissures trending north-south showing both horizontal and vertical movement with a few large east-west fractures 3 m deep and 50 cm wide; a somewhat sinuous fissure more than 6 km long, forming a circular

arc around the Beni-Rached plateau, whose trace is probably due to the topographic crest nearby; and a series of craterlets.—*B. T. E.*

173–43. Miranda, Raul de. O sismos de Cabo Verde nos anos de 1944 e 1945 [The earthquakes of Cape Verde in the years 1944 and 1945 (with Spanish, French, and English summaries)]: Conf. internat. Africanistas ocidentais 6° Sess., São Tomé, 1956, Communicacões, v. 2, p. 139–146, 1956.

Earthquakes in the Cape Verde Islands are attributed to epirogenic movements on faults. Three earthquakes occurred in 1944 and 1945: at Villa Nova de Cintra, on Brava island, on February 26, 1944, with an intensity of 6° on the Rothé scale, related to epirogenic movements of the coastal zone; at Tarrafal de Monte de Trigo, on Santo Antão island, on May 13, 1945, intensity 5°, caused by movement on fractures; and at Passagem, also on Santo Antão, on October 10, 1945, intensity 4°, caused either by epirogenic movement or by movement on an unrecognized fault.—*D. B. V.*

173–44. Shor, George D., and Roberts, Ellis. San Miguel, Baja California Norte, earthquakes of February 1956: a field report: Seismol. Soc. America Bull., v. 48, no. 2, p. 101–116, 1958.

The San Miguel, Baja California Norte (Mexico), earthquakes of February 9 and 14, 1956 were felt over most of northern Baja California and parts of southern California. They originated on the newly-named San Miguel fault running from the southern end of the Sierra Juárez about N 60° W across the Álamo plain. At least 12 miles of surface rupture occurred along this line, with cracks uniformly open and arranged en echelon stepping to the left. Magnitude of displacement was variable but direction was always right-lateral and up to the northeast. Surface evidence indicates that the fault was nearly vertical. A zone of springs, linear hills and valleys, displaced drainage, and closed basins extends beyond the zone of surface rupture for 50 miles northwest to the vicinity of Guadelupe. The main shock on February 9 occurred close to the northwest projection of the surface trace and the two major aftershocks on February 14 were near the southeast projection, implying progressive faulting from northwest to southeast similar to that in the Arvin-Tehachapi earthquake in California. Slides occurred on the steep slopes of the Sierra Juárez; temporary warm springs appeared a few miles from the fault; and the flow of nearby existing springs varied. Damage was slight because the region is relatively unpopulated.—*D. B. V.*

173–45. Bonelli Rubio, Juan M., and Esteban Carrasco, Luis. El primer sismo europeo de foco profundo [The first European deep-focus earthquake]: Rev. Geofísica, v. 15, no. 59, p. 301–321, 1956.

Careful analysis of available records shows that the earthquake of March 29, 1954 in Granada, Spain, had its epicenter at lat 37°2.5′ N, long 3°46′ E, focal time of $06^h17^m05.2^s$ (GMT), and focal depth of 654 km. This is the first deep-focus earthquake known in Europe; heretofore only intermediate earthquakes had been known in the Mediterranean geosyncline region, and those limited in number and distribution. The epicenter was on the Motril fault, part of a fracture system in the Penibetic cordillera. The data from 111 observatories all over the world are tabulated.—*D. B. V.*

173–46. Dilgan, Hamit, and Hagiwara, Takahiro. Le tremblement de terre de Yenice (18 mars 1953) [The Yenice earthquake (March 18, 1953)]: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 287–295, 1956.

The earthquake of March 18, 1953 in northwestern Turkey caused major damage in Yenice, Gönen, and Çan, with more than 250 victims and 8,000 houses destroyed or damaged. Pen recorders at Kandilli observatory were thrown out of action by the first waves. Maximum intensity was 10 (Mercalli-Sieberg scale) at Yenice which is built on alluvium. Magnitude (Gutenberg-Richter scale) was estimated as 7¾ by Pasadena and 8 by Berkeley. Origin time was $19^h06^m11^s$ (U. S. Coast and Geodetic Survey). A fault 70 km long was formed between Yenice and Gönen, characterized by horizontal displacement with fissures more or less diagonal to its general direction. The epicenter calculated by the USCGS (lat. 40.0° N, long 27°30′ E) falls on this fault midway between Gönen and Yenice. Similar horizontal faulting has been described for other earthquakes in northern Anatolia in 1939, 1942, 1943, and 1944. Some vertical displacement also occurred in the zone of maximum intensity but with no fixed direction of throw; this might be the effect of lateral movement on local irregularities of terrain.—*D. B. V.*

173–47. Pinar, Nuriye. Le séisme du 18 mars 1953 de Yenice-Gönen (Anatolie NW) en relation avec les éléments tectoniques [The Yenice-Gönen earthquake of March 18, 1953 (northwestern Anatolia) in relation to structural elements]: Bur. central séismol. internat. Pubs., sér. A., Travaux sci., no. 19, p. 297–306, 1956.

The epicenter of the earthquake of March 18, 1953 in northwestern Anatolia, Turkey, was closely related to the system of epirogenic faults crossing the country. The Yenice-Gönen fault had been suspected as a possible seismic line by Pinar because of the alinement of hot springs, although no previous activity was known along it. The occurrence of the earthquake on this line thus confirms the validity of mapping faults by the distribution of hot springs.—*D. B. V.*

173–48. Solov'yev, S. L. Severobaykal'skoye zemletryaseniye 29 Aprelya 1917 *g* [The north Baikal earthquake of April 29, 1917]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 4, p. 536–542, 1958.

The region around the Baikal Lake is characterized by high seismicity; during the period 1862 to 1950, thirteen earthquakes occurred with intensities ranging from 7 to 10 on the Modified Mercalli scale. Due to sparseness of population and the absence of seismic stations the region is insufficiently known seismologically, a lack which is now felt in the rapid industrialization of the area. The earthquake of April 29, 1917 has been studied, using the records of four Russian (Pulkovo, Irkutsk, Sverdlovsk, and Tbilisi), six Italian, and four Japanese stations. The coordinates of the epicenter, the magnitude and the depth of the focus are found to be ϕ=55° to 56° N; λ=115° to 116° E, M=6¼ ± ¼ and h=25–30 km, respectively.—*S. T. V.*

173–49. MacCarthy, Gerald R. A note on the Virginia earthquake of 1833: Seismol. Soc. America Bull., v. 48, no. 2, p. 177–180, 1958.

The earthquake of August 27, 1833 in central Virginia is described in terms of contemporary accounts. The affected area, about 52,500 square miles, was

a smooth ellipse elongated in a northeast-southwest direction as usual in Piedmont earthquakes. The epicenter was somewhere between Richmond and Charlottesville. Intensity must have been about 6. Most accounts mention subterranean rumblings accompanying the shock.—*D. B. V.*

173–50. Housner, G[eorge] W., and Hudson, D. E. The Port Hueneme earthquake of March 18, 1957: Seismol. Soc. America Bull., v. 48, no. 2, p. 163–168, 1958.

The earthquake at Port Hueneme, California, on March 18, 1957 was the first recorded strong-motion earthquake for which the ground motion consisted essentially of a single pulse. With all the energy concentrated in one pulse the ground acceleration (18 percent g, maximum) and response spectrum values were considerably larger than for more typical Pacific Coast earthquakes of the same magnitude; these abnormally high values are reflected in the unusual amount of damage reported for a shock of magnitude 4.7. The occurrence of a single pulse shock of this magnitude raises the question, highly important in construction engineering, whether shocks of larger magnitude could be of this type. On the basis of past experience the probability is considered to be small, but the possibility must be kept in mind.—*D. B. V.*

173–51. Housner, George W. The mechanism of sandblows: Seismol. Soc. America Bull., v. 48, no. 2, p. 155–161, 1958.

The production of sandblows by earthquakes can be explained without postulating any unusual properties of soils. The important parameters are the porosity, permeability, elasticity, and degree of consolidation of the soil; the important conditions are that the water table be appropriately high for a given consolidation and that the readjustment of soil particles by the passage of seismic waves be of sufficient magnitude. A jet occurs when an unstable balance between overpressure gradient at the surface and buoyant weight of the soil is locally upset.—*D. B. V.*

173–52. Arkhangel'skaya, V. M. Ispol'zovaniye zapisey poverkhnostnykh voln pri interpretatsii seysmogramm [The use of surface wave registrations in the interpretation of seismograms]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 81–88, 1957.

Determination of the azimuth of an epicenter and approximate determination of epicentral distance of an earthquake from surface wave data is possible because modern seismographs not only record the surface waves fully and accurately but also record them separately. Traveltime curves for such determinations have been constructed for Love (L_Q), and Rayleigh (L_R) waves and for the M_R component (maximum vertical displacement of the Rayleigh wave). Epicenters are determined from L_R-P, L_Q-P', M_R-P for distant earthquakes. In the case of near or local earthquakes it is almost impossible to distinguish between Love and Rayleigh waves, and epicenters are determined from $L-P$ (L=surface wave) and $M-P$ (M=maximum displacement). A new wave L_X is noted, similar to that observed by Leet among the waves produced by an atomic explosion. Its period is 7 to 10 sec. It appears to be propagated in the upper layers of the earth, probably in the granitic layer. This wave also may be used for determination of epicentral azimuth and distance.—*S. T. V.*

173–53. Hamamatsu, O., and Ichikawa, M. Sur une méthode asistante [sic!] de détermination rapide des épicentres des séismes éloignés [On a method assisting rapid determination of epicenters of distant earthquakes (in Japanese with French summary)]: Quart. Jour. Seismology, v. 21, no. 2, p. 41–50, 1956.

In order to determine the epicenters of distant earthquakes from a combination of the direction of propagation of the *P* wave with circles tracing the mean *P*—*S* time, Hamamatsu calculates the great circles passing through lat 36° N according to the formulas of spherical trigonometry. Ichikawa calculates the direction of propagation of *P* at a station by the tripartite method and traces the great circle of radius *R* on a stereographic map; the radius *R* and the center of the circle are a function of the direction of propagation and of the latitude of the station. The intersection of the circle thus obtained with the circle tracing mean *P*—*S* time marks the epicenter. The method proposed is useful in regions such as Japan, having a dense but not extensive seismological network.—*D. B. V.*

173–54. Gilić, Andro. Graphische Lokalisierung des Epizentrums eines Fernbebens aus den Ankunftszeiten [Graphic location of the epicenter of a distant earthquake from the arrival times]: Univ. Zagreb Geofiz. Inst. Radovi, ser. 3, no. 8, 119 p., 1957.

Zeissig's graphic method of locating earthquake epicenters is developed in two directions. First, the construction of guide lines is performed on large-scale maps, and secondly criteria are established to minimize the effect of incidental errors. The conditions that must be met to produce greatest accuracy are: distance of the station from the epicenter should preferably be not less than 10°, and in no case less than 5°; the construction should not extend beyond a range of about 1° (111.2 km) in diameter; and the geographic latitude of the epicenter should be less than approximately 65°. Under these conditions, which can be fulfilled in most cases in practice, an imprecision of $\pm\frac{1}{2}°$ in the azimuth used in the construction will have no appreciable effect. The method is illustrated by two examples (the Blue Mountain earthquake on July 16, 1956, in the U. S. and the Indian earthquake of April 4, 1905) and also compared with the Geiger and Gutenberg-Richter methods.—*D. B. V.*

173–55. Treskov, A. A. Differentsial'nyy metod opredeleniya glubiny ochaga blizkogo zemletryaseniya [A different method of determination of the depth of the focus of near earthquakes]: Akad, Nauk SSSR Izv. Ser. geofiz no. 4, p. 543–549, 1958.

Treskov suggests a new procedure for determination of the depth of focus of an earthquake. As the traveltime curves of the waves propagating through a homogeneous ground are hyperbolic, it is possible to find the depth of focus given the seismic velocity of a certain region and the time records of a single station. It is recommended that 6 to 9 stations be taken to construct the traveltime curve best fitting the observational data. This is done by the methods of observational calculus. The epicentral distances of the earthquakes selected can range from 30 to 100 km. The mathematical computations are presented in detail for an actual example. Accuracy of the results of the calculations is satisfactory.—*S. T. V.*

173–56. Asakura, K. A method of determining the location of the hypocenter (in Japanese with English summary): Quart. Jour. Seismology, v. 22, no. 4, p. 9–16, 1958.

A method is presented for determining the focus of an earthquake using the duration time of preliminary tremors at three stations. No map is necessary; the focus is determined with the aid of established traveltime tables and three formulas giving angular distance between two points on a spherical surface. The constants indicating the position of each station must be calculated in advance. As illustration, the location of the focus of the earthquake that occurred in the Marianas Islands at 16^h55^m (GMT) on July 26, 1953, is calculated from the records at Sapporo, Tokyo, and Fukuoda in Japan as lat 17° N, long 147° E, depth 300 km.—*D. B. V.*

173–57. Raimondi, Carlo. Alcune modificazioni al metodo di Kövesligethy per la determinazione delle profondità di terremoti tettonici [Some modifications of Kövesligethy's method for the determination of the depth of tectonic earthquakes]: Osservatorio Geofis. Trieste Pub. no. 77, 12 p., 1956 (reprinted from Tecnica Italiana, ser. 11, v. 21, no. 1, 1956).

The decay of seismic energy on the (plane) surface of the earth is examined, and the rule based on the law of inverse squares is modified to take into account the angle of the seismic ray with respect to the surface. As a result some modifications are suggested to Kövesligethy's method of determining focal depth from macroseismic data. The new method is applied to several central European earthquakes, particularly those of March 1, 1929, in Switzerland and of June 27, 1935, in Württemberg; agreement is adequate with the results obtained from microseismic observations.—*D. B. V.*

173–58. Båth, Markus. The problem of earthquake magnitude determination: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 5–93, 1956.

Earthquake magnitudes are determined using all waves possible from the records at Uppsala and Kiruna for 309 earthquakes from the years 1952–1953, and the results compared in various ways with each other and with determinations at other stations. It is found that large discrepancies may occur between determinations at different stations as well as between different waves at the same station. In determinations from surface waves it is necessary to use only waves with periods close to 20 sec, due to rapid variation of their extinction coefficient with period. In comparing the same wave at Uppsala and Kiruna, much less scatter of the differences is found for surface waves than for body waves. All differences investigated are in every way independent of epicentral distance but show distinct regional distribution. These distributions and their possible explanations (unsymmetrical energy distribution from focus, effects of path, local structure near station) are studied in some detail; such study may be of value in combination with first-motion studies in investigations of earthquake mechanisms.

The energy ratios between different waves determined at a single station are not representative for the earthquake; energy radiation from the focus is a very complicated process. The energy ratio of short-period to long-period *P* increases with increasing focal depth. The magnitude difference between short-period *P* and surface waves varies about twice as rapidly with depth as the

difference between S and surface waves, and, furthermore, short-period P give better accuracy. There are many more shocks at depths slightly below normal (30 to 80 km) than is obvious from the bulletins. Comparison with magnitudes from other stations shows positive corrections for both Kiruna and Uppsala and for all waves used; standard deviation of a single determination is about $\pm\frac{1}{4}$ of a magnitude unit. Regional corrections show striking variations with magnitude for both stations for earthquakes in Kamchatka and Japan, implying that body waves increase more slowly and surface waves more rapidly than corresponding increase of magnitude. On the average, magnitude scales based on surface waves and on body waves are inconsistent with each other.

Two new methods for obtaining greater accuracy in magnitude determination are outlined, the ϵ-method and the R-method. The former takes into account the energy partition on different waves for each individual earthquake and uses the formula $f[M]=m+\epsilon$, where m is determined from $M(P)$, $M(S)$, and $M(L)$ once the numerical values of p_1, s_1, and l_1 are agreed upon, and ϵ is a combined regional correction. M is calculable once $f[M]$ is known. This method is superior to PZ' and SH and of about the same accuracy as LH; for deeper shocks it is superior to LH. The lengthy calculations can be reduced by using special tables and graphs. An advantage is that only one regional correction is needed instead of one for each wave. The R-method is also based on a combination of P, S, and L; it is not as well based physically but of equal accuracy and is preferable because it uses simple calculus. The formula used is $M=\frac{1}{3}\ [M(P)+M(S)+M(L)]+R$ where R is the regional correction. All the data upon which the study is based are tabulated in an appendix.—*D. B. V.*

173–59. Kawasumi, Hirosi. Intensity and magnitude of shallow earthquakes: Bur. central séismol. internat. Pubs., ser. *A*, Travaux sci., no. 19, p. 99–114, 1956.

The quantitative relation between earthquake intensity and maximum acceleration of ground motion for shallow shocks is revised as $a=0.8\times10^{0.5(I-1)}$ where a=maximum acceleration in gals and I=intensity on the Japanese scale. This relationship is then applied to determination of magnitude of shallow earthquakes by obtaining intensity-distance and maximum amplitude-distance curves and deriving parameters related to magnitude in these curves. Other factors that are promising as means of determining magnitude of shallow earthquakes are total duration of motions and amount of damage of various kinds.—*D. B. V., P. E. B.*

173–60. Katsumata, M. A method of determination of magnitude for near and deep-focus earthquakes (in Japanese with English summary): Quart. Jour. Seismology, v. 22, no. 4, p. 17–21, 1958.

A method similar to Gutenberg and Richter's is proposed for determining magnitude on deep-focus earthquakes in and near Japan on the basis of data from Japanese stations. If the epicentral distance is established, the magnitude can be determined from amplitude and focal depth. Nomographs have been prepared showing these relationships at epicentral distances of 500, 900, and 1,300 km. Amplitudes were averaged from the observed values of maximum horizontal amplitude, mainly in the S phase. The Japanese seismic network is so dense that a magnitude can be determined easily from these three

kinds of nomographs. The curves on the nomograph also indicate clearly the conditions of absorption of seismic waves in the upper mantle.—*D. B. V.*

173–61. Asada, Toshi, Suzuki, Ziro, and Tomoda, Yoshibumi. On frequency distribution of seismic magnitude: Bur central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 95–98, 1956.

The frequency distribution of magnitude of large earthquakes has ben calculated by Gutenberg and Richter and others (see Geophys. Abs. 153–14521, 157–89). Generally it is impossible to determine the magnitude of minor shocks ($M<4$) because they are seldom registered simultaneously at several stations. It is possible to obtain the frequency distribution of maximum trace amplitude A recorded by a displacement seismograph at a given station and from this the frequency distribution of A_o, the amplitude at the focus. If A may be assumed to be the same as A_o the following distribution holds good for shocks with magnitudes between 4 and −1: $N(A)\ dA=\text{const}\ A^{-1.8}dA$. In practice this can be transformed to $N(M)\ dM=\text{const}\ 10^{-1.0M}dM$ to express the empirical distribution of magnitudes; the two formulas agree within the range of statistical fluctuations. It is concluded that a similar magnitude frequency curve can be applied both to earthquakes with $M>6$ and to minor aftershocks with $M<0$. (The weakest earthquake observed in Japan was −1 in magnitude with 10^{10} ergs of energy.) A discussion of energy frequency distribution and partition, based on published works, concludes the paper.—*D. B. V.*

173–62. Shebalin, N. V. Sootnosheniye mezhdu ball'nost'yu i intensivnost'yu zemletryaseniy v zavisimosti ot glubiny ochaga [The relationship between intensity and magnitude of an earthquake with respect to focal depth]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 122–126, 1956.

The determination of the intensity of a given earthquake at its epicenter from the records of remote stations is very important in the seismicity of regions for which only instrumental data are available. The equations of Gutenberg and Richter ($M=0.6\ I_o+1.3$ and $I_o=1.7\ M-2.1$, where M is magnitude computed from surface waves, I_o is intensity at the epicenter) are found to be satisfactory for a focal depth (h) of about 20 km but not for other depths. From simple physical considerations both M and I_o must be affected by the value of h; therefore, 159 earthquakes ranging from 3–5 to 60–76 km in depth, from 3.8 to 8.3 in magnitude and from 3–4 to 11–12 in intensity have been investigated in order to establish a correlation between the values of M, I_o, and h. This relationship is found to be $I_o=1.5\ M-3.5\ \log\ h+3$. Magnitudes were determined from surface wave data according to the procedure of Solov'yev and Shebalin, depth of focus mainly by Kondorskaya's method (see Geophys. Abs. 168–46) using the sP phase and the records of several stations. The results of calculation of I_o from h and M are compared with the observed values for 15 earthquakes (in Algeria, Indonesia, California, Greece, the Philippine Islands, China, the Caucasus, and Hungary); agreement is good.—*S. T. V.*

Shebalin, N. V. The use of correlation between earthquake magnitude and intensity for estimating the depth of the asthenosphere in the Vrancha region (Carpathians). See Geophys. Abs. 173–250.

173-63. Solov'yev, S. L. Nekotorye resul'taty primeneniya shkaly intensivnosti zemletryaseniy na seysmicheskikh stantsiyakh SSSR [Some results of the application of the earthquake magnitude scale at seismological stations of the USSR (with English summary)]: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 1, p. 40–46, 1958.

The magnitude of an earthquake (M) introduced by Gutenberg and Richter is determined in the U. S. S. R. on the basis of surface waves only. It has been found that the expressions $M=\log A/T-\log (A/T)^*$ and $M=\log A-\log A^*$, where A=maximum ground displacement in surface waves in μ, T=corresponding period, are more useful than the formula $M=\log A_{20}-\log A^*_{20}+C+D$ (where A_{20} is maximum ground displacement in the surface waves having a period of 20 sec, C=station correction, D=correction depending on focal depth and other parameters of the earthquake). Statistical correlation between the first two is given by the equation $M_A-M_{A/T}\approx 0.05(M-6)$, where $M_{A/T}$=magnitude determined by the first formula, M_A as determined by the second. The fact that no corrections to M are used in the U. S. S. R. probably is the main reason for the systematic discrepancy between values published in Soviet bulletins and those published elsewhere. It has been found that the stations of the Pacific coast, especially those in the Kamchatka-Japan region, give too small values of M for Pacific earthquakes compared with other stations in the country. In the case of continental earthquakes the difference between two ranges of magnitude values in general has the opposite sign.—*D. B. V.*

173-64. Ichikawa, M. Regional corrections of earthquake magnitude (in Japanese with English summary): Quart. Jour. Seismology, v. 22, no. 4, p. 23–30, 1958.

Regional corrections have been calculated for every seismic station in Japan, using the data from the shallow earthquakes that occurred in or near Japan during the period 1941–1956, in order to increase the accuracy of earthquake magnitude determinations based on Tsuboi's formula. These are tabulated and compared with corrections determined by other authors.—*D. B. V.*

173-65. Hahn, Evamaria. Die Anwendung der seismischen Magnitude und der Seismizität auf neuzeitliche Erschütterungsmesstechnik bei Verkehr und in der Industrie [The application of seismic magnitude and seismicity to modern vibration measurement techniques in traffic and in industry]: Freiberger Forschungshefte, C 25 Geophysik, 63 p., 1956.

An attempt is made to establish a scale of magnitude for industrial vibrations corresponding to the Richter scale of earthquake magnitudes. Inasmuch as the vibration relationships are more complex than those in earthquake seismology, application of the Richter method is accompanied by considerable difficulties. For instance, in defining a "partial magnitude" proportional to the "partial energy", or that which is transmitted through a unit volume in a unit time, the effect of the period of the vibration is not negligible as shown by the formula $E=A^2vd/T$ (E=energy, A=maximum amplitude, v=velocity, d=density, T=period of vibration at point of observation). Gutenberg and Richter's concept that magnitude is proportional to the elastic energy released at the focus is useful, but extensive experimental work will be necessary for its application to industrial vibration problems. The seismicity of a given point is defined as

$S=\Sigma E_i/t$ where E_i is energy at the point and t=time; maps can be constructed on the basis of measurement of the seismicity of a great number of points, which will indicate areas liable to greatest vibration damage.—*D. B. V.*

173–66. Tsuboi, Chuji. Energy accounts of earthquakes in and near Japan: Jour. Physics of Earth, v. 5, no. 1, p. 1–7, 1957.

The magnitudes have been determined for 1,025 earthquakes that occurred in or near Japan from 1931 through 1955, using the new formula $M=1.73 \log \Delta+A-0.83$ (M is the magnitude, A is the maximum ground amplitude in microns, at epicentral distance Δ in km). The mean annual number (N) of earthquakes according to magnitude is expressed by the formula $\log N=-1.08+0.72(8-M)$ for $M=0.1$. The mean rate of energy release for earthquakes in Japan and vicinity is estimated to be 1.5×10^3 ergs per cm^2 per year, or 0.1×10^{-6} cal per cm^2 per sec. As a whole Japan contributes well over 10 percent to the total seismicity of the world.—*D. B. V.*

173–67. Knopoff, Leon. Energy release in earthquakes: Royal Astron. Soc. Geophys. Jour., v. 1, no. 1, p. 44–52, 1958.

The technique of applying methods of static elasticity to the solution of problems involving the propagation of cracks in shear fields may be modified to include the solution of the problem of energy release upon introduction of a tear fault, such as the San Andreas fault, into an otherwise homogeneous medium subjected to uniform shear stress. The fault is assumed to be a strip fault of infinite length in a homogeneous, isostropic, elastic, infinite medium. The medium is subjected to a uniform shear stress at infinity and the shear stress is assumed to vanish upon the strip. This two-dimensional problem has a vector rather than a tensor solution, thus is analogous to the electrical problem of a perfectly conducting strip placed in a uniform electrical field or of a strip obstacle placed in a uniform hydrodynamic stream field. The stress distribution and relative motion throughout the medium before and after faulting can be obtained. Applied to the 1906 San Francisco earthquake, this model yields an energy release of 4×10^{23} ergs; this figure must include not ony the seismic wave energy but also the energy connected with non-elastic effects such as heat and plastic deformation.—*D. B. V.*

173–68. Båth, Markus, and Benioff, Hugo. The aftershock sequence of the Kamchatka earthquakes of November 4, 1952: Seismol. Soc. America Bull., v. 48, no. 1, p. 1–15, 1958.

The strain-release curve of the aftershock sequence of the Kamchatka earthquake of November 4, 1952 has been constructed using observations from Uppsala and Kiruna, Sweden. The data include more than 400 shocks with magnitudes of 6.0 and greater than occurred up to December 1956. The curve shows three segments, each of the form $\Sigma J^{1/2}=A+B \log t$, where J=energy and t=time elapsed since principal shock. The slope B changes abruptly at t=0.4 days and at t=195 days; the latter was particularly pronounced and was accompanied by other evidence suggesting a change in mechanism. The coefficients B have almost the exact ratio of 1 : 2 : 5 in the three intervals 0 to 0.4, 0.4 to 195, and after 195 days. The aftershock activity is most concentrated in the vicinity of the principal earthquake and tapers off towards both ends of the active fault segment. The majority of the aftershocks have clear pP impulses occurring generally 9 to 13 sec after P, indicating that the foci were

in or close to the Mohorovičić discontinuity. The rate of strain accumulation and release for the time interval from 1897 to 1956 for the entire Kamchatka-northern Japan stress system shows a slow decrease with time. Comparison of the rate of the entire system with that of the aftershock sequence leads to an approximate estimate of $t=15$ years for the possible duration of the sequence—*D. V. B.*

173–69. Båth, Markus, and Richter, Charles F. Mechanisms of the aftershocks of the Kern County, California, earthquake of 1952: Seismol. Soc. America Bull., v. 48, no. 2, p. 133–146, 1958.

Using directions of first motion of longitudinal waves recorded at near-by stations, the orientation of fault traces and the nature of fault motions have been deduced for fifty-seven earthquakes of the Kern County aftershock series. Unlike the main shock, the aftershocks exhibit considerable strike slip with left-hand strike slip dominating on and to the south of the White Wolf fault and right-hand strike slip and dip slip to the north of it. The two last-mentioned mechanisms represent a secondary strain release, beginning not earlier than thirty-seven hours after the main shock.—*Authors' abstract*

173–70. Droste, Zofia. Uglovoye raspredeleniye plotnosti energii, izluchennoy v ochage [The angular distribution of density of energy emanated from the focus]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 100–104, 1957.

Essentially a Russian version of a paper also published in Polish in the Przęglad geofiz., rocznik 1 (9), zeszyt 3–4, p. 241–252, 1956 (see Geophys. Abs. 170–78).—*S. T. V.*

173–71. Tocher, Don. Earthquake energy and ground breakage: Seismol. Soc. America Bull., v. 48, no. 2, p. 147–153, 1958.

In contrast to the prevalent notion that fault breakage is quite rare, every earthquake since 1906 with $M>6\frac{1}{2}$ and with epicenter on land in northern California or Nevada has been accompanied by some degree of fault breakage at the surface of the earth. The smallest shock for which such effects have been observed was of $M=5\frac{3}{4}$.

Earthquake energy in ergs (E), length of surface in km (l), and maximum ground displacement at the fault in cm (D) are related through the empirical equation $E=3.4\times10^{17}$ (lD) in the range $6\frac{1}{4}<M<8\frac{1}{4}$. This suggests that the energy released in these shocks is proportional to the area at the earth's surface of the zone of initially strained rocks, and, as a corollary, that the volume of the initially strained rock is no thicker for the very large shocks than for the smallest shock with a surface fault trace. Strain energy for large shallow-focus shocks in California and Nevada is stored in surface slabs of rock which are bounded below by a zone in which the rock can deform plastically at a rate that keeps up with the elastic deformation of the overlying slab.—*Author's abstract*

173–72. Scheidegger, A[drian] E[ugen]: On fault plane solutions of earthquakes: Geofisica Pura e Appl., v. 39, p. 13–18, 1958.

Fault plane solutions of earthquakes based on P wave observations have the drawback that they yield two orthogonal planes, either of which could be the fault plane. This ambiguity can be resolved if S observations are available.

In principle, only one single observation of the sign of the initial impulse of the *SH* phase is necessary. This requires that the records of *S* can be interpreted unambiguously; therefore, the station must be located so that the image of *S'* of the station falls into one of certain sectors in relation to the fault plane (shown in stereographic projection of a focal sphere).—*D. B. V.*

173–73. Scheidegger, A[drian] E[ugen]. Tectonophysical significance of fault plane solutions of earthquakes: Geofisica Pura e Appl., v. 39, p. 19–25, 1958.

Fault plane solutions of earthquakes are usually ambiguous to the extent that it is not known which of two orthogonal planes is the fault plane and which is the plane orthogonal to the motion vector (auxiliary plane). This makes it difficult to correlate fault plane solutions of earthquakes with tectonic features. To get around this difficulty, it has been proposed in the literature to investigate the *B*-axis, i. e. the intersection of fault- and auxiliary-plane which is always uniquely defined. No physical significance of the *B*-axis has been known heretofore. It is shown here that the physical significance of the *B*-axis lies in the fact that the latter always lies in a plane normal to the axis of the tectonic displacement-couple. In turn, if a series of fault plane solutions of earthquakes is available for a certain geographic area, it is possible to determine the tectonic displacement by a least squares solution. The pertinent formulas are developed and the method is illustrated by an example: viz., by analysing the available fault plane solutions in the Marianas–Volcano–Islands–Nampo–Choto–Islands area. A very striking result is obtained: In the area under consideration, the axis of the tectonic displacement is exactly parallel to the strike of the geographic feature, with the Pacific moving to the northwest and down on one side and southeast and up on the other side of the islands.—*Author's summary*

173–74. Hodgson, J[ohn] H., and Adams, W[illiam] M[ansfield]. A study of the inconsistent observations in the fault-plane project: Seismol. Soc. America Bull., v. 48, no. 1, p. 17–31, 1958.

The 65 solutions so far published in the fault-plane project of the Dominion Observatory of Canada are based on 2,476 observations of *P* and 722 of *PKP*. Of these observations, 18.3 percent have been inconsistent with the published solutions, but a small number of stations have contributed a high percentage of these inconsistencies. Rejection of some of the data in a revised appraisal reduces the inconsistencies to 14 percent. Contrary to expectations, observations close to the circular boundaries are slightly more accurate than those remote from them. The inconsistent observations show no significant variation with epicentral distance except that the percentage of inconsistencies is higher at shorter distances due to the anticipated effect of crustal layers. Examination of 282 observations of *P* and 135 of *pP* in order to ascertain whether they could be used to determine the value of Poisson's ratio under the continents and oceans showed that the percentage of inconsistencies was too high to allow a final conclusion. An attempt to define the density ratio at the boundary of the core from 17 observations of *PcP*, using a method suggested by Båth (see Geophys. Abs. 161–196), failed because of the inconsistency of the data. The failure of the reflected phases suggested that the data from them might be random; to test this, 23 new solutions were carried out based only on *P* and *PKP* data, and the observations for the reflected phases plotted on the diagrams.

For all reflected phases the inconsistencies approached 50 percent, showing that these phases, at least when reported by questionnaires, are not sufficiently accurate to be useful in fault-plane studies.—*D. B. V.*

173–75. Sutton, George H., and Berg, Eduard. Direction of faulting from first-motion studies: Seismol. Soc. America Bull., v. 48, no. 2, p. 117–127, 1958.

The effect of a crustal layer on the surface distribution of initial motion from a crustal earthquake is examined. For crustal earthquakes a simple modification of the extended distances given by Hodgson and Storey permits the direct comparison of data obtained from a network of near stations with data from distant stations treated by the Byerly method. The patterns of first motion expected at near and distant stations from a given geometry of faulting with different assumed crustal velocities are compared. In cases where either the fault or auxiliary plane dips at an angle less than about 60° there should be a significant difference in the first-motion pattern. Under certain plausible assumed conditions patterns resembling an explosion or implosion can be obtained.

Previously published first-motion studies are discussed in the light of the foregoing analysis, and in certain cases a modification of the interpretation is necessary. These results indicate more strike slip faulting than has been previously estimated for foci within the crust.—*Authors' abstract*

173–76. Vvedenskaya, A. V. O smeshcheniyakh na poverkhnosti razryva, soprovozhdayushchegosya skol'zheniyem [On the displacements on a surface of rupture accompanied by sliding]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 175–183, 1958.

Modern concepts of the cause and nature of earthquakes attribute them to the ruptures of the medium at the focus. Thus the determination of the displacement field over a certain volume of the terrestrial mass is of great interest in the studies of the processes taking place in the focus. This was done in the previous study (see Geophys. Abs. 166–80). In the present paper it is shown that the displacement field discussed really describes the rupture of an elastic medium as the sudden shift of both sides along a finite plane of rupture. This rupture leads to vibrations generated on its contour. If a double force is evenly distributed over a finite area, then at the source of disturbance under the action of this force, there is produced an additional rotation of the plane of sliding with respect to the axis along which is oriented the moment of the double force.—*S. T. V.*

173–77. Keylis-Borok, V. I., and Kogan, S. D. Issledovaniye mekhanizma zemletryaseniy [Investigation of the mechanism of earthquakes]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 96–99, 1957.

In the Institute of Physics of the Earth of the Russian Academy of Sciences, studies have been carried out since 1948 on the types of dislocations taking place at the foci of earthquakes. Many problems have been solved as to the kind of dislocation producing one or another pattern of seismic waves. The results obtained by Russian seismologists are in good agreement with those arrived at by the methods of Byerly in the U. S. A. and by Japanese authors. The most important difference is the use by Russian scientists of transverse waves which eliminates the ambiguity of the solution. Recently Ritsema in Indo-

nesia started to use the signs of *SV* waves, Gutenberg the ratio *SV/SH*. Some 300 earthquakes that occurred in Central Asia, the Caucasus, the northwestern Pacific, and in Turkmenistan have been investigated by Russian seismologists. In addition to these data scientists of other countries have studied some 120 earthquakes. The results of this work can be summarized as follows: Large regions, such as the Caucasus or Tyan' Shan, can be classified into different groups having similar dislocations at the foci, that is, the same dip, similar length of rupture, and so on. The type of dislocation characterizing each one of such groups is different from the adjoining groups; this is explained by the fact that the earthquakes of a given group are caused by a tectonic process deep in the crust or in the upper mantle. Horizontal displacement is more common in foci than in simple structures.

It is interesting to compare the dislocations in the foci with the geotectonic data on the recent and present movements, as well as with the results of gravimetric investigations.—*S. T. V.*

173–78. Sutton, George H., and Berg, Eduard. Seismological studies of the Western Rift Valley of Africa: Am. Geophys. Union Trans., v. 39, no. 3, p. 474–481, 1958.

Intensity, strain release, and first-motion studies of earthquakes along the Western Rift Valley of Africa are presented, based on data from the seismographic network in the eastern Belgian Congo during the period from May 1953 to April 1956. Regions of activity shifted during this period, with a noticeable increase west of Lake Albert in July 1955. Isointensity maps for three earthquakes (July 4 and 22, 1955, and February 3, 1956) show elongation parallel to the Rift. Rate of strain release increased with the commencement of the Lake Albert shocks, from 35×10^8 ergs$^{1/2}$ to 155×10^8 ergs$^{1/2}$ per 100 days. Strain released during several aftershock sequences was proportional to the logarithm of the time after the initial shock.

First motions from the Rift Valley earthquakes to the stations in question do not give a unique determination of the predominant type of faulting. The data are consistent with dip slip faulting along steeply dipping faults parallel to known faults in the region, with the elevated areas being further elevated and the depressed areas further depressed. They are also consistent with strike slip faulting along near-vertical faults with the eastern sides moving north. In agreement with the near station results, first-motion data from distant stations for two shocks west of Lake Albert indicate some combination of reverse dip-slip and sinistral strike-slip motion along a fault plane dipping toward the Rift Valley.—*D. B. V.*

173–79. Gibowicz, Sławomir. Charakterystyka dynamiczna ogniska Antarktycznego trzęsienia siemi z dnia 26. VI. 1924 r [Dynamic characteristics of the focus of the Antarctic earthquake of June 26, 1924 (with Russian summary)]: Acta Geophys. Polonica, v. 5, no. 3, p. 202–209, 1957.

A fault plane solution is presented for the earthquake of June 26, 1924, in the Antarctic, at lat 56.3° S, long 158.0° E, with a focal depth of 100 km. The force was a double force with moment, where movement occurs on both sides of the fault in opposite directions. The azimuth of the fault plane was 220°, its dip 86°; direction of the active force was 113° in azimuth, 14° in inclination. Intensity at the focus was approximately 10^{26} dynes per cm.—*D. B. V.*

173–80. Hordejuk, Józef. Charakterystyka dynamiczna ogniska trzęsienia ziemi z dnia 16, XI. 1911 r [Dynamic characteristics of the focus of the earthquake of November 16, 1911 (in Polish with Russian summary)]: Acta Geophys. Polonica, v. 5, no. 2, p. 103–109, 1957.

The values of the dynamic parameters of the earthquake of November 16, 1911 are calculated, using Keylis-Borok's method and Gutenberg's data. The earthquakes occurred at $21^h\ 25^m$ with its epicenter at lat 48°20′ N, long 9°5′ E, and focal depth of 40 km. The focus was of the double force with moment type; this means that shear displacements took place in the focal plane with step-movement in opposite directions. The azimuth of the plane of rupture was about 24°, its dip about 84°. The azimuth of the direction of the active force was 63°, its angle of inclination 10°. Intensity at the focus was of the order of 1.2×10^{24} dynes per cm. Mean value of the energy released by the *P* wave was 2.3×10^{19} ergs.—*D. B. V.*

173–81. Karapetyan, N. K. Dinamicheskiye parametry ochagov nekotorykh zemletryaseniy Kavkaza [Dynamic parameters of the foci of some earthquakes in the Caucasus]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 260–268, 1958.

Using Keylis-Borok's method of determining the dynamic processes at the focus of an earthquake, Karapetyan examines the focal mechanism of ten earthquakes in the Caucasus. For this purpose the signs of displacements produced by the *P* wave and the ratios P/S and P/S_H were analyzed. For three strong earthquakes, Vvedenskaya's procedure using records at remote stations was used as well. The results are shown in projections on Wulff's nets, in tabular form (giving type of force, strike and dip of plane of displacement, direction of displacements on hanging wall, and angle between hanging wall and the horizontal), and plotted on a map. All ten show double force with moment. The planes of displacement in earthquakes in the Great Caucasus are oriented in the direction of general Caucasian trend, and the earthquakes are strong; in the Little Caucasus the displacement is perpendicular to the general Caucasian trend, and the earthquakes are weak. In the latter the hanging wall movement is upward, probably related to continuing uplift of the Little Caucasus.

The foci of 22 earthquakes in the Akhalkalakskiy plateau are similarly analyzed. Sixteen show double force with moment, whereas the other six cases could be due either to double force with moment or to a simple force. The planes of displacement are oriented with the general trend of the Caucasus or close to it. With three exceptions, where displacement on the hanging wall side is northeast, the plane of displacement is approximately vertical; in all but one case the direction of movement is either northeast or southwest.—*S. T. V., D. B. V.*

173–82. Egyed, L[ászló]. Mekhanizm vozniknoveniya glubokikh zemletryaseniy (predvaritel'noye soobshcheniye) [The mechanism of production of deep earthquakes (Preliminary communication)]: Akad. Nauk SSSR, Sovet po Seysmologii Byull., no. 6, p. 89–95, 1957.

One of the fundamental points of Egyed's new theory of the constitution of the earth (see Geophys. Abs. 167–165) is the thesis that the earth expands its diameter at the rate of 1 mm per year due to physical changes in its interior. The energy thus produced, at the rate of 2.5×10^{24} ergs per year, is the cause of earthquakes. The foci of these earthquakes are located where the stress pro-

duced by the dilatation of the earth exceeds the strength of the terrestrial crust. Ewing and Heezen have concluded that the ocean deeps are produced by the action of tensile forces; that is, they are the result of the dilatation of the terrestrial globe.—*S. T. V.*

173–83. Guha, S. K., Ram, Gurdas, and Rao, G. V. Trigger causes in earth movements: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 345–355, 1956.

Swarms of local earthquakes recorded at Chatra Observatory near the Himalayas are related to the Himalayan boundary fault. An appreciable correlation of their frequency with the beginning and end of flood period suggests that rate of change of flood intensity may be a possible trigger mechanism.—*D. B. V.*

173–84. Sassa, Kenzô, and Nishimura, Eiichi. On phenomena forerunning earthquakes: Bur. central séismol. internat. Pubs., sér. *A*, Travaux sci., no. 19, p. 277–285, 1956.

This same paper has been published in the Kyōto University Disaster Prevention Research Institute Bulletin, no. 13, p. 1–8, 1956 (see Geophys. Abs. 169–70).—*D. B. V.*

173–85. Kondorskaya, N. V. O popravkakh k godografu Dzheffrisa-Bullena [Corrections to the Jeffreys-Bullen traveltime table]: Akad. Nauk SSSR Sovet po seysmologii, Byull. no. 6, p. 71–75, 1957.

It has long been noticed that the use of the Jeffreys-Bullen traveltime tables in the determination of epicenters in seismically active regions of Russia does not always give fully satisfactory results. Better results were obtained when regional traveltime tables, especially constructed for individual cases, were used; for instance the epicentral distances of Japanese earthquakes computed by Russian Far Eastern stations were determined more accurately when Wadati's traveltime tables were used. Kondorskaya has determined the arrival time t of the seismic waves from the equation $t=F(\Delta)+\frac{dt}{dh}h+\gamma$ where Δ is the epicentral distances, h the depth of the focus. Twenty-two earthquakes which occurred in the Far East regions have been investigated, using the records of Russian and foreign stations. The preliminary determination of the coordinates of these earthquakes was done by methods independent of the traveltime tables; thus the depths of the foci were determined from the time intervals of the arrival of the P wave and of the converted sP wave reflected not far from the station. The deviations between observed traveltime of P and S waves and those computed from the tables were plotted for each Russian seismic area. (See also Geophys. Abs. 171–78.)—*S. T. V.*

173–86. Khan, Abdul Qadir. Instrumental study of the Quetta earthquake of February 18, 1955: Seismol. Soc. America Bull., v. 48, no. 1, p. 77–81, 1958.

Aftershocks of the Quetta earthquake of February 19, 1955 (H=22:48:38 G. M. T.), were recorded at three temporary field stations, 10 to 15 kilometers from the macroseismic epicenter. A spare Wilmore seismograph operated in turn at the three stations. From the study of predominant S–P time intervals of aftershocks recorded at the field stations and at the permanent Observatory, velocity of P and depth of focus were calculated on the assumption that (i)

Poisson's ratio of rocks is ¼, thus $n=(P-O)/(S-P)=1.37$, and (ii) $S-P$ time intervals of peak frequency were due to aftershocks originating from the same point, probably the focus of the main shock. Velocity of P waves thus calculated was found to be 5.6 kmps and the depth of focus about 7 km.—*Author's abstract*

173–87. Nishimura, Eiichi, Takeshi, Mikumo, and Otsuka, Michio. On anomalous time-distance curves observed in local earthquakes: Tellus, v. 10, no. 1, p. 145–152, 1958.

Precise observations of 27 local shallow earthquakes were made in Wakayama District, Japan, in order to study the crustal structure and the nature of local shocks. Anomalous travel time curves fall into two groups according to the direction of initial motion. These anomalies are attributed to focal conditions such as mechanism of occurrence or the shape of the focal area. The time gap between the two groups was 0.2 to 0.4 sec; in larger destructive earthquakes this gap should be greater and should afford a strong clue to focal behavior. Analysis of ground motion and ground strain is expected to throw further light on the subject.—*D. B. V.*

173–88. Usami, T[atsuo]. Seismometrical study of Boso-Oki earthquake of Nov. 26, 1953 (in Japanese with English summary): Quart. Jour. Seismology, v. 21, no. 3, p. 1–13, 1956.

Records of the Boso-Oki earthquake off the Pacific coast of Japan on November 26, 1953 obtained at 61 Japanese and 8 Formosan stations are analyzed. Three phases (a, b, c) are identified near the initial motion, the first corresponding to the initial P phase. In first approximation the epicenter is determined as long 141°54′ E, lat 34°09′ N, focal depth as 80 km. The traveltime curve consists of three straight lines, one each for stations in the pull, northern push, and southern push regions of initial motion. Exact calculation of the epicenter from these curves by Geiger's method shows that the focus migrated westward at the rate of 9.8 kmps. The push-pull distribution of initial motions of the b and c phases are also discussed.—*D. B. V.*

173–89. Schulz, Rudolf. Curvas de tiempo-distancia del terremoto de Chiapas (Mexico) del 5 de Febrero de 1954 [Time-distance curves of the Chiapas (Mexico) earthquake of February 5, 1954]: Servicio geol. nac. El Salvador Bol. sismol., v. 1, p. 50–54, 1955 (1956).

Seismograms of the Chiapas earthquakes in Mexico on February 5, 1954, from seven stations ranging from 350 to 780 km epicentral distance have been analyzed. Arrival times of the waves registered at each station are tabulated and plotted in a time-distance diagram. A wave having a velocity of 810 kmps is clearly *Pn;* one with 7.6 kmps may be a *Pn* that traversed a less dense medium. It is not certain whether velocities of 6.82 and 6.0 kmps both represent the *Pb* wave or two different waves propagated in different layers. The *Pg* wave cannot be recognized definitely due to lack of stations near the epicenter; it may be represented by a strong arrival at Guatemala and a weak one at San Salvador, whose velocity is calculated to be 5.55 kmps. The *S*-waves are difficult to recognize, being superimposed on some of the *P*-waves; *Sb* is recognized, with a velocity of 3.75 kmps. Two stations showed a wave with 3.58 kmps velocity. For most stations *Sg* was determined with a velocity of 3.28 kmps.

The curves suggest that the depth of focus, determined from rather distant stations as about 100 km, is actually probably much less than that.—*D. B. V.*

173–90. Oliver, Jack, [E.] and Ewing, Maurice. Normal modes of continental surface waves: Seismol. Soc. America Bull., v. 48, no. 1, p. 33–49, 1958.

When the path between epicenter and station traverses only continental structure, the dispersion of the entire train of directly arriving seismic surface waves can be explained as the result of normal mode propagation in a crust-mantle system in which velocity increases in some manner with depth within the crust. At least four modes, the Rayleigh mode, Sezawa's M_2 mode, and the first two Love waves, may appear prominently in the seismogram. When the characteristics of the higher-mode dispersion curves are considered in addition to the more familiar Rayleigh and first Love modes, it is possible for the first time to explain virtually all the surface waves traversing a purely continental path. These include the phases previously labelled *Lg* and *Rg* (see Geophys. Abs. 151–14043) and Lg_1 and Lg_2 (see Geophys. Abs. 163–99) and in some cases *Sa*, without recourse to a low-velocity layer in the crust or mantle. In contrast to the Rayleigh and first Love modes, the M_2 and second Love mode have similar dispersion curves; hence, they permit the arrival of waves at about the same period on all three components simultaneously. This is a possible explanation of Leet's *C* or coupled wave. The occurrence of the higher-mode waves is widespread; they are found on the four continents for which data is available. Higher-mode data, particularly in combination from the fundamental modes, make surface wave dispersion a much more potent method of crustal study.—*D. B. V.*

173–91. Oliver, Jack [E], and Ewing, Maurice. Short-period oceanic surface waves of the Rayleigh and first shear modes: Am. Geophys. Union Trans., v. 39, no. 3, p. 482–485, 1958.

Waves corresponding to the short-period segment of the Rayleigh mode and to the first shear mode are identified for paths traversing the deep ocean, apparently for the first time, from the shock generated by the atomic explosion Operation Wigwam deep in the Pacific Ocean. Their conspicuous absence in other cases suggests that earthquake sources are generally too deep to excite short-period surface waves efficiently. The new data strongly support the normal mode explanation for the dispersion of Rayleigh waves crossing the Pacific Ocean and furnish supporting evidence for the crustal structures previously deduced from surface wave dispersion and from refraction shooting. The unusual characteristics of the body phases and the *T'* phase may probably be explained by assuming that the source was within the water layer.—*D. B. V.*

173–92. Hamamatsu, O. On the Queen Charlotte Islands earthquake (Aug. 22, 1949) observed in Japan (Second paper): Quart. Jour. Seismology, v. 21, no. 3, p. 33–46, 1956.

Identification of Love waves from the Queen Charlotte Islands earthquake on seismograms from various Japanese stations is difficult because of interference by *SSS* or the later group of *S* waves. Though the period of Love waves is unknown, their velocities seem to be included in dispersion curve for the path across the Pacific Ocean. The arrival times of Rayleigh waves at distances between 52° and 58° are later than the mean travel time curve, suggesting the

influence of path and refraction on the propagation of Rayleigh waves. The amplitudes and periods of Rayleigh waves between 60° and 64° are rather large, a phenomenon that appears frequently in records of distant earthquakes at central Honshu. Rayleigh waves registered at Honshu seem to have been propagated through a path deviating about 18° to the east of the direction to the epicenter, suggesting refraction at the continental margin near Honshu; the boundary surface thus obtained shows good agreement with the strike of the Japan Trench. The dispersion curve of Rayleigh waves across Honshu is somewhat smaller than that obtained for the North American continent by Ewing and Brilliant.—*D. B. V.*

173–93. Akima, T[etsuo] S., and Nagamune, T. Dispersion of seismic surface waves and the structure of continents and oceans: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 223–228, 1956.

A discussion of the determination of crustal structure under continents and oceans from both Love and Rayleigh wave dispersion, using data from the Assam earthquake of 1950 recorded at several Japanese stations, and from nine selected oceanic and seven selected continental earthquakes recorded at the Matusiro observatory in Japan. For the Assam earthquake three models of crustal structure fit the Love wave data but only one of these satisfies the Rayleigh wave data as well; in this model the first layer has a velocity of 3.3 kmps, density of 2.7, and thickness of 16 km, in the second layer v=3.8 kmps, ρ=3.0, and H=15 km., and in the third v=4.2 kmps, ρ=3.3 and $H=\infty$. In conclusion it is emphasized that crustal structure estimated from Love wave dispersion alone may not satisfy that of Rayleigh waves; that a torsion pendulum low-pass filter is very useful in such a study especially when many short period waves appear in the surface wave portion of the seismogram; that dispersion of surface waves, particularly Rayleigh waves, is very sensitive to crustal structure; that differences in wave path to Japan through the central and western Pacific region influence Rayleigh wave dispersion greatly but Love wave dispersion hardly at all; and that the special character of the structure under the Sea of Japan and the Tibet plateau are clearly shown by the surface wave dispersion in spite of their small proportion to total path length.—*D. B. V.*

173–94. Båth, Markus, and Vogel, Adreas. Surface waves from earthquakes in northern Atlantic–Arctic Ocean: Geofisica Pura e Appl., v. 39, p. 35–54, 1958.

Earthquakes in the region of Jan Mayen exhibit two different appearances on record of near-by stations: class *a* with extremely well developed Love waves and less well developed Rayleigh waves, class *b* with poorly developed or missing Love waves but with clear Rayleigh waves. The difference between the two classes is ascribed to different focal depths. The Love waves of class *a* start simultaneously with the *S* wave and have initial periods over 40 sec; they have a small vertical component increasing along the wave train. They are unable to propagate beyond the continental margin for any considerable distance, probably due to a breakdown of the condition for constructive interference valid for their oceanic propagation.

The oceanic dispersion curves both of Love and Rayleigh waves have been deduced using records at Kiruna, Uppsala, Bergen, Copenhagen, Scoresby Sund, Reykjavik, and Akureyri. The average thickness of the oceanic crust is around 15 km in the Norwegian Sea. For the Mid-Atlantic Ridge southwest of Reykja-

vik a crustal thickness of 10 km is obtained. The average thickness of unconsolidated sediments is round 2.4 km for the Norwegian Sea, and around 1.0 km in shallower regions of the ocean toward Iceland and Greenland.—*Author's summary*

Egyed, L[ászló]. Investigations on seismology and the physics of the interior of the earth, in Hungary, 1954–1956. See Geophys. Abs. 173–249.

173–95. Olczak, Tadeusz. Seismology in Poland 1954–1957: Acta Geophys. Polonica, v. 5, no. 2, p. 110–115, 1957.

A brief review of recent seismological work in Poland. Observatories are located at Warsaw, Cracow, Racibórz, Bytom, Zabrze, and Dąbrowa Górnicza; the instruments at each and their constants are listed.—*D. B. V.*

173–96. Schulz, R[udolf], and Montufar, J. R. La nueva estación sismológica del Servicio Geológico Nacional [The new seismological station of the national geological survey]: Servicio geol. nac. El Salvador Bol. sismol., v. 2, p. 1–9, 1956 (1957).

A brief description of the physical plant and instrumentation of the modernized seismological station at San Salvador, illustrated by photographs and diagrams. The constants of the three seismographs (horizontal and vertical Weichert, horizontal Katsushima) are tabulated.—*D. B. V.*

173–97. Boletin Sismológico del Servicio Geológico Nacional de El Salvador. La nueva estación sismológica de Santiago de Maria en la Republica de El Salvador [The new seismological station at Santiago de Maria in the republic of El Salvador]: Servicio geol. El Salvador Bol. sismol., v. 2, p. 38–39, 1956 (1957).

A brief description, with photographs and diagrams, of the physical plant and instrumentation of El Salvador's second seismological station, established at Santiago de Maria (lat 13°29′10″ N, long 88°28′14″ W). The constants are given for the north-south horizontal seismograph; this and the east-west component still under construction have been built entirely by the National Geological Survey. The new station went into operation in January 1957.—*D. B. V.*

173–98. Boletin Sismológico del Servicio Geológico Nacional de El Salvador. Informe sobre la nueva estación sismológica de Ayagualo en la Republica de El Salvador [Report on the new seismological station at Ayagualo in the republic of El Salvador]: Servicio geol. nac. El Salvador Bol. sismol., v. 3, p. 2, 1957.

A north-south horizontal long-period seismograph has been installed at the Colegio Salesiano at Ayagualo in El Salvador, located at lat 13°37′46″ N and long 89°17′22″ E. The constants of the instrument are given. An east-west component will also be installed.—*D. B. V.*

173–99. Gamburzev (Gamburtsev), G. A. On some new methods of seismological research: Bur. central séismol. internat. Pubs., sér. A. Travaux sci., no. 19, p. 373–381, 1956.

A report on seismological research methods used in the U. S. S. R. Azimuth seismic stations, based on the idea of azimuth phase correlation of seismic waves, consist of groups of differently oriented identical inclined seismographs directed along the generatrices of a given cone at equal azimuth intervals.

From their records longitudinal, transverse, and surface waves can be distinguished visually from irregular background disturbance waves, and simple waves can be distinguished from those complicated by interference effects. In principle the same results can be obtained from ordinary three-component records, but their treatment is more laborious and there are no simple visual criteria. "Seismotiltmeters" devised to extend the low frequency range of seismic records differ from the usual tiltmeters in that they measure rates of inclines rather than the inclines themselves; they permit recording of seismic waves with periods from several to several dozen minutes. Apparatus similar to that used in seismic prospecting extends the upper range to frequencies of 10 to 30 Hertz. Deep seismic sounding has been developed in the U. S. S. R. along the lines of correlation refraction shooting, for investigation of deep layers of the crust. Detailed longitudinal and transverse profiles made in connection with deep sounding detect deep faults. See also Geophys. Abs. 172–220.—*D. B. V.*

173–100. Kirnos, D. P. Razvitiye otechestvennykh instrumental'nykh seysmicheskikh nablyudeniy [The development of instrumental seismic observations in Soviet Russia]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 9–15, 1957.

A brief review of the development of seismic observations in Russia. The beginning of instrumental observations was the construction by Orlov of a special seismoscope about 1870–1871. Between 1892 and 1899 seismic observations were begun at the Naval Observatory in Nikolaev, at the university observatories in Kharkov, Tartu, and at the Tbilisi Observatory. In 1900 the permanent Central Seismic Commission was established for the coordination of the work of different seismic stations; the most active member of this commission was Golitsyn, who also designed several new types of seismographs. In 1913 the Central Seismic Station at Pulkovo, six stations of the first, and twelve of the second class were in operation in Russia. After the first World War regional networks of stations in several seismically active regions, such as Central Asia, the Caucasus, and the Crimea were organized. After the second World War the number of seismic stations was substantially increased, their instrumentation much improved, and the scope of operation of Russian seismologists extended into such fields of the internal structure of the earth, investigations of geologic processes leading to earthquakes, and the effect of earthquakes on industrial and public buildings.—*S. T. V.*

173–101. Savarenskiy, Ye. F. Development of seismic research and analysis of seismic observations in the USSR: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 249–257, 1956.

A review of seismological work in Russia, mentioning the contributions of the various seismologists. Establishment of a seismic committee of the Russian Academy of Sciences in 1899 paved the way for systematic observations. At present there are 69 stations operating in the U. S. S. R.; all use the same equipment and the same methods of observation and treatment of data, thereby greatly facilitating the drawing of general conclusions. Fifteen stations are equipped with strong-motion seismographs. The locations of seismic stations and epicenters of strong earthquakes are plotted on a map.—*D. B. V.*

173–102. Lazareva, A. P. Pulkovskaya seysmicheskaya stantsiya [The Pulkovo seismic station]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 5–8, 1957.

A brief review of the history and development of the main seismic station of Soviet Russia at Pulkovo.— *S. T. V.*

International Geophysical Year Bulletin. Earth strain measurements in South America. See Geophys. Abs. 173–113.

173–103. Hosoyama, Kennosuke. On the observation of secular phenomena of the tilting motion of the ground: Kyōtō Univ. Coll. Sci. Mem., ser. A, v. 28, no. 3, p. 253–282, 1957.

It is concluded from twenty years of observation of crustal deformation by means of a tiltmeter at Kamigamo Geophysical Observatory, Kyōto University, supported by observations at 25 other stations in Japan, that the secular variations recorded by highly sensitive tiltmeters at a sufficient number of places in a limited area are probably valuable in indicating phenomena that precede a destructive earthquake and that study of such phenomena can be of value in determining the nature and mechanism of earthquakes. Problems which affect the interpretation of the observations such as reliability of the instruments, solidity of the foundations, disturbing effects of meterological change, and other local conditions, are discussed in detail.—*V. S. N.*

173–104. Kirnos, D. P., and Kharin, D. A. Seysmograf dlya izucheniya kolebaniy sooruzheniy, seysmicheskogo effekta vzryvov i registratsii blizkikh zemletryaseniy [Seismograph for study of building vibrations, seismic effect of explosions and registration of near earthquakes (with English summary)]: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 2, p. 147–156, 1958.

A short description of the new universal seismograph VEGIK and its parameters, used in the U. S. S. R. for recording vertical and horizontal oscillatory movements of the ground and of enginering structures, illustrated by examples of its use for registration of vibrations of dams and different hydro-aggregates, and of ground movements in near earthquakes, microseisms, and explosions.— *D. B. V.*

173–105. Ul'man, V. Problema postoyanstva znacheniy perevodnykh mnozhiteley'v obshchem sluchaye uravneniya dvizheniya seysmografov, vibrografov i izmeriteley kolebaniy [The problem of the constancy of the conversion factors in the general case of the equation of motion of seismographs, vibrographs and oscillographs]: Akad. Nauk SSSR Sovet po Seysmologii, Byull, no. 6, p. 127–129, 1957.

This is a very brief mathematical discussion of the general equation of motion of an idealized system having one degree of freedom whose displacement can be measured. No solution of the quoted differential equation is presented and references are made to the studies of Gassmann (1937–1951) (see Geophys. Abs. 95–4627, 149–13596, 149–13597).—*S. T. V.*

173–106. Higuti, T. On the dynamical characteristics of recording system of Wiechert's 200 kg horizontal seismograph (in Japanese with English summary): Quart. Jour. Seismology, v. 21, no. 2, p. 25–35, 1956.

The recording system of a Wiechert 200-kg horizontal seismograph now in use in Japan includes a compression strut between the vibration system, which contains a recording lever and controlling spring, and an aluminum lever to which the pendulum is connected. The strut is held up by the initial stress of the controlling spring, but it is shown that there is a certain limitation of its function for earth movement by this mechanism. Neglecting the effect of friction on the recording system, the necessary condition is $p/n \leqq (1+x_o/x_{pm})^{1/2}$, where p equals angular frequency of pendulum motion, n equals proper angular frequency of recording system, x_o equals circumferential displacement of connecting pivot in recording system caused by twisting of the controlling spring to render the initial stress, and x_{pm} equals circumferential amplitude of connecting pivot in recording system.—*D. B. V.*

173–107. Ostrovskiy, A. Ye. Seysmonaklonomer s fotoelektricheskoy registratsiyey [Seismotiltmeter with photoelectric recording]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 130–134, 1957.

The recording of earthquakes is usually made with seismographs with periods of natural vibrations ranging from 1 to 20 sec. The construction of a reliable seismograph with much greater period is very difficult. The construction of tiltmeters recording inclinations of the ground rather than linear displacements is much simpler. An unfavorable factor is the excessive sensitivity of such instruments to temperature variations. This decreases the sensitivity from 10,000 to 1,000 mm per sec of arc. A short description is given of this instrument, called the seismotiltmeter. Its basic characteristic is the division of the measuring scale into two equal halves, each covered by a photoelectric cell. In the horizontal position of the instrument the illuminated spot falls in the middle of the scale and the pointer remains at zero. If the instrument is tilted the spot moves to one side, the photocells produce amplifying electromotive forces resulting in greater deviation of the pointer. The problem of finding the solution of the general motion of the instrument for various frequencies of applied moments of inclination is analyzed.—*S. T. V.*

EARTH TIDES AND RELATED PHENOMENA

173–108. Ellenberger, Heinrich. Die Erdgezeitenforschung–Überblick und Ausblick [Earth tide research–review and outlook]: Freiberger Forschungshefte C 38 Geophysik, p. 19–35, 1957.

The causes, quantitative relationships, measurement, and present state of knowledge of earth tides are reviewed. Refinement of the theory to fit the true figure of the earth more closely will require greater precision of measurement—simultaneous measurement of three components at least and also determination of tidal expansion. A double bifilar gravimeter that measures three components simultaneously, is being constructed at the 1. Abteilung des Deutschen Geodatischen Forschungsinstituts (First Division of the German Geodetic Research Institute); simplified diagrams are given of this and of the bifilar gravimeter and two horizontal pendulums (Zollner and tension-band suspension) also used in earth tide measurements.—*D. B. V.*

173–109. Molodensk[i]y, M. S., and Pariysk[i]y, N. N. Elastic tides and irregularities of the earth's rotation in connection with its structure: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 217–222, 1956.

For all depths of the earth's shell the relationship between rigidity and bulk modulus of elasticity to density can be determined from seismological data, but for the core rigidity it can be estimated only from observations of free nutation and earth tides. A series of models was studied with this latter aim (see Geophys. Abs. 160–192). It was found that the theoretical values of Love's numbers K and h depends mainly on the rigidity of the core. From the observed values of the period of free nutation one of two possibilities follows: either the rigidity of the core is close to 0.6×10^{12} dynes per cm^2, or else the core is liquid and its moment of inertia is not less than 10 percent of the earth's moment of inertia. The choice between these possibilities must be based on the study of amplitudes of short period terms of the forced nutation and of elastic luni-solar tides. In the latter the effect of ocean tides can be excluded but reliability is questionable in view of the paucity and imprecision of available data.

Quantitative study of processes at the surface and within the earth that could cause variation in angular velocity leads to the conclusion that the effect of surface changes is imperceptible whereas only slight changes within the earth are required. These changes cause such small variation of height and gravity at the surface that they could easily remain undetected. It is far more probable, however, that these inner changes do not embrace the whole earth as it is represented by the zero and second order spherical functions but rather as it is represented by higher order functions; in that case, greater changes in gravity and vertical displacements, detectible by existing methods, are to be expected. Investigations of gravity variation with time have been instituted in the U. S. S. R., using a method of relative gravity measurement developed by Boulanger which has an accuracy of 0.1 to 0.2 mgal for a difference of several gals and which does not require standardization by means of pendulum observations.—*D. B. V.*

173–110. Picha, Jan. Die Gezeitenbeobachtungen in der Tschechoslowakischen Republik [Earth tide observations in the Czechoslovakian Republic]: Freiberger Forschungshefte C 38 Geophysik, p. 36–38, 1957.

A summary of the history of earth tide observations in Czechoslovakia. These have been made, with several interruptions, since 1910. Systematic pendulum observations have been made uninterruptedly since 1952 at a new station 1,000 m underground in a mine in the Březové Hory.—*D. B. V.*

173–111. Ozawa, Izuo. Observations of tidal strains of the earth: Jour. Physics of Earth, v. 5, no. 1, p. 9–13, 1957.

Observations of the components tidal strain of the earth's surface were made by means of extensometers at Osakayama Observatory in Japan in three horizontal, one vertical, and two diagonal directions. Using the observed values, the horizontal areal strain, vertical strain, and cubic dilatation are obtained; from them numerical values of $h-3l$, v, and C are calculated to be 0.45 ± 0.03, -0.28 ± 0.04, and 0.60 ± 0.04 respectively (h=Love's number, l=Shida's number, v and C are constants; $C=v+2h-6l$). The effect of ocean tides have not been determined, but must be negligible as the observed value of $h-3l$ is considered an

accurate value for the primary effect of earth tide and is in good agreement with the theoretical value derived by Takeuchi (see Geophys. Abs. 143–12343).—*D. B. V.*

173–112. Ozawa, Izuo. Study on elastic strain of the ground in earth tides: Kyōtō Univ. Disaster Prevention Research Inst. Bull., no. 15, 36 p., 1957.

The M_2-terms of the components of tidal strain have been analyzed on the basis of observations at three stations in Japan (in 6 directions at Osakayama, 65 km inland, and in 3 horizontal components at Kishu Mine, 15 km inland, and Suhara, on the coast) using various types of extensometers. Relative differences between pairs of stations are compared with the theoretical values expected from the theory of elasticity. Agreement is found to be good in the first approximation, especially for the pair Osakayama-Kishu; somewhat anomalous results at Suhara are attributed to the complex geological structure in that vicinity.

Equations are derived by two different methods for the effect of ocean tide on tidal strain. It is shown that horizontal areal strain due to ocean tidal load nearly vanishes at these stations; consequently, as the cubic dilatation due to distant tidal load is nil at the earth's surface because no body force acts in the case of oceanic tide effect, it is deduced that vertical strain is also nil. Therefore the primary earth tide effect is obtained directly from the observations: vertical strain from vertical extension, horizontal areal strain as the sum of linear strain in directions orthogonal to each other along the surface of the earth, and cubical dilatation as the sum of vertical and horizontal strains.—*D. B. V.*

173–113. International Geophysical Year Bulletin. Earth strain measurements in South America: Am. Geophys. Union Trans., v. 39, no. 2, p. 380–382, 1958.

Two fused-quartz extensometers, relatively new instruments for measuring earth strain, have been installed in the Andes Mountains near Santiago, Chile and near Lima, Peru as part of the U. S. International Geophysical Year program in seismology, to provide three kinds of observational data: measurements of secular strain changes in the Andes; measurements of diurnal tidal strains in the earth; and recordings of ultra-long period seismic waves including possible free vibrations of the earth excited by earthquakes. Each installation consists of two horizontal extensometers mounted at right angles in tunnels bored in igneous rock. Sensitivity is expected to be the same as that of the extensometer tidal strain recorder used at Isabella, California, in which one division on the record represents a strain increment of 8.6×10^{-10} or the equivalent of $\frac{1}{10}$ inch in 2,000 miles.—*D. B. V.*

173–114. Bondi, H., and Gold, T. On the damping of the free nutation of the earth: Royal Astron. Soc. Monthly Notices, v. 115, no. 1, p. 41–46, 1955.

The free (420^d) nutation is known to be heavily damped, the characteristic damping time being less than ten periods. The origin of this damping is unknown, but must be due to dissipative, non-rigid-body movements of the Earth.

The view, which has been widely held, that this may arise from the relative motion between the liquid core of the Earth and the mantle is shown to be based on an error. When account is taken of its small moment of inertia, the core cannot be held responsible for this damping, nor can a limit be derived for its viscosity. This confines the origin of the damping to a non-elastic behavior of the mantle.—*Authors' abstract*

173–115. Dungen, F. H. van den, Cox, J. F., and Mieghem, J. van. Sur les fluctuations saisonnières de la rotation de la Terre [Seasonal fluctuation of the earth's rotation]: Acad. royale Belgique Bull., Cl. sci., ser. 5, v. 40, no. 7, p. 693–695, 1954.

On the basis of Willett and Starr's data on barometric pressure (reduced to sea level) for the northern and southern hemispheres, the variations in the moment of inertia of the earth due to seasonal air movements over the globe are calculated. The maximum variation in the duration of the sidereal day is found to be ±0.3 millisecond for the years 1949 and 1950.—*S. T. V., D. B. V.*

173–116. Markowitz, W[illiam]. The annual variation in the rotation of the earth, 1951–1954 (abstract): Astron. Jour., v. 60, no. 5, p. 171, 1955.

Variation in rotation of the earth for each of the three years from September 1951 to October 1954, determined at the U. S. Naval Observatory with the aid of two separate quartz-crystal clocks, was found to be fairly regular from year to year—about 35 milliseconds fast on October 1 and about 35 milliseconds slow on June 1. Harmonic analysis gives a one year term of 30 milliseconds amplitude and a 0.5 year term of 10 milliseconds amplitude. Two new terms of 1 millisecond each were also found, as predicted, with periods of 13.6 and 27.6 days, respectively. The one year term is apparently due to meteorological causes, the 0.5 year term to solar tide *Ss*, and the other two terms to the lunar tides *Mf* and *Mm*, respectively; tides affect the moment of inertia of the earth and hence its rate of rotation.—*D. B. V.*

173–117. Essen, L., Parry, J. V. L., Markowitz, W[illiam], and Hall, R. G. Variation in the speed of rotation of the earth since June 1955: Nature, v. 181, no. 4615, p. 1054, 1958.

Changes in the speed of rotation of the earth are calculated from time and frequency comparisons made from June 1955 to January 1958 between the National Physical Laboratory at Teddington, England, and the U. S. Naval Observatory in Washington, D. C. (The precision of the cesium standard is so high that accuracy depends entirely on the accuracy with which Universal Time can be determined.) Speed of rotation was at a maximum about September 1955 and has been decreasing at a practically constant rate since. Seasonal variation is practically the same as that determined for previous years by means of quartz-crystal clocks. The non-periodic portion of the variation of rotation has been a constant deceleration of 5 parts in 10^9 per year, equivalent to an increase in the period of rotation of 0.43 milliseconds a year. This is about 50 times as large as that attributed to tidal friction. It is probable that this represents the irregular variation that has been surmised but not previously exhibited; however, further observations are needed to confirm this.—*D. B. V.*

ELASTICITY

173–118. Teisseyre, Roman. Optico-geometrical approximation for seismic waves in non-homogeneous media: Acta Geophys. Polonica, v. 3, no. 4, p. 161–166, 1955.

Approximate expressions are derived for the equations of seismic wave propagation in non-homogeneous media. It is assumed that the longitudinal and transverse wave velocities (a and b respectively) and density (ρ) are regular functions of one variable. First the case of a non-homogeneous half-space is treated where a, b, and ρ are functions of z, the axis perpendicular to the boundary plane. The non-homogeneous half-space can be represented by plane parallel homogeneous layers of infinitely small thickness; the result of passage of a seismic wave through several layers can easily be generalized to obtain the expression for a translation at an arbitrary point (x, z) of the half-space. Then an analogous procedure is applied to the case of a non-homogeneous cylinder in which a, b, and ρ depend only on the radius r. Neglecting damping, the variation of amplitude of the seismic wave can be obtained in both cases. The formulas derived are valid for a parallel bundle of seismic rays. For the case of a divergent bundle of rays Teisseyre uses the results of Riznichenko's work (see Geophys. Abs. 157–92) and gives formulas for the amplitude of the waves both for a line source and for a point source. (*See also* Geophys. Abs. 173–252).—*S. T. V.*

173–119. Teisseyre, Roman. Ideal seismic wave guides: Acta Geophys. Polonica, v. 5, no. 2, p. 95–102, 1957.

The newly discovered phases of surface waves, L_g and R_g travelling in exclusively continental paths suggest the existence of specific channels guiding the vibrations. A mechanism based on the existence of a low velocity layer has been suggested by Båth (Geophys. Abs. 163–99). In this paper the method used for electromagnetic wave guides is applied to Båth's type "a" channel (bounded on both sides by higher velocity layers) and type "b" channel (bounded on top by the free surface of the earth and on bottom by a zone of increasing velocity), in order to obtain a simple scheme for the propagation of surface waves in these conditions. Solutions are obtained for critical velocity distributions. Variation of amplitude with depth is shown for the first wave, and dispersion curves are given for the first few waves.—*D. B. V.*

173–120. Teisseyre, Roman. Seismic waves in an ideal guide with an arbitrary point source: Acta Geophys. Polonica, v. 6, no. 1, p. 32–48, 1958.

Solutions are derived for the production of seismic waves in an ideal wave guide (a homogeneous layer bounded by media with critical velocities—zero, infinity) by a point focus represented by an arbitrary system of forces having a time dependence expressed by $\exp(-\omega t)$. Expressions corresponding to surface and body waves are obtained. Although the quantitative results of this approach may deviate from real relationships, the qualitative picture may aid in the solution of some difficult basic problems of wave propagation.—*D. B. V.*

173–121. Skuridin, G. A., and Gvozdev, A. A. O krayevykh usloviyakh dlya skachkov razryvnykh resheniy dinamicheskikh uravneniy teorii uprugosti [Boundary conditions for the jumps of discontinuous solutions of dynamic equations of the theory of elasticity]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 145–156, 1958.

Asymptotic considerations in the dynamic theory of elasticity have been recently applied by several authors to the solution of problems of propagation of elastic and electromagnetic wages in different media (see Geophys. Abs. 166–109). In the case of media with various mechanical properties, reflection, refraction, and diffraction introduce discontinuities in the solutions found. In this paper the problem of finding the boundary value conditions affected by such discontinuities is discussed, and a method is shown for determining these discontinuities without resorting to solving the differential equations of wave-propagation by the general method of Lamé. The article is a purely mathematical study.—*S. T. V.*

173–122. Yamakawa, Norio. On the strain produced in a semi-infinite elastic solid by an interior source of stress (in Japanese with English abstract): Zisin, v. 8, no. 2, p. 84–98, 1955.

Japanese seismologists explain the push-pull distribution of the initial motion of earthquakes by assuming two types of stress distribution on the sphere which includes the focus: type *A*, the combination of hydrostatic pressure and pressure with distribution expressed in spherical harmonics $P_2(\cos\theta)$; and type *B*, the distribution of pressure expressed in $P_2^1(\cos\theta)\cos\phi$. In this paper, Yamakawa calculates the strain produced in a semi-infinite elastic solid when hydrostatic pressure $-P$ and pressure distributions expressed in spherical harmonics $P_2(\cos\theta)$, $P_2^1(\cos\theta)\cos\phi$, $P_2^2(\cos\theta)\cos 2\psi$ were applied at the interior spherical cavity. For cases in which the axis of spherical harmonics does not coincide with the vertical axis, Sato's formulas expressing the transformation of the spherical harmonics by the rotation of the coordinate system are used.—*V. S. N.*

173–123. Yamakawa, N[orio]. Investigation of the disturbance produced by spherical obstacles on the elastic waves (II). On the scattering of the elastic waves by a spherical obstacle (II) (in Japanese with English summary): Quart. Jour. Seismology, v. 21, no. 2, p. 1–3, 1956.

Formulas are derived from those developed in the preceding paper (see Geophys. Abs. 166–113) for the scattering of *P* and *S* waves incident in a spherical obstacle whose radius is small compared with the wave length. The intensity distribution of scattered *P* and *S* waves is shown in figures.—*D. B. V.*

173–124. Yamakawa, N[orio]. Investigations of the disturbance by spherical obstacles on the elastic waves (III) (in Japanese with English summary): Quart. Jour. Seismology, v. 22, no. 1, p. 1–4, 1957.

Formulas are derived for the decrease in intensity of plane *P* waves passing through a small distance in a medium containing *N* spherical obstacles per unit volume, and for intensity itself, analogous to formulas obtained in previous papers (see Geophys. Abs. 166–113 and 173–123) for the scattering of energy of *P* waves in unit time by a spherical obstacle.—*D. B. V.*

173–125. Shamina, O. G., and Silayeva, O. I. Rasprostraneniye vprugikh impul'sov v sloyakh konechnoy moshchnosti so svobodnymi granitsami [The propagation of elastic impulses through strata of finite thickness with free boundaries]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 3, p. 302–316, 1958.

Experiments on the propagation of elastic impulses through layers of finite thickness with free boundaries are reported in this article. The ultrasonic impulse method was used, following the procedure of longitudinal profiling. It was established that longitudinal waves can propagate through such layers with only two velocities; one of these is the velocity of longitudinal waves in a solid, the other is the velocity of longitudinal waves in an infinitely thin plate of the same material. The shape of the wave and the preponderant wave length are determined by the thickness of the layer. It is important to note that near the source of impulses one seismic velocity can be produced, whereas at a certain distance from it the other velocity can be recorded. The wave length of the longitudinal wave propagating with the velocity corresponding to the plate varies with the thickness d of the stratum, but the relation $d/\lambda \leq 0.25$ always remains valid. The transition zone from one velocity to the other at a greater distance from the source of impulses is not continuous and does not follow the Lamb's law; the entire transition takes place in a zone where both waves are mixed and interfere with one another.—*S. T. V.*

173–126. Kobayashi, Naota, and Takeuchi, Hitoshi. Wave generations from line sources within the ground: Jour. Physics of Earth, v. 5, no. 1, p. 25–32, 1957.

Continuing the study of wave generation from line sources in the ground (see Geophys. Abs. 170–75), displacements at several points in the ground are calculated. For a compressional origin with step function variation in time there are three pulses deep in the ground corresponding to the direct *P* and reflected *P* and *S* phases; no displacement corresponding to the Rayleigh wave is found. The profiles of surface displacements at certain fixed times are then calculated for a source of impulsive compressional type; the results agree well with those obtained by Dix in his study of the mechanism of generation of long waves from explosions (see Geophys. Abs. 160–90).—*D. B. V.*

173–127. Ogurtsov, K. I., and Burova, A. V. Ob intensivnostyakh pryamykh, prodol'nykh i poperechnykh voln, rasprostranyayushchikhsya po granitse poluprostranstva [On the intensity of direct longitudinal and transverse waves, propagating along the boundary of a semispace]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 157–164, 1958.

Calculations of the dynamic characteristics of non-steady direct waves produced by a point source and propagating over the boundary surface of an ideal elastic semispace are presented in the paper. This problem, first formulated and solved for certain conditions by Lamb more than 50 years ago, is of great interest owing primarily to the possibility of checking the theoretical results by direct experiments. The problem is studied by applying Lamb's formulation as also leading toward the solution of several other problems such as Stoneley waves, certain types of head waves propagating in stratified media, and so on. First the special case is discussed where the source of the seismic waves can be described by a single Heaviside function. From the solution for this case it is not difficult to establish the theoretical seismograms for any distance from

the source acted upon by an arbitrary impulse. Furthermore, when wave lengths are sufficiently small compared with this distance, the intensities at the transverse and longitudinal wave fronts can be determined from a table of computed constants. Also a graph is given showing the ratios *Is/Ip* of the intensities of these waves. This ratio tends toward infinity when Poisson's ratio σ approaches the value 0.5 and becomes infinitely small where σ approaches zero.—*S. T. V.*

173–128. Malinovskaya, L. N. O dinamicheskikh osobennostyakh poperechnykh voln pri polnom vnytrennem otrazhenii [Dynamic features of transverse waves in the case of full internal reflection]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 184–195, 1958.

Dynamic characteristics of the transverse waves of the type *SV* are discussed, in continuation of previous studies (see Geophys. Abs. 170–77 and 170–280). The effect of a free surface on form, polarization, and ratios of horizontal and vertical components of displacement in a direct, reflected, or refracted transverse wave is examined, and the effect of a surface layer with low velocity on a surface wave incident on the bottom of the layer at an angle greater than the critical angle is calculated. Master charts and curves are given for determining the ratios of horizontal and vertical components for the special case where $a_o/b_o=1.73$ (a_o and b_o=longitudinal and transverse wave velocities in layer under free surface) and for arbitrary value of a_o/b_o, and for the effect of low velocity surface layer.—*S. T. V.*

173–129. Menzel, H[einz]. On the stress-strain relation in a not perfectly elastic solid body: Bur. central séismol. internat., Pubs., sér. A, Travaux sci., no. 19, p. 125–127, 1956.

A discussion is presented of a stress-strain relation proposed by Nakamura to account for adiabatic and isothermal elasticity of media. In order to explain observed dissipation of energy, it is suggested that the stress-strain relationship be generalized to the form

$$\sum_{n=0}^{N} A_n \frac{d^n}{dt^n} P = \sum_{n=0}^{N} b_n \frac{d^n}{dt^n} e,$$

where P and e represent stress and strain, respectively. It will be necessary to establish absorption frequencies to determine the general form of the stress-strain relation (that is, the number N). Then perhaps estimates can be made of constants involved.—*P. E. B.*

173–130. Sentis, André. Sur la propagation des ondes dans un milieu visco-élastique [On the propagation of waves in a visco-elastic medium]: Acad. Sci. Paris Comptes Rendus, v. 244, no. 5, p. 558–560, 1957.

A mathematical study of the propagation of plane waves in an isothermal visco-elastic medium having a specific mass ρ, Lame coefficients λ and μ, and time of response τ. Velocity depends on the initial conditions of the movement of which the theory of elasticity consider itself to be independent. The greater the initial velocity imparted to the material, the greater the discrepancy between the elastic and visco-elastic concepts. This may explain why the elastic constants of a substance are generally higher when measured by the dynamic method than when measured by the static method.—*D. B. V.*

173–131. Zvolinskiy, N. V. Otrazhennyye i golovnyye volny, voznikayushchiye na ploskoy granitse razdela dvukh uprugikh sred. III [Reflected and head waves produced on a plane boundary separating two elastic media, pt. 3]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 165–174, 1958.

This is the concluding section of the study by the author on the properties of reflected and head waves (see Geophys. Abs. 172–56 and 172–57). This paper deals with the head waves *PSP* and *PSS* appearing against the background of preceding waves *PPP* and *PPS*, and *PP* and *PS* waves in the zone beyond the critical angle of reflection. From the theory expounded approximate formulas can be derived, valid in the zones adjoining the waves under consideration. The reflected waves *PP* and *PS* preserve their shape (that of the incident wave) up to the initial point of the head wave.

For the head waves *PPP* and *PPS* the shape of vibrations is obtained by the integration of the functions describing the shape of the incident wave. The shape of the reflected waves *PP* and *PS* changes beyond the first point of the head wave, where a term is added to it conjugated with the shape of the incident wave. The head waves *PSP* and *PSS* are also composed of two terms. One is the repetition of the waves *PPP* and *PSP;* the second is a conjugate expression. The intensity of vibration (amplitude) of separate waves is determined not only by their type, properties of the medium and amplitude of incident waves, but also by their shape.—*S. T. V.*

173–132. Lieber, Paul, and Farmer, Arthur. Studies on wave propagation in granular media: Am. Geophys. Union Trans., v. 39, no. 2, p. 313–321, 1958.

Experimental studies relating to the propagation and attenuation of disturbances in unconsolidated materials encouraged a theoretical investigation suggesting a mechanism governing propagation in such materials. From these physical considerations it is inferred that a disturbance imparted to a granular material is propagated in two principal parts. One consists of a wave of small amplitude which anticipates a wave of much higher amplitude propagating at a lower velocity. The first wave is called here a precursor and is identified with the visco-elastic deformation of the grains of the unconsolidated material. The second component propagating at a lower velocity and carrying most of the energy imparted by the disturbance is identified with consolidation, accomplished by filling the voids between the grains. It is thus inferred that there would be appreciable dissipation of energy associated with the second wave and little attenuation of the precursor wave. Further experiments were conducted to check these conclusions. The results of these experiments show the composite wave structure predicted from theoretical considerations.—*Authors' abstract*

173–133. Yoshikawa, Soji. Mechanism of fracture of rock by explosion (II) (in Japanese with English summary): Zisin, v. 8, no. 2, p. 108–113, 1955.

The strain rate of rock near an explosion is measured by an instrument newly devised for the purpose. The strain waves are calculated from the records. A

shear wave produced at the free surface as a reflexion of a compressional wave caused by the explosion is very remarkable near the surface, the fracturing of rock being attributed chiefly to this wave. The relationship between stress and strain must be in the plastic region for this case.—*D. B. V.*

173–134. Kubotera, Akira. Rayleigh and Sezawa waves generated by explosions: Jour. Physics of Earth, v. 5, no. 1, p. 33–41, 1957.

Ground motions generated by small dynamite charges have been studied, using seismometers set up at various depths in boreholes and varying the shothole depths. The surface waves observed can be considered to be Rayleigh and Sezawa waves The Rayleigh wave has a velocity of 60 m per sec, period of 0.22 sec, and its amplitude decreases exponentially with depth. The Sezawa wave has a velocity of 500 m per sec, period of about 1.0–0.08 sec, and its vibration mode has one node in the upper layer. These results are in good agreement with the theoretical behavior of Rayleigh and Sezawa waves.—*D. B. V.*

173–135. Tazime, Kyozi. Relations between charge amounts and periods in resulting seismic wave groups: Jour. Physics of the Earth, v. 5, no. 1, p. 51–59, 1957.

Variations of periods in surface waves were observed with various charges ranging from a cap to about 0.2 kg and buried at depths of one and two meters. The waves observed were considered to be the zero and first orders of Rayleigh and Sezawa waves respectively, due to a surficial layer 19 m thick. As the charge size was increased, the periods of the wave groups were found to increase toward asymptotic values satisfying quarter wave-length laws. If H is the thickness of the surficial layer, and V_{p1} the P velocity in this layer, the quarter wave-length laws for the Rayleigh and Sezawa waves observed are $4=T_q V_{p1}/H$ and $4=3T_q V_{p1}/H$, respectively. The asymptotic periods correspond to the Airy phases, and hence it is concluded that the stationary phases of wave groups will be observed as a result of a large explosion.—*P. E. B.*

173–136. Beaufils, Y[vonne], Bernard, P[ierre], Coulomb, J[ean], Duclaux, F[rançoise], Labrouste, Y., Richard H[enri], Peterschmitt, É[lie], Rothé, J[ean]-P[ierre], and Utzmann, R. Enregistrement des ondes séismiques provoquées par de grosses explosions. I.—Camargue 1949 [Registration of seismic waves generated by large explosions. I.—Camargue 1949]: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 325–326, 1956.

About 60 records were obtained, at distances varying from 1.7 to 26 km, from explosions in Camargue, France, in 1949. Five P phases were recognized. High velocity layers were encountered at relatively shallow depth (about 2,000 m); comparison with the gravity map shows that the seismic profile crosses the axis of an anticline. A velocity of 6.0 kmps corresponds to the Paleozoic basement. Four phases appear to represent S waves, and a train of surface waves with an apparent velocity of 500 m per sec are identified as Rayleigh waves.—*D. B. V.*

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173–137. Beaufils, Y[vonne], Coulomb, J[ean], Geneslay, R[aymond], Jobert, G[eorges], Labrouste, Y., Peterschmitt, É[lie], and Rothé, J[ean]-P[ierre]. Enregistrement des ondes séismiques provoquées par de grosses explosions. II.—Champagne 1952 [Registration of seismic waves generated by large explosions. II.—Champagne 1952]: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 327–329, 1956.

Fifty-two records were obtained from 11 explosions in Champagne, France, in 1952. In the first three explosions the stations were situated to the east of the shot point at distances between 1.6 and 25 km, in the rest they were arranged en echelon between 1.3 and 70 km to the west. Six *P*-phases were identified. The Paleozoic basement with a velocity of 6.0 kmps was found to be somewhat deeper than at Camargue (see Geophys. Abs. 173–136). Three *S* phases were recognized, and surface waves with a velocity of 0.9 kmps are interpreted as Rayleigh waves. Arrivals at 10 sec at three stations were presumably deep reflections indicating a crustal thickness of 30 km.—*D. B. V.*

173–138. Labrouste, Y., and Beaufils, Y[vonne]. Réfractions multiples dans les enregistrements séismographiques des explosions de Champagne, octobre 1952 [Multiple refractions in the seismographic records of the Champagne explosions, October 1952]: Bur. central séismol. internat. Pubs., sér. *A*, Travaux sci., no. 19, p. 335–338, 1956.

Several noteworthy trains of refracted waves were recorded by the Companie Générale de Géophysique from the Champagne, France, explosions of October 1952. A P_1 phase travelled with a velocity of 1.80 kmps along a surface layer about 60 m thick. P_2 (v=2.92), P_3 (v=3.80), and P_4 (v=4.50) correspond to boundaries at 369, 745, and 2,435 m depth. A weak P_5 (v=5.20) was the first arrival at distances between 5,300 to 5,550 m, corresponding to a boundary at 2,897 m, and P_6 (v=6.00) appeared at distances between 13 and 40 km. Three series of multiple refractions, sometimes of large amplitude, complicated the seismograms; these included PP_4, SS_4, SP_4, PP_3, PPP_3 . . ., SS_3, SSS_3 . . ., and S_2P_3.—*D. B. V.*

173–139. Geneslay, R[aymond], Labrouste, Y., and Rothé, J[ean]-P[ierre]. Réflexions à grande profondeur dans les grosses explosions (Champagne, octobre 1952) [Deep reflections in large explosions (Champagne, October 1952)]: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 331–334, 1956.

Records obtained by the Companie Générale de Géophysique from the Champagne, France, explosions in October 1952 have been interpreted, with a particular view to verifying the existence of deep reflections. Three groups of reflected waves are recognized, one corresponding to reflections from boundaries within or at the base of the sediments, a second group representing multiple reflections in the sedimentary layers, and finally a group of deep reflections. For the first of the deep reflections only the order of magnitude of velocity (4.5 kmps) and depth (about 5,000 m) can be determined. For the next four reflections a depth of 8 to 11 km is estimated, assuming a velocity of 6.00 kmps; this could be the top of the basalt layer. The principal train of reflections, at 10 sec, probably corresponds to the Mohorovičić discontinuity; assuming a mean velocity of 7 kmps for the lower part of the crust, its depth is about 30 km.—*D. B. V.*

173–140. Beaufils, Y[vonne]. Étude des ondes superficielles dans les enrégistrements séismographiques des explosions de Champagne, octobre 1952 [Study of the surface waves in the seismograph records of the Champagne explosions, October 1952]: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 339–343, 1956.

Surface waves from the Champagne, France, explosions of 1952 were particularly well registered on the Mintrop seismographs. Comparison of the three components shows four distinct phases. First to appear are very regular *L*-waves with constant period (about 0.3 sec at 24 km), polarized in the plane of propagation. A little before the end of the first phase, Love waves (*Q*) appear on the transverse component with an apparent period that is large at first, then decreases rapidly. Then follows a brief *M* train of large amplitude on all three components. Immediately following these are Rayleigh waves (*R*) of large period (0.5 to 0.9 sec), polarized in the plane of propagation, whose amplitude decreases gradually. Love wave dispersion is normal and indicates a velocity decreasing from 1.7 to 1.1 kmps as the period decreases from 0.40 to 0.30 sec. Rayleigh wave dispersion is normal for short periods, anomalous for large; velocity decreases from 1.0 to 0.7 kmps as period increases from 0.3 to 0.9 sec. *L*-waves with periods of 0.2 to 0.4 sec are superimposed on the shorter-period Rayleigh waves so that dispersion curves of the two are confused. The anomalous dispersion of the Rayleigh waves is attributed to a subjacent low-velocity layer. It is concluded from study of the phase velocities that the surface waves are formed at some distance from the origin and thus with some retardation.—*D. B. V.*

173–141. Kárník, Vít. Les vitesses des ondes séismiques excitées par les explosions industrielles en Bohême [The velocities of seismic waves generated by industrial explosions in Bohemia]: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 319–324, 1956.

Quarry explosions in Czechoslovakia have been recorded since 1950 at the Praha seismological station and often have been registered also at Collm, Jena, and Stuttgart. This study is based on an analysis of all available records of 38 of these explosions. The following phases have been identified: $\overline{P}_1$ (v=5.30), $\overline{P}_2$ (v=5.90), P^* (v=6.35), P_n (v=8.15), $\overline{S}$ (v=3.30), S^* (v=3.67), and five phases designated *X* were probably due to waves travelling in the sediments. The thickness of the granitic layer is calculated from the $\overline{P}$ *and* P^* phases as 10.9 km, from the $\overline{S}$ and S^* phases as 9.1 km, or using the $\overline{P}_1$, $\overline{P}_2$ modification as 6.0+4.5 km. The gabbro-basalt layer (from $\overline{P}$, P^*, and P_n) is 19.9 km thick.—*D. B. V.*

173–142. Bremaecker, J. Cl. de. Transmission and reflection of Rayleigh waves at corners: Geophysics, v. 23, no. 2, p. 253–266, 1958.

The methods of two dimensional model seismology were used to investigate the phenomena occurring when a Rayleigh wave is incident upon a corner whose angle is comprised between 0° and 180°. The wave bends its path only for angles between 130° and 180°. For smaller angles large and abrupt variations in reflection and transmission occur; the wave travels to the extremity of the corner and never "cuts corners"; only about 50 percent of the energy of the incident surface wave is preserved as such, the rest goes into body waves; for a 90° corner the proportion is about 23 percent in *P* and 26 percent in *S*, with

sharply preferential angles of incidence. The percentages given were found for a "plate Poisson's ratio" of 0.17.—*Author's abstract*

173–143. Nagamune, T. M_2 waves in a medium with double surface layers (in Japanese with English summary): Quart. Jour. Seismology, v. 21, no. 2, p. 5–12, 1956.

An English version of the this paper has been published in Geophys. Mag., v. 27, no. 3, 1956 (see Geophys. Abs. 169–86).—*D. B. V.*

173–144. Tazime, Kyozi. Minimum group velocity, maximum amplitude, and quarter wave-length law–Love waves in doubly stratified layers: Jour. Physics of the Earth, v. 5, no. 1, p. 43–50, 1957.

The period characteristics of the amplitude function of Love waves have been obtained by the use of dispersion curves. In a two-layer medium, with thickness of the upper layer H and S velocity in this layer v_1, the quarter wave-length is expressed by $Tqv_1/H=\lambda q/H=4$. For comparatively small rigidity ratios between the layers, the maximum of the amplitudes is for periods closer to that given by the above "quarter wave-length law" than to that corresponding to the Airy phase, but as the rigidity ratio increases the quarter wave-length law comes closer to satisfying both maximum amplitude and minimum group velocity. The quarter wave-length law can be better approximated at the Airy phase of Rayleigh and Sezawa waves than at that of Love waves. Tazime believes that a layer will serve as a narrower band pass filter for Rayleigh and Sezawa waves than at that of Love waves.—*P. E. B.*

173–145. Ginzbarg, A. S., and Strick, E. Stoneley-wave velocities for a solid-solid interface: Seismol. Soc. America Bull., v. 48, no. 1, p. 51–63, 1958.

Stoneley wave velocities for a solid-solid interface have been calculated for a wide range of elastic parameters. For density ratio $\rho_1:\rho_2<1$ the ratio of the Stoneley velocity V_{ST} to shear velocity of the first medium b_1 is almost independent of Poisson's ratio σ_1, and similarly for $\rho_1:\rho_2>1$ the ratio V_{ST}/b_1 is almost independent of σ_2. Results are presented in 20 graphs.—*D. B. V.*

173–146. Chavet, R., Deconinck, B., Naville, S., and Soukiassian, L. Mesure de la vitesse des ondes sismiques sur carottes. Description de l'appareillage construit par l'Insitut Français du Pétrole [Measurement of the velocity of seismic waves on core samples. Description of the apparatus constructed by the Institut Français du Pétrole]: Rev. Inst. Français du Pétrole, v. 12, no. 6, p. 715–729, 1957.

A description of the apparatus constructed by the electronics laboratory of the Institut Français du Pétrole for direct measurement of seismic velocities in rock samples, with photographs and a number of circuit diagrams. The system includes two quartz crystals which act as emitter and detector of seismic pulses, an electronic device for the measurement of the time of propagation, and a high pressure and temperature chamber where conditions in the earth at depths up to 4,000 meters can be simulated.—*D. B. V.*

173–147. Hughes, D[arrell] S., and Maurette, C[hristian]. Détermination des vitesses d'onde élastique dans diverses roches en fonction de la pression et de la température [Determination of elastic wave velocities in various rocks as a function of pressure and temperature]: Rev. Inst. Français du Pétrole, v. 12, no. 6, p. 730–752, 1957.

This paper described briefly the method and apparatus used and presents the results obtained in measurements of longitudinal and transverse wave velocities (here designated V_D and V_R, respectively) in different rocks at pressures ranging from 1 bar to 8,000 bars and temperatures varying from 25° C to 300° C and 400° C in one case. The maximum temperature and pressure used probably correspond to a depth of 25 km in the earth's crust. Three groups of rocks were investigated: 4 sedimentary rocks (Solenhofen limestone, Caplen Dome sandstone, Dandy marble, and a shaly limestone), 3 granites (gray and pink granites from Texas, Woodbury granite from Vermont), and 6 basic igneous rocks (San Marcos gabbro, bytownite gabbro, hornblende gabbro, hornblende basalt, and 2 dunites). In general the shape of the curves obtained for V_D and V_R is the same for different rocks. In the Woodbury granite, for example, V_R remains practically constant; V_D increases rapidly for the first 1,000 bars, but increases very slowly above that pressure. At temperatures above 100° C V_D decreases appreciably. The effect of temperature always diminishes rapidly when pressure is increased.

The distribution of seismic velocities with depth in the earth is calculated on the basis of these measurements. The pressure gradient is assumed to be 260 bars per km in the sedimentary and granitic layers (Sial) and 280 bars per km in the basic layer (Sima); and the temperature gradient for 0 to 15 km depth is calculated as $(24.8-0.9\ X)°$ C where X=depth in km and from 50 to 35 km as $[13.0-0.26\ (X-15)]°$ C per km. Tables give V_D, V_R, and density for the sedimentary rocks at depths of 0.5, 1, 2, 3, and 4 km; for the granites at depths of 1, 2, 5, 10, and 15 km; and for the basic rocks at depths of 1, 2, 5, 10, 15, 20, and 25 km. The maximum values of V_D, occurring at depths ranging from 5 to 15 km, are 6.30 kmps in granites, 5.90 kmps in basalts, 7.00 kmps in gabbros, and 8.75 kmps in the dunites; values of V_R near these maxima of V_D are approximately 3.60 kmps in the granites, 3.25 kmps in the basalts, 3.60 kmps in the gabbros, and 4.40 kmps in the dunites. These laboratory results confirm those obtained on seismograms by Gutenberg (see Geophys. Abs. 145–12744 and 163–251).—*D. B. V.*

173–148. Meisser, Otto. Zum Problem der seismischen Grenzschichtwelle [On the problem of seismic boundary layer waves]: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 1, p. 91–92, 1958.

An apparatus for optical determination of ultrasonic wave velocities in rocks is described briefly, and the longitudinal and transverse wave velocities measured for nine specimens of different rocks are tabulated.—*D. B. V.*

ELECTRICAL EXPLORATION

173–149. Hladík, Josef. Geoelektrický prieskum v prostredí všeobecne anizotropných vlastností elektrickej vodivosti [Geoelectrical investigation of electrical conductivity in a generally anisotropic medium]: Geol. Práce 1954, v. 2, p. 115–124, 1955.

A detailed mathematical analysis of the conductivity vector in a generally anisotropic medium, such as a sedimentary rock. The results of the analysis can yield increased precision in electrical exploration.—*F. C. K.*

173–150. Henkel, John H. Some theoretical considerations of induced polarization: Geophysics, v. 23, no. 2, p. 299–304, 1958.

The induced electrical polarization noted in resistivity measurements of ground is treated as an induced electromotive force, a polarization constant is included as part of the effective resistivity, and theoretical relations are established for transmission of sinusoidal electromagnetic waves and direct current through polarizable earth. Applying a polarization constant to Yost's experimental data for a. c. signals transmitted within a homogeneous earth conductor results in a slightly better comparison with theoretical curves. Tabulated data given to evaluate the induced polarization in resistivity measurements in two-layered earth show that the only time polarization effects contribute to depth indications in addition to those given by resistivity measurements is when the ratio of resistivities is much different from the ratio of polarization constants for the two layers.—*G. D. B.*

173–151. Hanzlík, Jiří. Kombinované nesymetrické profilování [Combined asymmetrical profiling]: Czechoslovakia Ústřední ústav geol. Věstník, v. 30, no. 1, p. 1–16, 1955.

The method of asymmetrical electrical profiling described in Soviet publications has been modified for use with less sensitive instruments and with less manpower. Two current electrodes are used, one permanently fixed at infinity and two movable potential electrodes. The second current electrode is movable and is placed in line with the potential electrodes to either side or between them in various relationships to the fault under study. Hanzlík gives the theoretical basis of the method and constructs interpretation curves for the different electrode configurations. As a practical example an evaluation is given of the Cretaceous Litoměřic fault in central Bohemia. This method has been used for a number of studies in Czechoslovakia with good results. However, it is not precise enough for studies of complex faults, and further developments with better equipment are planned.—*F. C. K.*

173–152. Kruszewski, Zdisław. Sondowania potencjalne [Potential sounding]: Przegląd Geol., v. 5, no. 2, p. 74–83, 1957.

A discussion of the method of potential sounding using direct and alternating currents. Different positions of the energizing and measuring electrodes are considered and formulas are derived for the apparent resistivity of various layers and for their depth. The procedure is economical because the energizing electrodes remain fixed during the measurements. Greater depth can be attained by this method than by resistivity methods. Numerous graphs illustrate the results.—*S. T. V.*

173–153. Iwatsu, Jun, and Otsuki, Yukio. Revised standard resistivity curves of K. Sundberg for electrical resistivity method: Osaka City Univ. Inst. Polytechnics Jour., ser. G, v. 1, no. 1, p. 67–71, 1954.

The log-log standard curve sheets usually used in Japan for analysis of resistivity data in the case of the 4-electrode process on horizontal strata were found to lead to serious error in a resistivity survey at Saheki City; a mud shown to be 15 to 20 m deep by the survey was actually encountered at about 10 m. The standard curves published by Watanabe, therefore, were extrapolated and accurate values computed directly from the original formula for the depth range in question. As the curve thus obtained was found to be quite different from the current standard curve, the ordinates have been recomputed directly from the original formula, and the results presented in tables.—*D. B. V.*

173–154. Francaviglia, Antonino. Sulle misure di resistività del suolo applicate alle ricerca di sacche di bauxite [Resistivity measurements of the ground in prospecting for bauxite lenses]: Industria Mineraria, v. 5, no. 10, p. 609–612, 1954.

A description of a resistivity survey of bauxite lenses in limestone in Italy. Although the contrast in resistivity between bauxite and limestone as measured in the laboratory is sufficiently high to expect good results, the measurements were made in July when the difference in saturation of the two types of rock would be greatest. The resistivity of the bauxite, measured in place in a quarry, was found to be 180 ohm-m. Measurements in place on the limestone in a zone known to be barren showed two layers, the upper having a resistivity of 2,500 ohm-m, the lower of about 5,100 ohm-m. Vertical resistivity profiles were then made on an outcropping body of bauxite, on a quarry where part of the bauxite was covered by limestone, and on a known underground lens, using different electrode set-ups. The results are described; they show that the resistivity method can be used to delineate bauxite bodies of this type.—*D. B. V.*

173–155. Mosetti, Ferruccio. Misure geoelettriche per la ricerca di taluni minerali cristallini [Geoelectric measurements in prospecting for certain crystalline minerals]: Industria Mineraria, v. 5, no. 12, p. 719–724, 1954.

Resistivity surveys in an alabaster quarry and a fluorite mine are described as examples of electrical exploration for crystalline minerals. The chief difficulties in such surveys are apt to be insufficient contrast in resistivity between the deposits and surrounding formations and topographic irregularities preventing sufficiently great electrode spacing. The difference between resistivity measured in the laboratory and of the same formation in place, impregnated with ground water, must also be taken into account. The use of four electrodes, as in the Wenner arrangement but with the position of the measuring electrodes varying from one end to another, gives better results. Several graphs obtained with such a set-up are given.—*S. T. V.*

173–156. Ogil'vi, A. A. Geoelektricheskiye metody izucheniya karsta [Geoelectrical methods of studying karst]: Moscow, Izdatel'stvo Moskov. Univ. [Moscow University Press], 161 p., 1957.

The study of karst phenomena is important in the U. S. S. R. where carbonate formations, either at the surface or buried, underlie about 40 percent of the

territory and occur in all structural units from ancient platforms to young geosynclines. Different chapters of this monograph on the application of electrical methods to the study of karsts deal with a review of contemporary methods of studying karsts; the application of electrical methods in general; the electrical study of superficially buried karst formations and of underground karst formations and fissures; the study of caverns by radiowave surveys (ondometry); the application of electrical methods to hydrological questions with a choice of methods in different cases; and as practical examples, the electrical study of the origin of large springs such as the Greminskiy spring. A discussion of the problems encountered by geophysicists and engineers in the southwestern Ufa district at the southern tip of the Urals is also included.—*S. T. V., D. B. V.*

173–157. Deshpande, B. G., and Sen Gupta, S. N. Geology of ground water in the Deccan traps and the application of geophysical methods: Geol. Survey India Bull., ser. B, no. 8, 27 p., 1956.

Experimental resistivity surveys were made of selected areas in the Deccan traps of India to locate weathered zones which form the principal source of ground water and to determine their extent in depth. The electrical data was often difficult to interpret because of wide variations in resistivity values of the traps and their derivatives and the uneven character of the weathering. The data are useful when considered in the light of known geological features and can assist in estimating the degree and extent of weathering, and, thus, of ground water possibilities.—*V. S. N.*

173–158. Paucă, Mircea M. Appareil de mesure du rapport $\Delta V/I$ pour la détermination de la résistivité apparente en courant continu [Apparatus for measuring the $\Delta V/I$ ratio for the determination of apparent resistivity in direct current]: Geofisica Pura e Appl., v. 39, p. 102–108, 1958.

An apparatus is described, allowing the direct measurement of the $\Delta V/I$ ratio of the apparent resistivity formula. It supersedes the galvanic compensatory element of the potentiometer for measuring the potential difference ΔV. Instead of a constant tension, the apparatus furnishes a tension proportional to the current I. The necessary conditions for the linearity and stability of the apparatus are described. The description of the apparatus is followed by a presentation of the results obtained by its means.—*Author's summary*

ELECTRICAL LOGGING

173–159. Kozurin, A. K., and Babenkov, V. Ye. Kazhushchiyesya i istinnye soprotivleniya porod rudnykh mestorozhdeniy po dannym karotazha [The apparent and true resistivity of rocks in ore deposits from logging data]: Razvedka i okhrana nedr, no. 3, p. 27–36, 1958.

The apparent (ρ_a) and true (ρ) resistivity of different rocks were determined in drill holes, using the laterlog procedure. The ore-bearing rocks studied included various schists and porphyrites with their deeper portions often consisting of quartz porphyry. If the zones traversed by the drill hole contained more than ten percent of porphyrite the resistivity was lowered, whereas the quartz porphyry showed higher resistivity. Either of these zones was clearly recognizable on the ρ_k curve and the analysis of this curve alone can give

important information on the lithologic section of cover sediments. The procedure used is discussed and illustrated by a number of profiles. There are also numerous data on the resistivity of different formations. These data refer to whole sections of formations and rocks in place, which are nearer to reality than laboratory specimens. Many of the data differ from values obtained in the laboratory by as much as 50 percent.—*S. T. V.*

173–160. Davis, C. R. Water resistivity determination in the Denver Basin: Canadian Oil and Gas Industries, v. 11, no. 3, p. 42–47, 1958.

Determination of formation water resistivity from self-potential log is hampered in the Denver Basin by clay-bonded sands, thin productive beds, fresh but not uniform formation waters, salts other than sodium chloride, and high pressure differentials across formation faces. Two recent quantitative methods, the Hill–Milburn and the Gondouin (Schlumberger), that account for the effects of clay and dissolved salts other than sodium chloride are discussed and an attempt is made to use the proposed relationship in log calculation using directly measured water resistivity values as a comparison.—*V. S. N.*

173–161. Ritchie, Ian. Logging program southern Manitoba Mississippian fields: Canadian Oil and Gas Industries, v. 11, no. 3, p. 55–59, 1958.

A logging technique has been developed for the southwest Manitoba area which permits analysis for porosity and water saturation of beds down to one foot in thickness. Mud resistivity is controlled to a value such [as] that [of] $R_{xo}=R_t$ for reservoir intervals which are marginally productive. Comparison of Laterlog-3 and MicroLaterlog readings for bed indicated by a gamma log to be non-argillaceous permits rapid and easy determination of optimum completion intervals.—*Author's summary*

ELECTRICAL PROPERTIES

173–162. Minaw, Faris. Penetration of electric waves into desert rocks: Geofisica Pura e Appl., v. 39, p. 55–64, *1958*.

The penetration of electromagnetic waves into rocks in arid regions has been investigated theoretically and experimentally. It is found that in the frequency range of 100 kilocycles per sec to 1 megacycle per sec, penetration increases as frequency decreases, resistivity of the rock increases, and as relative humidity of the rock decreases. These relationships are shown graphically for 14 different rocks including sedimentary, igneous, and metamorphic types.—*D. B. V.*

173–163. Fritsch, Volker. Geoelektrische Messungen an Zementmörtel und Beton [Geoelectrical measurements on cement mortar and concrete]: Geofisica Pura e Appl., v. 39, p. 152–158, 1958.

Investigation of the electrical properties of concrete and mortar shows that the specific resistivity depends on the water and cement content and on the nature of the sand, and it changes considerably in the course of time. Geoelectrical control of grouting of a dam is discussed; the cement injections can be recognized clearly by the decrease in specific resistivity of the dam.—*D. B. V.*

EXPLORATION SUMMARIES AND STATISTICS

173–164. Dunlap, Henry F., and Johnson, Curtis H. Research and progress in exploration: Geophysics, v. 23, no. 2, p. 267–284, 1958.

This is a general review of new developments in geophysical exploration in 1957. In the Eastern Hemisphere, the strong emphasis on the use of refined seismograph techniques in virgin territories despite extreme operating problems is a development of primary importance. In mining geophysics a new Swedish development employs a rotary electromagnetic field and two-plane operation to improve substantially the economy and effectiveness of reconnaissance for conductive ore-bodies.

In the United States new developments include work on a method of seismic exploration using continuous waves rather than pulses, the incorporation of transistors into seismic units, a trend toward simplified equipment for plotting seismic record sections, an electrical prospecting method which permits detection of near surface structures in water-covered areas, and the increased use of continuous velocity logs. Other developments have occurred in the field of chemical logging, including the use of mass spectrometers, infrared analyzers, and gas chromatographic columns. Academic research into techniques for dating feldspar-bearing rocks has advanced spectacularly. It is now possible to obtain dates on certain kinds of rocks extending from a few thousand years to a few billion years in age.—*Authors' abstract*

173–165. Smellie, D. W. Exploration geophysics: Canadian Mining Jour., v. 79, no. 2, pt. 5, sec. A, p. 160–161, 1958.

A description of advances made during 1957 on instruments for airborne, ground, and subsurface methods of geophysical exploration.—*V. S. N.*

173–166. Evrard, Pierre. Les recherches géophysiques dans la cuve congolaise [Geophysical exploration in the Congo basin]: Inst. Royal Colonial Belge Bull., v. 25, pt. 2, p. 919–932, 1954.

An outline of the geophysical program adopted as part of the survey of the geology and mineral deposits of the Congo basin in the Belgian Congo. The seismic refraction method was judged most suitable for the region concerned, with supplementary gravity and ground magnetic surveys along most of the accessible routes. The survey began in the Ponthierville area and progressed westward into unknown territory. The results (not yet available) of the first campaign justified an extension of the geophysical work to other parts of the basin; a second survey is in progress.—*B. T. E., D. B. V.*

173–167. Abadie, J. Résultats sommaires d'études géophysiques entreprises au Tchad. Application des diverses méthodes aux recherches d'eau [Summary results of geophysical studies undertaken in Tchad. Application of different methods to exploration for water]: French Equatorial Africa Direction des Mines et Géologie Bull., no. 8, p. 134–141, 1957.

Several geophysical surveys were made between 1952 and 1956 in Tchad, French Equatorial Africa, in connection with ground water exploration. Depth to the basement was determined gravimetrically, the nature of the sediments investigated electrically. The gravity surveys showed a sedimentary basin in the Doba region, more complex structure to the north. Electrical surveys were

made in the vicinity of Haraze, Djedda Sountaye, and south of Haddad to help select drilling sites, and in Ouaddai to determine more exact profiles of shallow alluvial valleys. Results were satisfactory except in the last survey, where there was too little contrast in resistivities of the formations involved.—*D. B. V.*

173–168. Kuznetsova, N. P., and Karzarinov, V. P. Geofizicheskiye metody razvedki v poznanii regional'nogo geologicheskogo stroyeniya Zapadno-Sibirskoy nizmennosti [Geophysical methods of exploration in the determination of the regional geologic structure of the West Siberian lowland]: Geologiya Nefti, no. 4, p. 11–16, 1958.

Geophysical methods have played a very important role in geological exploration of the West Siberian lowland, a deep depression in Precambrian and Paleozoic formations filled with Mesozoic and Cenozoic sediments. The lowland extends from the Urals to the Yenisey River, from the Altay Mountains to the Arctic Sea. The northern part is covered with vast areas of tundra, and outcrops of the older formations are almost completely lacking everywhere. Gravimetric and magnetic methods were used first. The airplane was used not only for airborne magnetic surveys but as a means of transportation between stations in almost inaccessible swamps or forested areas. Helicopters have been tried out recently in magnetic, gamma-ray, and even gravimetric surveying. Electrical surveys included vertical profiling, dipole profiling, and telluric current surveys. Seismic methods were very important, and exploratory drilling was extremely useful. On many occasions several methods were used in combination. As a result of these combined efforts the geologic mapping of the entire West Siberian lowland has been completed on a scale of 1:1,000,000. The maps on a scale of 1:200,000 will be finished in two or three years. This should answer many questions on the structure of the area and on probable location of petroleum deposits.—*S. T. V.*

173–169. Bennett, Roy F. Exploration geophysics—1957: Geophysics, v. 23, no. 2, p. 193–197, 1958.

Text of the presidential address before the 27th annual meeting of the Society of Exploration Geophysicists in 1957, reviewing the role of geophysics in petroleum exploration in the United States in 1957.—*D. B. V.*

173–170. Sans Huelin, Guillermo. Prospección del petróleo por métodos geofísicos en los Estados Unidos [Petroleum prospecting by geophysical methods in the United States]: Rev. Geofísica, v. 15, no. 59, p. 365–367, 1956.

A Spanish summary of the presidential address by Paul L. Lyons before the Society of Exploration Geophysicists in Denver 1955. The original was published in Geophysics, v. 21, no. 1, p. 1–15, 1956.—*D. B. V.*

GENERAL

173–171. Ertel, Hans. Ein Theorem über die Feldstärke in Potentialfeldern [A theorem concerning the field strength in potential fields]: Deutsch. Akad. Wiss. Berlin Sitzungsber. Kl. math. naturw., no. 2, 10 p., 1954.

At a point P (x_1, x_2, x_3) in a potential field, three curves intersect and are orthogonal to one another. Two of these are the "main normal sections" of the

equipotential surfaces ϕ=constant, running through P and having radii of curvature R_1 and R_2 respectively, and the third is the line of force through P having radius of curvature R_3. A simple formula is derived for the variation of field strength F relative to these radii of curvature: $\Delta F/F=1/R_1^2+1/R_2^2+1/R_3^2$.—*D. B. V.*

173–172. Manfredini, Antonio. La geofisica ed i problemi di ingegneria civile [Geophysics and civil engineering problems]: Geotecnica, v. 2, no. 2, p. 45–64, 1955.

The author describes the geophysical prospecting methods which can be used in the field of civil engineering, especially in the study of foundations, impermeability of artificial lakes, and design of tunnels. The best geophysical methods for the solution of such problems are mainly electrical depth profiling and seismic reflection profiling.—*Author's summary, D. B. V.*

173–173. Ediger, N. M. Formation evaluation trends in western Canada: Canadian Oil and Gas Industries, v. 11, no. 3, p. 39–42, 1958.

This is a general discussion of the trends in development of tools for making a quantitative appraisal of the stratigraphic section penetrated by a drill bit. An excellent history of various logging techniques in tabular form and a list of electrical logging symbols are included.—*V. S. N.*

173–174. Rusanov, B. S. Razvitiye aerometodov geologicheskogo kartirovaniya v SSSR [The development in USSR of airborne methods in geologic mapping]: Sovetskaya Geologiya, no. 61, p. 121–129, 1958.

This is a brief review of the development in the U. S. S. R., of the application of aviation to geophysical and geological exploration. The first aerophotographic procedures for this purpose were used in 1924. Later the development of airborne methods was closely related to the progress of aviation and of photogrammetry. The information obtained by color-photography and infrared photography from the air is of interest in the search for radioactive veins and for outcrops of other minerals. Great progress is in store for airborne surveying with helicopters. Much better results can be achieved with much less time and effort on the part of the geologist or geophysicist. The development of a small helicopter adapted for this work, as well as the development of special photogrammetric procedures, is imperative.—*S. T. V.*

GEODESY

173–175. Lozano Calvo, Luis. Interpretación geofísica de las reducciones ortométrica y dinámica [Geophysical interpretation of orthometric and dynamic reductions]: Rev. Geofísica, v. 13, no. 50, p. 143–154, 1954.

Geodesists define altitude orthometrically as the vertical distance (in meters) of a point on the earth's surface above the geoid. Physicists, however, define altitude in terms of equipotential surfaces of gravity; the difference in altitude Δk between two points (one on the geoid and the other at altitude Δz above it) is given in units of energy (joules) by the formula $\Delta k=-g_o\Delta z$ ("energetic altitude difference") where g_o is gravity at the geoid, and in metric units as $-\Delta k/g_n=\Delta z+(\Delta g/g_n)\ \Delta z$ ("dynamic altitude difference") where g_n=gravity at an arbitrary point on the geoid and $\Delta g=g_o-g_n$. In view of the decision of

the International Union of Geodesy and Geophysics to study the two concepts, a critical analysis is presented of their general lines and the relationships that can be established between them. The "energetic" altitude (T) of a point can be converted to its metric value (X) by the formula $X=(\sqrt{g^2+aT}-g)/a$ where g=gravity at that point, g and T are measurable, and a is a constant derived from combined Faye and Bouguer reductions. It is suggested finally that as energetic altitudes are unequivocal, they might be used for closing of polygons, compensation of networks, and international tie-ins, but metric altitudes converted from the energetic would be published for general use.—*S. T. V., D. B. V.*

Lozano Calvo, Luis. Precision in calculations of gravity potentials. See Geophys. Abs. 173–192.

173–176. Hradilek, Ludvík. Bestimmung der relativen Lotabweichungen und des [sic!] Refraktionskoeffizienten beim Ausgleich trigonometrisch-gemessener Höhennetze [Determination of the relative deflection of the vertical and of the refraction coefficient by adjusting of trigonometrically measured altitude networks]: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 2, p. 101–121, 1958.

A method of adjustment of trigonometrically measured altitude nets is developed in which the measured angles are adjusted directly, all possible dependent conditions enter in, and at each point on the net the deflection of the vertical and changes in the refraction coefficient are taken into account.—*D. B. V.*

173–177. Burša, Milan. Bestimmung der absoluten Lotabweichung aus gravimetrischen und astronomisch-geodätischen Grössen [Determination of the absolute deflections of the vertical from gravimetric and astronomic-geodetic values]: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 2, p. 122–132, 1958.

The combintion of astronomic-geodetic and gravimetric data worked out by Molodenskiy is applied to the determination of the absolute deflection of the vertical at any arbitrary point M whose astronomical coordinates have not been determined. The solution is possible if at least three astronomical points lie in the astronomic-geodetic net outside point M, and if the elements of the orientation of the reference ellipsoid and normal spheroid with respect to one another are known for at least one point. From the standpoint of accuracy it is desirable that the astronomical points used in the solution be evenly distributed in the region σ and that their number be larger than the number of independent parameters of each of the interpolation functions f_1 and f_2. With an excess of astronomical points the parameters of the interpolation functions can be determined by means of least squares adjustment and at the same time the accuracy of the deviation of the components $\xi_{\Sigma'}$ (M) and $\mu_{\Sigma'}$ (M) can be estimated. With sufficiently dense astronomical points in the net the dimensions of the region σ can be chosen so that the value of the integration radius R simplifies the calculation of the ξ_{Σ} and μ_{Σ} components at point M and at the astronomic points used. The gravity field can be regarded as plane and a simplified Vening Meinesz formula for a plane is used.—*D. B. V.*

173–178. Pick, Miloš, and Kožíšková, Milada. Příspěvek k určování tvaru geoidu [Contribution to the determination of the form of the geoid (with German and Russian summaries)]: Československá Akad. Věd Geofys. Ústav Práce, Geofys. Sbórník, no. 20, p. 15–18, 1955 (1956).

In this work the effect of the choice of formula for normal gravity on the values of deflection of the vertical and on the height of the geoid above the ellipsoid is investigated, and it is shown that this effect is significant. Equations are derived for the change in deflection of the vertical in the meridian and for the height of the geoid above the ellipsoid. The changes in these parameters for conversion from Helmert's formula to Cassinis' formula are calculated numerically for geographic latitude $\phi_0=50°$. For this case we obtain $\Delta\zeta''=-2.7''$, $\Delta N=+20.1$ m. This result is confirmed by graphical integration.—*Authors' German summary, D. B. V.*

Jones, L. Symposium on recent movements of the ground in Belgium and the information they convey. 1—The synthesis of the results of geodetic measurements (Levelling and gravimetry). See Geophys. Abs. 173–205.

173–179. Pick, Miloš. Vorläufige Karte des Geoids auf dem Gebiet der tschechoslowakischen Republik [Preliminary map of the geoid in the territory of the Czechoslovakian Republic (with Czech and Russian summaries)]: Československá Akad. Věd Geofys. Ústav Práce, Geofys. Sborník, no. 15, 13 p., 1954.

Five maps of Czechoslovakia are presented showing deflections from the vertical with respect to meridians and to parallels, mean errors in individual altitude differences, height of the geoid at node points, and finally the contours of the geoid. Mean errors in calculation of deflection of the vertical are $m_\phi=\pm0.02''$, $m_\lambda=\pm0.03''$. It can be shown that this preliminary geoid map adequately suits the requirements of geodetic practice. Conversion from the preliminary geodetic coordinates to the final coordinates will not alter the geoid surface as a whole. The greatest inaccuracy in the derived heights of the geoid above the ellipsoid is due to errors in astronomical measurements, but even considering such sources of error the accuracy of the derived surfaces is within ±3 m. Working up of recent astronomical measurements and supplementing the astronomical-geodetic material with gravity measurements will make possible more accurate calculation of the geoid; such work is in progress.—*D. B. V.*

173–180. Kääriäninen, Erkki. On the use of different adjustment methods for the determination of land uplift from precise levellings: Finn. Geod. Inst. Veröffentl., no. 46, p. 89–94, 1955.

In computing the rate of land uplift by comparison of precise levellings executed at different times, the common adjustment of the networks is a more natural and easier method if the networks are identical. If the networks are not identical, as in the case of Finland, and if other usable levellings exist outside the part they have in common, the networks can be treated as a whole without any practical difficulties by using the approximation method. Thus, by using more extensive observation material a more reliable result is reached. Both methods are outlined.—*D. B. V.*

173–181. Regöczi, E. Les travaux géodésiques en Hongrie. Rapport établi à l'occasion de l'assemblée générale de l'Union Géodésique et Géophysique Internationale à Toronto, 1957 [Geodetic work in Hungary. Report prepared for the occasion of the general assembly of the International Geodetic and Geophysical Union at Toronto, 1957]: Acta Tech. Acad. Sci. Hungaricae, v. 18, no. 1–2, p. 103–115, 1957.

An outline of recent geodetic work in Hungary, including the establishment of a new triangulation network; a new precise levelling survey, made in 1950 to 1956 and tied in with the nets of Czechoslovakia and Poland; astronomical observations of position. New measurements of the deflection of the vertical, based on the new triangulation network and astronomical determinations, are in progress with the object of preparing a map of the geoid in Hungary.—*D. B. V.*

GEOTECTONICS

173–182. Tamrazyan, G. P. Geotektonicheskaya gipoteza [Geotectonic hypothesis]: Akad. Nauk Azerbaydzhan SSR Izv., no. 12, p. 85–115, 1957.

In accordance with the cosmo-geotectonic hypothesis previously developed by Tamrazyan, the geologic history of our planet is the result not only of its internal development as a separate celestial body but has been strongly influenced by the external cosmic conditions prevailing in the solar system and in the galaxy. The fact that the plane of revolution of the solar system and the plane of the galaxy are inclined to each other has been of great importance in the earth's evolution. A very important cosmic factor is the periodic crossing of the galactic plane by the earth every 200–220 million years. In this position the earth is acted on by a much stronger gravitational field; this affects its shape and internal structure. Therefore, it is concluded that the interval of time between two epochs of intensified tectonic evolution of the sialic shell must be approximately equal to this interval. The crossing of the plane of the galaxy by the solar system probably has occurred six times; this fact must be reflected in the history of the earth. Tamrazyan emphasizes his opposition to the theory officially approved in the Soviet Union, that the earth was found by direct agglomeration of meteoritic and other particles in cold state, thus avoiding the molten phase. Mathematical proof of these cosmic processes is impossible because of lack of knowledge of many constants entering into the equations. Any theory concerning these processes must be demonstrated by its ability to explain and logically coordinate the multitude of known facts and features established by astronomy, geology, and seismology. According to this principle Tamrazyan considers his cosmo-geotectonic hypothesis to be the most plausible.—*S. T. V.*

173–183. Egyed, László. A földkéreg egyensúlya [The equilibrium of the earth's crust (with English and Russian summaries)]: Földtani Közlöny, v. 85, no. 1, p. 44–69, 1955.

An attempt at a comprehensive explanation of crustal equilibrium; isostasy alone is not deemed adequate to explain all the facts. Vening Meinesz' buckling hypothesis is dismissed as false. A hypothesis is offered for the formation of deep sea troughs and related phenomena that involves the interaction of tectonic, elastic, and isostatic forces and is in good agreement with the physical and geological evidence both qualitatively and quantitatively. The

same explanation is extended to the Alps and mountain building in general and to the African rift valleys. The "hidden range" hypothesis of the structure of India is shown to be untenable; instead, the crustal deformation there is explained by admitting tectonic forces and elasticity in addition to buoyancy of the magma. Finally the uplift of Fennoscandia is considered; the rapid rate of uplift becomes intelligible if elastic energy of the crust bent under the weight of ice is added to isostatic forces. Geodetic and seismic evidence corroborate the hypothesis in this and the other regions cited.—*D. B. V.*

173–184. Hess, H. H. The oceanic crust: Jour. Marine Research, v. 14, no. 4, p. 423–439, 1955.

An outline of present knowledge of the oceanic crust obtained from seismic, gravity, and petrological investigations. Analysis of the gravity and seismic data leads to the conclusion that the trenches are far out of isostatic equilibrium; considering their large horizontal area, some force must be acting to keep them out of balance, such as a compressive force acting tangentially. The evolution of an island arc into an alpine mountain system is outlined. The first two stages may be illustrated by the Tonga Trench and the Barbados Ridge. Then, where an island-arc type of deformation impinges on the edge of a continent the thin sialic crust may be downbulged in the manner postulated by Vening Meinesz for the negative anomaly strip of island arcs; the Alpine-Himalaya chain probably began along a mediterranean of oceanic character and transgressed in places on the border of a continent. The apparent termination of some continental mountain systems abruptly at the sea may mean that their extensions are inconspicuous and perhaps covered by sediment. Island arc-alpine deformation rarely occurs within continents proper which have the normal thickness of sialic crust.—*B. T. E., D. B. V.*

Beloussov (Belousov), V. V. The internal structure and the evolution of the earth in the light of geotectonic data. See Geophys. Abs. 173–235.

Hsee, K. Jinghwa. Isostasy and a theory for the origin of geosynclines. See Geophys. Abs. 173–257.

173–185. Fourmarier, P[aul]. Symposium sur les mouvements récents du sol belge et les enseignements qu'ils apportent. 4.—Conclusions géologiques et géographiques [Symposium on recent movements of the ground in Belgium and the information they convey. 4.—Geologic and geographic conclusions]: Cong. nat. Sci., (Belgium) 3d, Brussels, v. 4, p. 35–38, 1950 (1954).

Comparison of old and new precise levellings in Belgium shows that there has been systematic deformation, with uplift in the southern and eastern part of the country and subsidence (with the exception of limited zones) in the north and northwest. These recent movements are the resumption or continuation of earlier large-scale deformation. There is a broad correlation between gravity anomalies and the recent movements; Bouguer anomalies are predominantly positive in the north, negative in the south, east, and northwest. The distribution of seismic areas (see Geophys. Abs. 173–21) and magnetic anomalies (see Geophys Abs. 173–310) suggests that deep geologic conditions have played an essential role in governing the recent deformation. The fact that earthquakes in the Haine valley are much shallower than those of Flanders and Limbourg is difficult to explain at the moment.—*D. B. V.*

173–186. Kääräinen, Erkki. On the recent uplift of the earth's crust in Finland: Finn. Geod. Inst. Veröffentl., no. 42, 106 p., 1953.

Land uplift in Finland is determined from a detailed study of precise levelling and tide gage data. Lines common to the First Precise Levelling of 1892–1910 and the Second Precise Levelling initiated in 1935 are available for a total length of 3,716 km. The relative uplift between different places is determined from the differences between the old and new levels; the principles and procedure of the calculations are described in some detail. Absolute values can then be calculated, using tide gage data on the Finnish coast. The results are presented in the form of a map of isobases for southern and central Finland, with their broad outlines for northern Finland, and also in the form of tables of bench marks. The present rate of uplift is found to be 2.9 mm per year in the Helsinki-Utti region, 5.0 mm in the Turku-Kalvola-Pieksamaki region, 6.0 mm in the Eura-Vilppula region, and 7.4 mm in the Lauhavuori-Alavus region. Rate of tilting between the northwestern and southeastern parts of the area studied is approximately one inch in 300 years. Comparison with the raised beaches shows that uplift has been more retarded in the center of the affected mass. No striking correlation can be noted between the isobases and the latest gravity chart (free air anomalies) except in the vicinity of the Gulf of Bothnia. The various possible causes of uplift are reviewed; of the several explanations offered, the theory of glacial isotasy best fits the observed facts.—*D. B. V.*

173–187. Bonchkovskiy, V. F. Nekotoryye osobennosti periodicheskikh izmeneniy naklonov zemnoy poverkhnosti [Some features of the periodical changes of the inclination of the earth's surface]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 135–138, 1957.

The results are presented of the observation made in Pulkovo (near Leningrad), Yalta (Crimea), Garm and Stalinabad (Russia-Central Asia) on the slow periodic movements of inclinometers. The sensitivity of these pendulums was 0.1″ per 1 mm displacement of the point of light on the photographic film. All stations showed a daily variation having an amplitude less than 0.1″, and an elliptical vector diagram with its long axis changing from month to month. This axis rotates counterclockwise from December to June and clockwise from June to December. The greatest change in inclination occurs near midday and midnight, the smallest variation near the time when the observation point crosses the boundary between the day and night hemispheres. This phenomenon is explained in the following manner: owing to the rotation of the earth, half of its surface is illuminated and consequently heated and undergoing expansion, whereas the opposite side is cooled and contracts. This simultaneous expansion and contraction of opposite sides produces a deformation of the terrestrial surface so that every point undergoes horizontal and vertical displacements with a period of 24 hours. It has been determined experimentally that the amplitude of the daily displacement of two points, one meter apart was about 3.0μ. It is also probable that the change of the temperature of the northern and southern hemispheres from summer to winter produces similar deformation of the earth's surface.—*S. T. V.*

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173–188. Wilt, James W. Measured movement along the surface trace of an active thrust fault in the Buena Vista Hills, Kern County, California: Seismol. Soc. America Bull., v. 48, no. 2, p. 169–176, 1958.

Data obtained from measurements made over the past 24 years are presented, showing the rate and accumulated ground movement normal to the strike of an active thrust fault in the Buena Vista Hills oil field in California. Maximum accumulated movement between four pairs of control points has been 1.637 feet, corresponding to an average rate of 0.068 feet per year.—*D. B. V.*

GLACIERS

173–189. Jacobs, J. A. Geophysical determinations of thickness of glaciers: Canadian Mining Jour., v. 78, no. 4 ,p. 136–138, 1957.

Extensive seismic and gravity surveys were made of the Salmon and Leduc glaciers near the coast of British Columbia, lying between the retreating Juneau ice fields to the north and the advancing Cascade and Olympic ice fields to the south. Preliminary seismic results indicate that in general the depth of the ice is about half the width of the glacier, amounting to 2,000–2,400 feet. Results of the gravity surveys are not yet available. A second expedition is planned to measure precisely recent changes in volume of the glaciers.—*V. S. N.*

173–190. Glen, J. W. Measurement of the slip of a glacier past its side wall: Jour. Glaciology, v. 3, no. 23, p. 188–193, 1958.

Measurements of velocity of flow of the Austerdalsbre glacier in southern Norway were made in two places along the ice margins where there was no morainal debris between clear ice and the unfragmented rock sides. The velocity at the two sites was found to be of the same magnitude as that in the center of the glacier; although conditions are different at depth, this high rate of slip suggests similar rapid flow next to the rock face at depth and is in accord with ideas of flow of ice below ice falls.—*V. S. N.*

173–191. Weinman, James A. Ice shelf oscillations: Jour. Glaciology, v. 3, no. 23, p. 187, 1958.

Vertical oscillations of the Filchner Ice Shelf in the Antarctic introduced uncertainties into gravity measurements of approximately 0.5 mgal. A gravity survey to map these displacements could be used to study the structure of the shelf and to predict anchor points such as islands under the shelf or sites where calving would take place.—*V. S. N.*

GRAVITY

173–192. Lozano Calvo, Luis. La precisíon en los cálculos de los potenciales de gravedad [Precision in calculations of gravity potentials]: Rev. Geofísica, v. 14, no. 54, p. 91–100, 1955.

Formulas are given for calculating errors in determination of the gravity potential in precise levelling surveys. Sources of error are threefold. The first, a measurement error, cannot be reduced by calculation. The second depends on the precision of the gravity map used and on the sum of the absolute values of altitude differences; it reaches its minimum if gravity is measured directly in the field rather than deduced from a map. The third depends on the horizontal gradient of gravity and the slope, which cannot be controlled,

and on the spacing of gravity readings; it is at a minimum if gravity is determined for every segment in a traverse. The optimum number of segments into which a traverse should be divided is shown to depend on the distance between its center point and the point at which the gravity reading is made, in proportion to the total length of the traverse.—*D. B. V.*

Lozano Calvo, Luis. Geophysical interpretation of orthometric and dynamic reductions. See Geophys. Abs. 173–175.

173–193. Boaga, Giovanni. Sulla compenzazione rigorosa delle reti gravimetriche [On the precise adjustment of gravimetric networks]: Boll. Geodesia e Sci. aff., v. 14, no. 1, p. 17–26, 1955.

Criteria are discussed mathematically for rapid and accurate compensation of gravity nets over broad areas; for standardization of procedure, stations must be selected according to a predetermined scheme of planimetric distribution.—*D. B. V.*

173–194. Bott, M[artin] H[arold] P[hillips], and Smith, R. A. The estimation of the limiting depth of gravitating bodies: Geophys. Prosp., v. 6, no. 1, p. 1–10, 1958.

A variety of formulas have been obtained which permit the rapid estimation from the gravity anomaly of maximum possible depth to the top of a body of anomalous density. The estimates are based on easily obtainable numerical characteristics of the anomaly. Both two-dimensional and three-dimensional density distribtuion can be treated. The formulas apply only to bodies whose density is entirely positive or entirely negative, relative to the surrounding material, but no other restriction need be placed on the magnitude or variation of the density or on the shape of the body.—*D. R. M.*

173–195. Vyskočil, Vincenc. The gravitational effect of a two-dimensional body for a change in density with depth: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 1, p. 31–39, 1958.

The gravity effect of some two-dimensional bodies (inclined step, vertical step, prism) whose density is a function of depth are derived. The dependence of density on depth is expressed by any power series; in other words, fairly generally. From this point of view, this paper is a contribution to the generalization of the theory of quantitative interpretation of gravity anomalies. From the examples given, it is clear that in a majority of cases in practice the effective density of a body can be considered, instead of the variable density with depth, without committing any great errors.—*D. B. V.*

173–196. Coloma Pérez, Antonio. Sobre la gravimétria cortical no uniforme: Aplicaciones [On non-uniform crustal gravimetry: Applications]: Rev. Geofísica, v. 15, no. 58, p. 111–148, and no. 59, p. 245–299, 1956.

The gravity of a non-uniform crust is studied, assuming linear variation of density with depth. The cases of a finite annular cylinder, a semi-infinite annular cylinder, a plane plateau having radius R, and an infinite plane plateau are calculated. For the last two cases five different methods of reducing the value of gravity to the geoid are presented. The value of R for which the error is less than a given value is found algebraically. Graphic representations of the gravitational attraction and of the error can be merged into a single curve

to simplify the calculations. In appended tables, the systems of gravimetric corrections are applied to the line of levels in Italy from Florence to Bologna.—*D. B. V.*

173–197. Wittinger, Max. Tabulky normálního tíhového zrychlení pro ϕ=47° 30′ az 51°20′ (Helmert 1901, Cassinis 1930) [Tables of normal gravity values for latitude 47°30′ to 51°20′ (Helmert 1901, Cassinis 1930)]: Československá Akad. Věd Geofys. Ústav Práce, Geofys, Sborník, Supp., 97 p., 1954.

Normal gravity values for latitudes between 47°30′ and 51°20′, calculated to 0.001 mgal for each 1″ of latitude according to the Helmert and Cassinis formulas, are presented.—*D. B. V.*

Jung, Karl. Remarks on the foundation of the conception of isostasy. See Geophys. Abs. 173–258.

173–198. Innes, M. J. S. The establishment of a calibration standard for gravimeters in eastern Canada and the United States: Am. Geophys. Union Trans., v. 39, no. 2, p. 195–207, 1958.

A program of gravimeter measurements for the establishment of a suitable gravity standard in eastern Canada and United States is described. It is shown that the consistency of nine independent measurements of the gravity differences between stations forming a north-south line from Ottawa to Washington is highly satisfactory and that this line is suitable for calibration purposes. The gravity differences depend fundamentally upon a gravimeter calibration made against values of gravity at Cambridge pendulum stations in Canada.

The combined gravimeter results lead to a value of -501.44 ± 0.25 mgal for the difference in gravity between the Dominion Observatory, Ottawa, and building of the Department of Commerce in Washington. Although this determination agrees within the limits of error with recent Gulf pendulum results, it is concluded that more pendulum work is required before an absolute basis for this calibration line may be adopted.—*Author's abstract*

173–199. Cook, A[lan] H[ugh]. The calibration of gravity meters by comparison with pendulums: Royal Astron. Soc. Geophys. Jour., v. 1, no. 1, p. 18–31, 1958.

The only satisfactory way to calibrate a gravity meter for a large interval of gravity is to compare its readings with pendulum observations over the whole of the interval. The use of least squares in adjusting the observations is discussed. A general formula is obtained for the dependence of the calibration factor of the gravity meter on the relative weights assigned to the pendulum and gravity meter observations, and further expressions are derived for identical pendulum and gravity meter nets and for nets with no redundant observations. Although redundant observations tend to increase the precision of results, this can in general be accomplished more effectively by increasing the overall difference in gravity.—*H. R. J.*

173–200. Cunietti, M[ariano], and Inghilleri, G[uiseppe]. Studio sperimentale della influenza della temperatura sulla deriva dei gravimetri Worden [Experimental study of the effect of temperature on the drift of Worden gravimeters (with English summary)]: Boll. Geodesia e Sci. aff., v. 15, no. 3, p. 287–311, 1956.

The effect of changes of temperature on the drift of five Worden gravimeters has been investigated in two series of tests. In the first series the temperature was jumped from 19° C to 37° C, back to 19°, to 1.5°, and back to 19° again, over two periods of 33 days. In the second series the temperature variation was sinusoidal, with constant amplitude and 24-hour period. The results are tabulated and in part plotted graphically. Analysis establishes the effect of temperature on molecular drift, on total reading variation, and on hourly drift. It is shown that different parts of the instrument respond to temperature changes at different rates, so that the action of the more external parts is affected by external phenomena causing non-systematic irregularities in the drift curves.—*D. B. V.*

173–201. Kolbenheyer, Tibor. O niektorých vlastnostiach Nörgaardovho gravimetra [On some properties of the Nörgaard gravimeter (with German and Russian summaries)]: Československá Akad. Věd Geofys. Ústav Práce, Geofys. Sborník, no. 12, 10 p. 1954.

Some questions of the theory of the Nörgaard gravimeter are treated, giving a method which allows determination of the torsion angle of the quartz fiber and some other construction details of the instrument on the basis of coincidence readings. The formulas derived are used for theoretical treatment of the question of error in reading different coincidences. Finally a method is given for ascertaining the exact value of the micrometer constant by means of coincidence readings. The theoretical considerations are supplemented by data of practical measurements with the TNK 39 instrument.—*Author's German summary, D. B. V.*

173–202. Spiess, F. N., and Brown, G. L. Tests of a new submarine gravity meter: Am. Geophys. Union Trans., v. 39, no. 3, p. 391–396, 1958.

Comparisons of the LaCoste and Romberg submarine gravity meter with the Vening Meinesz pendulum gravity apparatus have been carried out on board USS *Tilefish* and USS *Baya*. Discrepancies between measurements made simultaneously with the two instruments show a root mean-square value of about three milligals, indicating that the gravity meter is an adequate replacement for the pendulum equipment with the added advantage of improved ease of obtaining numerical results at the conclusion of each observation.—*Authors' abstract*

173–203. Meisser, O[tto]. Ableitung der Gebrauchsformeln für ein Pendel, das an einem Bandrollgelenk mit vier Zylindern schwingt [Derivation of working formulas for a pendulum that oscillates on a support with a four-cylinder strip-linkage]: Koninkl. Nederland. Geol.–Mijnb. Genootschap Verh., geol. ser., pt. 18, p. 223–230, 1957.

The working formulas for a pendulum with suspension consisting of a four-cylinder strip-linkage are given in the form of a series expansion in the angle

of displacement from equilibrium. These calculations form the basis of broader practical application of this coupling mechanism to the replacement of the knife edge support in invariable period pendulums, tiltmeters, and balances.—*P. E. B.*

173–204. Knapman, W. H. Gravity and magnetic traverses in the far northwest of South Australia: South Australia Dept. Mines Mining Rev., no. 104, p. 89–93, 1956 (1957).

Some magnetic and gravity traverses in the area northwest of Oodnadatta were curtailed before results were sufficient to give an accurate picture of the bedrock structure and its relation to the younger beds of the Great Artesian Basin. The surveys were of limited value in determining the limits of artesian water. The results obtained, however, suggest that further work is desirable.—*V. S. N.*

173–205. Jones, L. Symposium sur les mouvements récents du sol belge et les enseignements qu'ils apportent. 1.—La synthèse des résultats de mesures géodésiques (Nivellement et gravimétrie) [Symposium on recent movements of the ground in Belgium and the information they convey. 1.—The synthesis of the results of geodetic measurements (Levelling and gravimetry)]: Cong. nat. Sci. (Belgium), 3d, Brussels, v. 4, p. 42–45, 1950 (1954).

Results of the First (1889–1892) and Second (1946–1955) Precise Levellings of Belgium are compared. Areas of uplift and subsidence are listed, giving amount of change. These results are then compared with those of gravimetric surveys, showing a general correlation between negative Bouguer anomalies and zones of uplift and between positive anomalies and zones of subsidence. Few isostatic reductions have been made, but study of those available (Airy, T=60 km) shows that there is a notable divergence between Bouguer and isostatic anomalies in the whole area south of a line through Maaseik, the center of the Démer-Gette Bouguer anomaly, Rebecq-Rognon, and Mons; this suggests that isostasy plays a part in the recent crustal movements of Belgium. It would be valuable in this connection to make a comparative study of the seven isostatic maps now being prepared (Airy for four crustal thicknesses, Pratt for three depths of compensation). See also Geophys. Abs. 173–185.—*D. B. V.*

Jacobs, J. A. Geophysical determinations of thickness of glaciers. See Geophys. Abs. 173–189.

173–206. Boddin, Hans. Das Schwerenetz der Deutschen Demokratischen Republik [The gravity net of the German Democratic Republic]: Freiberger Forschungshefte C 38 Geophysik, p. 39–47, 1957.

Geophysicists and geodesists began work in 1954 on the new uniform gravity net for East Germany; gravimeter measurements were expected to be completed in 1957, international tie-in measurements to be executed in 1958. Older measurements were to be reworked and incorporated in the net. As planned, the net consists of 62 triangles with 106 lines of measurement, contains 42 first order points with 354 second order points 10 to 20 km apart along the lines

between. Supplementary measurements in the Erzgebirge in the south will tie in with the Czechoslovakian regional gravity measurements. The Potsdam absolute gravity value is the base value. The results will be published as maps of free-air, Bouguer, and isostatic anomalies.—*D. B. V.*

173–207. Gerke, Karl. Die Karte der Bouguer-Isoanomalen 1:1,000,000 von Westdeutschland [The 1:1,000,000-scale map of Bouguer anomalies of West Germany]: München, Deutsch. Geod. Komm., 12 p., 1957; also published as Deutsch. Geod. Komm. Veröffentl., ser. B, no. 46, pt. 1, 1957, or Inst. angew. Geodäsie Mitt. no. 25.

The first edition of the map of Bouguer anomalies of Western Germany on the scale of 1:1,000,000, with explanatory text, compiled by the second division of the German Geodetic Research Institute (Abteilung II des Deutschen Geodätischen Forschungsinstitut) from gravity surveys made during 1934 to 1945 by the Office of Earth Research (Amt für Bodenforschung) and by the Seismos Company. For all field stations the Bouguer anomalies were reduced to the international gravity formula, to a uniform chart datum, and to a surface density of 2.67. The map is printed in six colors, with areas of positive anomalies tinted red, negative blue.—*D. B. V.*

Clasen, Gerhard. Determinations of the edges of salt domes with the help of gravimetric and seismic methods. See Geophys. Abs. 173–353.

173–208. Renner, J. Report on the gravitational investigations in Hungary in 1954–56: Acta Tech. Acad. Sci. Hungaricae, v. 18, no. 1–2, p. 117–122, 1957.

Gravity investigations in Hungary in 1954 to 1956 were made chiefly by the Roland Eötvös Geophysical Institute. The national gravimeter base network was completed and provisional results published. Detailed exploratory surveys were made in various parts of the country, partly with the torsion balance, partly with gravimeters; in most cases Bouguer anomalies have been computed from gravimetric surveys and in some interesting areas residual anomalies as well, or in other areas the second vertical derivatives from gradients of torsion balance surveys. The great number of gravimeter observations afforded many opportunities for studying the characteristics of these struments, and some experimental tests were made. A number of theoretical papers were published dealing with the gravity or magnetic effects of masses of different shape and position. A new model of the torsion balance was constructed. Deflections of the vertical were calculated using two methods, one based on Stokes' theorem, the other using curvature data of the niveau surface measured by the torsion balance. Theoretical studies were made on the question of a suitable correction of levelling data on the basis of gravity data. Finally, two general geophysical handbooks were published.—*D. B. V.*

173–209. Norinelli, Armando. Nuovi dati geofisici sul distretto eruttivo euganeo-berico-lessineo. Parte prima: Dati gravimetrici [New geophysical data on the Euganeo-Berico-Lessineo igneous area. Part 1: Gravimetric data (with French summary)]: Boll. Geodesia e Sci. aff., v. 14, no. 1, p. 33–89, 1955.

A gravity survey was made in 1952 and 1953 of an area of about 7,000 km^2 in northern Italy bounded by the Adige, the Po, and Venetian lagoon, and the

parallel of Bassano del Grappa, in which the Euganeo-Berico-Lessineo igneous complex occurs. Two Worden gravimeters, no. 50 and no. 11, were used; 541 stations were occupied, with a mean density of one station per 13 km², but denser in the vicinity of the Colli Euganei. Mean observational error was ±0.06 mgal. The results are presented in the form of Faye and Bouguer anomaly maps; tables give all observed data and reductions for each station.—*D. B. V.*

173–210. Salvioni, Guido, Cecioni, Enrico, and Donnini, Vittorio. Rilievo gravimetrico dell'Umbria e del Lazio settentrionale eseguito dall'-Istituto Geografico Militare nel 1954 [Gravimetric survey of Umbria and northern Lazio carried out by the Istituto Geografico Militare in 1954]: Boll. Geodesia e Sci. aff., v. 14, no. 4, p. 485–515, 1955.

The results of a gravity survey of Umbria and northern Lazio, Italy, are presented in detail. Base stations were measured by means of two Worden gravimeters, no. 91 and no. 116, detail stations with the no. 91 alone. A total of 133 stations were occupied. Tables give data for each station, including precise location, altitude, observed and normal gravity, Faye reduction and corresponding anomaly; maps show the area surveyed, the gravity net, and the Faye anomalies.—*D. B. V.*

173–211. Salvioni, Guido. Errata–corrige all'articulo "Rilievo gravimetrico della Toscana (1953) (Anomalie di Faye e di Bouguer)" [Errata—correction to the article "Gravimetric survey of Tuscany (1953) (Faye and Bouguer anomalies)"]: Boll. Geodesia e Sci. aff., v. 14, no. 1, p. 91–92, 1955.

Corrected values are given for six stations in the gravity survey of Tuscany (see Geophys. Abs. 162–26), with revised Faye and Bouguer anomalies for the area affected.—*D. B. V.*

173–212. Ballarin, Silvio. Criteri e accorgimenti nella costruzione delle tabelle per la riduzione isostatica dei valori della gravità nel sistema di Airy e nelle ipotesi locale e regionale e modalità de loro impiego [Criteria and premises in the construction of the tables for isostatic reduction of gravity values in the Airy system and in the local and regional hypotheses and their mode of use]: Boll. Geodesia e Sci. aff., v. 14, no. 4, p. 427–452, 1955.

Tables used by the Italian geodetic commission for isostatic reductions of gravity values are presented and the criteria and premises adopted for their construction are discussed. Some of the zones (*L*, *M*, *N*, O_1, and O_2) established by the International Gravity Commission were found to be too large and were further subdivided for convenience. Reductions were made according to the Airy system, and according to Heiskanen's hypothesis for local and Vening Meinesz's for regional anomalies. The reductions are expressed in units of 10^{-5} gal; an altitude (or ocean depth) interval of 100 m was chosen for the tabulations so that intermediate values not given can be found by linear interpolation. Auxiliary tables (for the last 11 zones only) permit conversion of the complete topographic-isostatic reductions from the Airy-Heiskanen system to the Pratt-Hayford system and vice versa.—*D. B. V.*

173–213. Ballarin, Silvio. Modalità tenute e procedimenti adottati nel calcolo delle riduzioni delle misure di gravità eseguite per la costruzione delle Carta gravimetrica d'Italia [Methods followed and procedures adopted in the calculation of the reductions of gravity measurements made for the construction of the gravity map of Italy]: Boll. Geodesia e Sci. aff., v. 15, no. 1, p. 21–41, 1956.

A detailed discussion of the methods and procedures used in calculating normal international gravity and the free air, modified Bouguer, and isostatic reductions of gravity measurements (the last for the Airy system and for Heiskanen's local and Vening Meinesz's regional hypothesis) used in construction of the gravity map of Italy.—*D. B. V.*

Tsuboi, Ch[uji]. Earthquake epicenters, volcanoes and gravity anomalies in and near Japan. See Geophys. Abs. 173–24.

173–214. Plassard, J[acques], and Stahl, P[ierre]. Étude gravimétrique du Liban sur l'ensemble du territoire en 1954 [Gravimetric study of Lebanon over the entire territory in 1954]: Observatoire Ksara (Lebanon) Annales, Mém., v. 2, no. 1, 46 p., 1956.

The results of the gravimetric survey of Lebanon, based on campaigns in 1952–53 and in 1954, are tabulated. The gravity network included 11 principal stations, 218 secondary stations, four "complementary" stations, and ten "auxiliary" stations, totalling 243 stations occupied. The Beirut-Médécine gravity value, g=979,692.5, was adopted. Free-air and Bouguer reductions were calculated, the latter in two ways based on actual values of density from geologic data and on an assumed value of 2.67 for the mean density of the crust. Two maps are presented, the first showing the "geologic" Bouguer anomalies, the second the "common" Bouguer anomalies; their curves are comparable although the values differ.—*D. B. V.*

173–215. Plassard, J[acques], and Stahl, P[ierre]. Compléments sur la gravimétrie au Liban [Supplements to the gravimetry of Lebanon]: Observatoire Ksara (Lebanon) Annales, Mém., v. 2, no. 3, 42 p., 1957.

In addition to some corrections and additions to the data of the preceding memoir, three supplementary maps and five profiles are presented. The first map shows the geographic location of the gravimetric stations and other information necessary for use with the profiles. The second shows the common Bouguer anomalies (d=2.67) corrected for topography; in general the anomaly increases from negative values toward the Syrian trough to positive values at the coast, with a minimum gradient in the northern part of the country, maximum along a line between Damascus and Beirut. The third map, of isostatic anomalies, shows that the territory in general is not compensated, with a minimum of +34 under the Ras-Chekka and maximum of about 90 running from near Beskinta to beyond Bcharre. The methods used for the topographic and isostatic reductions and the structure and basis of the Lebanese gravity net are described. Measurements of absolute gravity at Ksara by means of a static gravimeter in 1952–1954 give a value of 979,430.25, which is within 2 mgals of values determined earlier by means of pendulums (979,431.8 in 1923 and 979,428.3 in 1936, reduced to the principal station in Ksara).—*D. B. V.*

173–216. Lozano Calvo, Luis. Los trabajos gravimétricos del Instituto Geográfico y Catastral [The gravimetric work of the Instituto Geográfico y Catastral]: Rev. Geofísica, v. 15, no. 60, p. 435–440, 1956.

An outline of the work of the geographic and cadastral Institute in Spain during 1954 and 1955. With the acquisition of a Worden gravimeter, first and second order gravity systems were initiated, and projects were undertaken to determine the constants of the instrument.—*D. B. V.*

173–217. Lebedev, T. S. Geologicheskoye istolkovaniye gravitatsionnykh anomaliy Pripyatskoy vpadiny [A geologic interpretation of gravitational anomalies of the Pripet depression]: Sovetskaya Geologiya, no. 61, p. 101–111, 1957.

The deep geology of the Pripet basin is analyzed in the light of recent gravity surveys in southern White Russia. The results of these surveys confirm the hypothesis that the Pripet depression is a distinct structural element of the Russian Platform, bounded on the south by the Ukrainian shield, on the west by the Polesiye anticline, on the north by the White Russian-Lithuanian massif, and on the east by the Chernigov eminence. The heterogeneity of the gravitational field within the basin is attributed to differences in the internal structure of this region.—*S. T. V.*

HEAT AND HEAT FLOW

173–218. Jacobs, J. A. The thermal history of the earth with particular reference to a number of radioactive Earth models: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 155–164, 1956.

The results of solutions (presented elsewhere) of the equation of heat conduction for a radioactive earth worked out for three different models are discussed. The first is a simplified model consisting of a 20-km granite-granodiorite crust, a uniform dunite mantle, and a dense core of the composition of iron meteorites. The second consists of four 15-km crustal layers becoming increasingly basic downward, a dunite layer from 60 to 1,600 km, a pallasitic layer from 1,600 to 3,000 km, and a nickel-iron core like the first. The presence of relatively high amounts of radioactivity to a depth of 60 km in this model should give an indication of thermal conditions under the ocean. Temperature-time distribution curves for various depths in this model show that in spite of very low concentrations of radioactivity in the deep mantle and core there is still a heating up of two or three hundred degrees. Near-surface conditions appear to have been greatly different in the far past from those at present—in fact there may even have been remelting at depths of 50 to 100 km during the first billion years or so, but this brief temperature rise soon gave way to cooling. The rate of cooling for both models was greater in the past than now, suggesting that orogenic activity may have decreased with time and perhaps was caused by different processes in the far past. The present surface heat flow obtained for the first model agrees well with observed values; that for the second is higher suggesting that too much radioactivity has been included in its surface layers.

The third model is a modification of the second having two 15-km crustal layers and dunite from 30 to 1,600 km. The present surface heat flow for this model, 40 cal per cm per year, agrees well with the observed value of 38 cal per cm per year. In conclusion it is emphasized that the value of such calculations lies not so much in the particular result of any earth model as in the fact that a general solution has been set up which will give the thermal properties of a model with any desired distribution and concentration of radioactivity.—*D. B. V.*

173–219. Mullins, R., and Hinsley, F. B. Measurement of geothermal gradients in boreholes: Inst. Mining Engineers Trans., v. 117, pt. 6, p. 379–393, 1958.

A method is described for measuring temperatures of strata in exploratory boreholes in undeveloped coalfield areas in the East Midlands, England. Using a maximum-type mercury thermometer, measurements were made at the bottom of the holes during weekend breaks in drilling with a minimum of eight hours allowed between cessation of drilling and making temperature readings. Systematic observations in a drill hole allowed to stand open three months at a depth of 2,102 feet were successfully used as a check on the method. The true geothermal gradient re-established itself over the eentire depth of this hole in two and a half weeks after cessation of drilling. Heat flow values calculated from thermal conductivity and diffusivity tests on core samples showed marked variation over the area. A great difference was observed between geothermal gradients in the coal measures and the unconformable Permo-Triassic formations. It is not recommended that single temperature readings be used to extrapolate temperatures to a greater depth or to assume a geothermal gradient from the surface.—*V. S. N.*

173–220. Boldizsár, T. New terrestrial heat flow values from Hungary: Geofisica Pura e Appl., v. 29, p. 120–125, 1958.

The results of temperature and heat conductivity measurements in wells in Hungary show that in southern Transdanubia (west of the Danube) heat flow is about 2 to 2.4×10^{-6} cal per cm^2 per sec, and in the Hungarian Plain (east of the Danube) between 2.3 and 2.8×10^{-6} cal per cm^2 per sec. The temperature gradient is high everywhere, from 5.0 to 5.8×10^{-4} degrees C per cm. At 1,000 m the virgin rock temperature is about 60° to 70° C, at 2,000 m about 110° to 130° C.—*D. B. V.*

173–221. Gregg, D. R. Natural heat flow from the thermal areas of Taupo Sheet District (N 94): New Zealand Jour. Geology and Geophysics, v. 1, no. 1, p. 65–75, 1958.

Heat flow from the thermal areas of Sheet District N 94 [New Zealand] has been estimated to be 274,000 kcal per sec ($3{,}910\times10^6$ Btu per hr) above 0° C. The figure is based on measurements made during the period March 1951 to April 1952. The heat flow is equivalent to a loss of 24×10^{-6} cal per cm^2 per sec over the whole area covered by the sheet. The heat flow could be produced by the flow upwards of 1,440 kg per sec of water with a temperature of 169° C.—*Author's summary*

173–222. Babinets', A. Ye. Pro osoblyvostī heotermīchnoho rezhymu ī prychyny anomal'noho rozpodīlu tepla v platformeniy chastynī Ukrayins'koyi RSR ta Modavs'koyi RSR [On peculiarities of the geothermal regime and causes of the anomalous distribution of heat in parts of the Ukrainian SSR and Moldavian SSR (in Ukrainian with Russian summary)]: Akad. Nauk Ukraynskoy RSR Geol. Zhur., v. 17, no. 1, p. 15–28, 1957.

The geothermal gradient is higher in the Ukrainian crystalline shield and bordering areas of shallow basement but decreases in the center of the platform basins. At depths greater than 1,000 m there is usually a decrease. For the Krivoy Rog region in the shield the geothermal gradient is given as 112 m per ° C. The gradient increases along the axis of the Dneiper-Donets basin toward Byelorussia. Anomalous conditions in the salt dome area of the Radchenk petroleum deposits are explained by the rise of mineralized waters from depth. A relatively high geothermal gradient is observed in the western flank of the shield, decreasing in the Galicia-Volyn region. Low gradient characterizes the southern flank of the shield and the environs of the Black Sea and Sea of Azov, decreasing as the basement dips toward the Sivash; west of the Black Sea the gradient is higher. The Moldavian plateau shows a relatively high gradient, explained by cooling of the upper layers by deep circulation of water and by erosion. The general steepening of the geothermal gradient at a depth of 1,000 m in areas of thick sediments is almost entirely related to the recharge and deep circulation of ground waters. The southward decrease in heat loss is evidently related to the gradual regular rise in mean annual temperature toward the south.—*D. B. V.*

173–223. Duhanov, H. V. Doslīdzhonnya heotermīyi Kryvorīz'koho zalīzorud noho baseynu [Geothermal investigations in the Krivoy Rog iron ore basin (in Ukrainian with Russian summary)]: Akad. Nauk Ukraynskoy RSR Geol. Zhur., v. 17, no. 1, p. 79–83, 1957.

Geothermal measurements made in 1954–1955 at depths of 172 to 607 m in mine shafts in the northern and central part of the Krivoy Rog iron ore basin show an almost linear increase of temperature with depth, with an average geothermal gradient of 60 m per degree C. The zone of constant temperature begins at a depth of 25 m, where the average temperature is 8° C. Structural control is suggested by an increase of temperature in the crests of anticlines, but further investigations are necessary to confirm this relationship.—*D. B. V.*

173–224. Kashpur, Ya. N. Deyakī zakonomīrnī osoblyvostī heotermīchnoho rezhymu Donbasu [Some systematic features of the geothermal regime of the Donbas (in Ukrainian with Russian summary)]: Akad. Nauk Ukraynskoy RSR Geol. Zhur., v. 17, no. 4, p. 33–39, 1957.

Although the geothermal conditions in the southwestern part of the Donbas (Donets Basin) in the Ukraine are found to be very complex, several consistent features are noted: the geothermal gradient increases from the center of synclines toward the crest of anticlines; it is greater in areas richer in coal; it decreases as the degree of metamorphism of the rocks increases; and it is steeper where the crystalline basement is relatively shallow and more gentle where the basement is deeper.—*D. B. V.*

173–225. Swiatlowskij, A. E. (Svyatlovskiy, A. Ye.) Die Ausnutzung der Tiefenwärme der Erde [The utilization of the heat of the earth's depths]: Zeitschr. angew. Geologie, v. 2, no. 11/12, p. 554–555, 1956.

A German version, somewhat abridged, of a paper in "Priroda" (no. 5, 1955) concerning exploitation of geothermal power in various parts of the world with some data on heat energy released in volcanic eruptions and thermal areas. In Russia, the power possibilities of Kamchatka and the Kurile Islands are being investigated.—*D. B. V.*

173–226. McIntyre, Michael P. Geothermal power in California: Science, v. 127, no. 3305, p. 1035–1036, 1958.

New exploratory and test borings are being made at Big Geysers, a 3,200-acre fumarole area near Santa Rosa, California, with a view to developing geothermal power. Eight wells drilled with primitive equipment in 1923–1925 to depths of 500 to 600 feet are still blowing an estimated 6,000 kilowatts of energy into the air with undiminished vigor. The new campaign will test the energy potential of the property by drilling at many different locations and varying depths. Temperatures at the 600-foot level have been determined to be 600°; if the heat gradient continues to rise in proportion to depth, 1,000- to 1,500-foot wells might be expected to yield at least the equivalent of 4,000 kilowatts per well (New Zealand steam bores have averaged 6,000 kilowatts). So far the steam has proved to be dry. The ultimate potential, it is hoped, will exceed 30 wells, or 100,000 kilowatts.—*D. B. V.*

173–227. Goguel, Jean. Le mécanisme des explosions phréatiques [The mechanism of phreatic explosions]: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 165–175, 1956.

A discussion of the thermodynamic properties of water leads to the hypothesis that phreatic explosions are initiated by the intrusion of a molten mass into humid rock. The water is vaporized on contact, and when its pressure exceeds the pressure that can be supported by the solid rock, it raises the rock; in so doing it facilitates intrusion. The infiltrating steam condenses as it meets cooler rock and in condensing heats it; this type of heating is much more active than simple conduction. The heat accumulates in each layer until the saturation temperature has been reached; then the steam proceeds to heat the next higher layer. When vapor tension becomes equal to hydrostatic pressure conditions are so favorable for an explosion that one is possible even where porosity is low; however, the rock must be permeable in order for heat to be transferred by the mechanism suggested. If instead of progressing gradually through the interstices the steam reaches a fissure and escapes to the surface, the sudden drop of pressure in the fissure provokes an explosion of the contiguous rocks, with violent projection of debris and propagation of the explosion in the whole heated mass.—*B. T. E.*

173–228. Boldizsár, T. The distribution of temperature in flowing wells: Am. Jour. Sci., v. 256, no. 4, p. 294–298, 1958.

The distribution of temperature in the liquid in a flowing well is calculated by an approximate theory based on Jaeger's solution for the conduction of heat from a cylinder in an infinite medium. Satisfactory agreement is found with observatories by Birch for a well near Colorado Springs. In principle, analysis

of the temperature distribution and rate of flow can provide values of thermal gradient and of heat flow.—*Author's abstract*

173–229. Vladicka, L. An investigation of the recorded bottom hole temperatures while running logs: Canadian Oil and Gas Industries, v. 11, no. 3, p. 52–55, 1958.

This investigation was made to show the need for improved methods of recording, estimating, and utilizing temperature for log interpretations. To improve log interpretation it is necessary to know both the temperature of the mud at the time the log is run and the temperature of the formation close to the borehole. The present application of the recorded bottom hole temperature while running logs to find *Rw*, *Rxo*, *Rmf*, and *Rmc* is incorrect; each parameter should be found at the actual or closely estimated temperature prevalent some distance from the borehole.—*V. S. N.*

173–230. Lasky, Bernard H. Surface alteration utilized in structural mapping—a function of earth temperature (Part 1): World Oil, v. 143, no. 6, p. 123–127, 1956.

This is a review of previous findings of the relationships of earth temperatures to geologic structure. In general, highest temperatures were found over the crests of anticlines and domes.—*L. C. P.*

173–231. Lasky, Bernard H. Earth temperatures alteration studies reflect subsurface structure (Part 2): World Oil, v. 143, no. 7, p. 116–121, 1956.

Recent studies of mineralization in surface sediments have established the fact that alteration occurred in these beds after deposition, and that this alteration represents the cumulative effects of geothermal variations at the surface over geologic time. This relationship can be used in structural mapping.—*L. C. P.*

INTERNAL CONSTITUTION

173–232. Balakrishna, S. A peep into the depths of the earth: Indian Minerals, v. 11, no. 1, p. 25–30, 1957.

A popularized review of the nature of the interior of the earth as revealed by geophysical evidence, with particular emphasis on seismological observations.—*V. S. N.*

173–233. Dauvillier, Alexandre. L'origine des éléments chimiques et l'évolution de l'Univers [The origin of the chemical elements and evolution of the universe]: Rev. Sci., v. 91, no. 2, p. 90–100, 1953; L'origine de la Terre: systèmes stellaires et planétaires—structure et origine [The origin of the earth: stellar and planetary systems—structure and origin]: no. 4, p. 263–276, 1953.

In the first paper Dauvillier presents in some detail his concept of an autonomous galaxy functioning in an almost closed cycle by the action of cosmic electromagnetism, according to which the universe is in static equilibrium; atoms, stars, and galaxies evolve according to closely related rhythms, constantly disappearing and reforming. The "false and insoluble" problem of the age of the universe gives way to real problems such as the mechanism of origin of the stars, cause of their rotation, and origin of cosmic magnetism.

In the second paper the origin of the planets is considered in the light of this theory. Planetary systems arise by grazing collisions at the center of the galactic nucleus. The existence of two families of planets such as in our solar system is explained as follows: the initial grazing collision causes the expulsion of pairs of giant planets, and the final oscillations of the parent star result in pairs of dwarf planets. The twin planets eventually approach one another and fuse. The satellites are born of this junction; in the same manner the planets are formed from twin stars and likewise occur as giant and dwarf types. In the case of our own solar system an encounter after several millenia while it was still gaseous produced Saturn and its satellites, but Jupiter and Uranus resulted from fusion of the twin planets without previous capture, and only four dwarf satellites were produced. In the case of the terrestrial planets the twin met after several centuries in the molten state, and normal satellites were not possible. The earth is an exceptional case in which the twin fused tangentially; this imparted considerable angular momentum leading to the earth-moon system, a double planet that evolved according to Darwin's theory. (See also Geophys. Abs. 167–160)—*D. B. V.*

173–234. Pettersson, Hans, and Frederiksson, Kurt. Magnetic spherules in deep-sea deposits: Pacific Sci., v. 12, no. 1, p. 71–81, 1958.

A count was made of the number of "cosmic spherules" present in sediment cores obtained from great depths in different parts of three oceans and the Mediterranean during the Swedish Deep-sea Expedition of 1947–1948. Spherules were extracted from the cores by means of a powerful electromagnet. The number obtained is many times greater than that reported by Sir John Murray and A. F. Renard in the *Challenger* expedition reports of 1876 and 1897.

Numerous nodules were found several meters below the surface of the sediments in Tertiary deposits, showing that the meteoric falls from which the spherules originated have not been limited to the recent past, although there are indications that the frequency of deposition of the spherules has been higher in the last few thousand years than in the remote past. The occurrence of intermediate maxima suggests greater frequency of meteoric falls during certain times. An estimate of the approximate rates of sedimentation can be made by comparing the frequency of spherules near the surface (that is, recent) in certain cores. The total addition in weight by the spherules to the weight of the earth is estimated at 2,400 metric tons annually. Even with a possible rise to 5,000 tons this is a fraction of the amount estimated by earlier investigators from magnetic spherules collected from the atmosphere. The presence of nickel in the chemical analysis of some of these deep-sea spherules is definite proof of their cosmic origin.—*V. S. N.*

173–235. Beloussov (Belousov), V. V. La structure interne et l'évolution de la Terre à la lumière des données géotectoniques [The internal structure and the evolution of the earth in the light of geotectonic data]: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 129–135, 1956.

A French version of a paper originally published in Russian in the Akad. Nauk SSSR Geofiz. Inst. Trudy, no. 26 (153) p. 51–100, 1955 (see Geophys. Abs. 164–191).—*D. B. V.*

173–236. Eyged, L[ászló]. Dinamicheskaya model' zemli [A dynamic model of the earth]: Akad. Nauk SSSR Sovet po seysmologii Byull. no. 6, p. 52–58, 1957.

This is a Russian version, somewhat condensed, of Egyed's new theory of the internal constitution of the earth that appeared earlier in "Acta Geologica" of the Hungarian Academy of Sciences. (See Geophys. Abs. 167–165, 171–203.)—*S. T. V.*

173–237. Evernden, J[ack] F[oord]. Finite strain theory and the earth's interior: Royal Astron. Soc. Geophys. Jour., v. 1, no. 1, p. 1–8, 1958.

It is shown that the Poincaré–Brillouin approach to finite elastic strain theory leads to equations completely equivalent to those obtained by the Murnaghan–Birch approach. Applying the Brillouin pressure–strain equation to the earth's interior (that is, to Bullen's models), it is evident that there are a multiplicity of possible conclusions. The relative accuracy of the determined parameters is discussed. It is suggested that final conclusions are more reasonably based on derived values of ρ_o and K_o (density and incompressibility at zero pressure p_o, respectively) than on a derived value of dK/dp_o. It is concluded that the Bullen data can be interpreted to mean that a lower mantle with ρ_o=4.0 g per cm^3, K_o/ρ_o=33 km^2 per sec^2, and an outer core having ρ_o=6.75 g per cm^3, K_o=1.2×10^{12} dynes per cm^2.—*D. B. V.*

173–238. Bullen, K. E., and Burke–Gaffney, T. N. Diffracted seismic waves near the PKP caustic: Royal Astron. Soc. Geophys. Jour., v. 1, no. 1, p. 9–17, 1958.

An examination is made of arrival times of P' waves in the range 137°<Δ<142°, as recorded from four hydrogen bomb explosions of 1954. Early readings in this range are attributed to diffracted *PKP* waves, near the caustic at 142°, arriving before *PKIKP* onsets. The results supply a small final link in the chain of evidence for the existence of the inner core.—*P. E. B.*

173–239. Nishimura, Eiichi, Kishimoto, Yoshimichi, and Kamitsuki, Akira. On the nature of the 20°-discontinuity in the earth's mantle: Tellus, v. 10, no. 1, p. 137–144, 1958.

Seismograms obtained at Japanese observatories for five prominent earthquakes in the Kamchatka-Kurile Islands region were analyzed in order to investigate the existence and nature of the 20°-discontinuity and the low-velocity layer in the mantle. The existence of the former was ascertained for Japan but the existence of the latter is questionable, at least in the form characterized by Gutenberg. Abnormal diminution of amplitude of the direct seismic wave, and conversely, the large and clear appearance of the refracted wave through the 20°-discontinuity were definitely observed for both *P* and *S* phases near the epicentral distance of 20°. A new discontinuity at about 25° is deduced from analysis of the *S* wave (the new phase is tentatively called Sr_2) but no corresponding *P* phase could be reliably identified; therefore, it is stated that the new discontinuity, if it exists, is effective for the *S* wave but not for *P*. It probably is related to the behavior of k/μ in the so-called *C*-layer calculated by Nishitake (see Geophys. Abs. 169–195) from the Jeffreys-Bullen velocity distribution. It is concluded that the nature and structure of the mantle may vary regionally.—*D. B. V.*

173–240. Shimozuru, Daisuke. Elasticity of materials near the melting point, with special reference to Bullen's region D'': Jour. Physics of Earth, v. 5, no. 1, p. 61–67, 1957.

The elastic properties of rocks at the melting point were investigated experimentally by measuring the velocity of an ultrasonic dilatational wave in polycrystalline sodium at temperatures ranging from room temperature to its melting point (97.6° C). Very marked decreases in the elastic moduli, with corresponding decrease in velocity, were observed as the melting point was approached; this is somewhat analogous to the order-disorder transition phenomena in a metal alloy. The results suggest that the observed small values of P and S velocity gradients in the D'' region (just outside the core of the earth) may be due not only to accumulation of denser matter as suggested by Bullen but also to a marked decrease in bulk modulus and rigidity modulus as observed in this experiment.—*D. B. V.*

173–241. Ringwood, A. E. The constitution of the mantle—I. Thermodynamics of the olivine-spinel transition. Geochim. et Cosmochim. Acta, v. 13, no. 4, p. 303–321, 1958.

It is calculated that transformation of Mg_2SiO_4 to a spinel modification should become thermodynamically stable at 1500° C in the pressure range of $(1.75\pm0.55)\times10^5$ bars, corresponding to a depth in the mantle of 500±140 km. Several extraneous factors affect the transition pressure: increase of temperature above 1500° C in the mantle would increase the pressure, whereas the effect of FE_2SiO_4 in solution, the presence of Mg_2SiO_3, Al_2O_3, CaO, and TiO_2, and departures from the ideal in NG—MS solid solutions all tend to decrease it. The net effect is to decrease the pressure, therefore, it is concluded that olivine in the mantle probably begins to invert to spinel at depths less than 500 km. These results are in good agreement with the depth of the 20° discontinuity found by seismology.—*D. B. V.*

173–242. Bugayevskiy, G. N. K voprosu o stroyenii obolochki Zemli [On the question of the structure of the earth's mantle]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 6, p. 63–66, 1957.

One of the efficient methods of studying the structure of the earth's mantle is the detailed analysis of traveltime curves of remote earthquakes. This makes it possible to determine, either by graphic means or numerical differentiation, the derivative of the traveltime curve at different depths. Bugayevskiy suggests a new procedure for this determination that avoids the construction of the entire curve. This is done by computing the derivatives of the traveltime curves of separate stations and later computing the average value of these derivatives. This method was applied to four normal earthquakes on the island of Taiwan during the years 1936–1938 as recorded at the Irkutsk seismological station. The traveltime curve of the longitudinal waves was computed by numerical integration to the average derivative. Comparing the derivatives of the computed curve with those obtained from the Jeffreys-Bullen tables shows several discontinuities. The position of these discontinuities is in good agreement with the points of abrupt changes in the seismic velocity at different depths in the earth's mantle noted by Vvedenskaya and Balakina (see Geophys. Abs. 173–245).—*S. T. V.*

173-243. Gutenberg, B[eno]. Velocity of seismic waves in the earth's mantle: Am. Geophys. Union Trans., v. 39, no. 3, p. 486–489, 1958.

On the basis of our present knowledge the earth's mantle may be divided into four sections: (a) from the Mohorovičić discontinuity to a depth of about 200 km, with small changes in the wave velocities which have minima in this section; (b) from 200 to 950±km with relatively rapid, fairly regular increase in velocity; (c) from 950 to 2,700±km with smaller and less regular increase in velocity; almost straight line portions of the traveltime curves and relatively small wave amplitudes at certain ranges of distance indicate at least two portions of (c) where the wave velocity increases relatively little with depth; (d) from 2,700 km depth to the core boundary with little change in velocity and probably maxima roughly 100 km above the core boundary.—*Author's abstract*

173-244. Lehmann, I[nge]. The velocity of *P* and *S* waves in the upper part of the earth's mantle: Bur. central seismol. internat., Pubs., sér. A, Travaux sci., no. 19, p. 115–123, 1956.

A discussion is presented of properties of *P* and *S* waves through the upper part of the mantle in Europe, California, and the northeastern United States. Trial solutions for increase of *P* velocity with depth in Europe, according to the Wiechert law, with a stronger increase beginning at a depth of around 250 km, suggest the possible existence of loops in the traveltime curve, with branches close together. A similar solution for *S*, with a decreasing velocity with depth in the first layer, and an increasing velocity below 250 km resulted in a long, more open loop. Its lowest point was 21 sec above the first progressive branch of the curve. To fit observed data on *S* from about 12° to 25° it would be necessary to assume that the decrease in *S* velocity does not continue to a depth of 250 km. In the examples considered, it seems as if the increase in Poisson's ratio in the mantle may take place entirely in a thin layer close to the upper boundary of the mantle. Although there is at present no way of determining the velocity distributions with certainty, the conclusion that there are regional differences in the velocity in the upper mantle is definite.—*P. E. B*

173-245. Vvedenskaya, A. V., and Balakina, L. M. O nekotorykh osobennostyakh polya smeshcheniy prodol'nykh i poperechnykh voln, rasprostranyayushchiksya v obolochke Zemli [Certain peculiarities of the displacement field of longitudinal and transverse waves propagating through the earth's mantle]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 6, p. 59–62, 1957.

In this paper an attempt is made to investigate the structure of the mantle by comparing the ratios of longitudinal and transverse wave amplitudes calculated from records at numerous Russian stations of 18 earthquakes in the Russian Far East, China, Turkey, Greece, and Algeria, with the theoretical ratios calculated for an elastic isotropic medium having constant Young's modulus and shear modulus. The ratios of the displacements u_P/u_{SH} and u_{SV}/u_{SH} were calculated from initial data on the seismograms. The theoretical ratios were calculated from the formulas $u_P/u_{SH}=(c^2/a^2)F_1(m, n, l, Az, e)$ and $u_{SV}/u_{SH}=F_2(m, n, l, Az, e)$ where a and c are longitudinal and transverse wave velocities, respectively; m, n, and l are the cosines of the angles between the tangent to the ray (at the point of emergence from the focus) and the axes of principal stress; Az is the azimuthal angle from the epicenter to the station;

and e is the angle formed between the ray emanating from the focus and the horizontal. The curves plotting the computed ratios of $(u_P/u_{SH})/F_1$ and $(u_{SV}/u_{SH})/F_2$ against epicentral distances Δ from 10° to 80° show sharp peaks at Δ=18°–20°, 40°, 52°–55°, and 68°–71°, corresponding to discontinuities at depths of 250–500, 900–1,000, 1,200–1,300, 1,900–1,950, and about 2,300 km; these are in good agreement with the discontinuities at 950, 1,200, 1,800, and 2,150 km suggested long ago by Repetti, Gutenberg and Richter, and other seismologists.—*S. T. V.*

173–246. Zharkov, V. N. Ob elektroprovodnosti i temperature obolochki Zemli [On the electrical conductivity and temperature of the earth's mantle]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 4, p. 458–470, 1958.

The experimental results of Hughes on the effect of pressure on the electrical conductivity of peridotite (see Geophys. Abs. 163–66) and of Coster on the electrical conductivity of rocks at high temperatures (see Geophys. Abs. 133–10079), together with the seismologic evidence of the changes of the compressibility with depth, now make it possible to estimate the ionic electroconductivity of the earth's mantle and thus to determine the temperature variation with depth within the earth. Formulas are derived for many physical constants of the earth at great depths on the assumption of certain properties of the olivine crystal-lattice. The sharp increase of electrical conductivity at the depth of 400–700 km is attributed to the transformation of olivine into a semiconducting state, while preserving its chemical composition.—*S. T. V.*

173–247. Treskov, A. A. Resul'taty opredeleniy moshchnosti zemnoy kory po nablyudeniyam nad udalennymi zemletryaseniyami [The results of the determination of the thickness of the earth's crust from observations of remote earthquakes]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 6, p. 76–80, 1957.

A discussion of the possibility of estimating the thickness of the earth's crust from the differences in the arrival time of various waves coming from the focus of a deep earthquake is given. The problem is simpler when the focus is located right at the boundary of the crust. The analysis leads to the conclusion that the time interval corresponding to the difference pP–pP^* corresponds to the thickness of the crust near the epicenter, whereas the difference PP–PP^* corresponds to the thickness of the crust at half the distance from the epicenter to the station. The results of some of the determinations of H for various parts of the world are tabulated; the values obtained range from 30 to 55 km.—*S. T. V.*

Beaufils, Y[vonne], Bernard, P[ierre], Coulomb, J[ean], Duclaux, F[rançoise], Labrouste, Y., Richard, H[enri], Peterschmitt, É[lie], Rothé, J[ean]-P[ierre], and Utzmann, R. Registration of seismic waves generated by large explosions. I.—Camargue 1949. See Geophys. Abs. 173–136.

Beaufils, Y[vonne], Coulomb, J[ean], Geneslay, R[aymond], Jobert, G[eorges], Labrouste, Y., Peterschmitt, É[lie], and Rothé, J[ean]-P[ierre]. Registration of seismic waves generated by large explosions. II.—Champagne 1952. See Geophys. Abs. 173–137.

Labrouste, Y., and Beaufils, Y[vonne]. Multiple refractions in the seismographic records of the Champagne explosions, October 1952. See Geophys. Abs. 173–138.

Geneslay, R[aymond], Labrouste, Y., and Rothé, J[ean]-P[ierre]. Deep reflections in large explosions (Champagne, October 1952). See Geophys. Abs. 173–139.

Beaufils, Y[vonne]. Study of the surface waves in the seismograph records of the Champagne explosions, October 1952. See Geophys. Abs. 173–140.

Kárnik, Vit. The velocities of seismic waves generated by industrial explosions in Bohemia. See Geophys. Abs. 173–141.

173–248. Stegena, Lájos. Seismische Untersuchungen der Tiefenstruktur der Erdkruste in Ungarn [Seismic investigations of the deep structure of the earth's crust in Hungary]: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 2, p. 177–181, 1958.

A summary of the results of investigations of crustal structure in Hungary using deep reflection surveys and earthquake and explosion data is given. The layer thicknesses and velocities determined by deep reflections at Sopron, Debrecen, Karád, Pécs, and Bonyhád are shown graphically; mean values are 20 km for the granite layer, about 5 km for the basaltic layer, with velocities of 7.43 kmps at the Conrad and 8.83 kmps at the Mohorovičić discontinuity. Crustal thicknesses and velocities as determined from the Dunaharaszti earthquake of January 12, 1956, and from the Helgoland and Haslach explosions are also shown in the same diagram.—*D. B. V.*

173–249. Egyed, L[ászló]. Investigations on seismology and the physics of the interior of the earth, in Hungary, 1954–1956: Acta Tech. Acad. Sci. Hungaricae, v. 18, no. 1–2, p. 123–131, 1957.

Seismic work in Hungary in 1954 to 1956 included investigations of the crustal structure under the Hungarian Basin from deep reflections; study of the seismicity of Hungary was in progress based on earthquake data for the last 50 years; earthquake magnitude studies were also in progress, and theoretical investigation of the physical nature of the earth's interior.—*D. B. V.*

173–250. Shebalin, N. V. Ispol'zovaniye sootnosheniya mezhdu intensivnost'yu i ball'nost'yu zemletryaseniy dlya otsanki glubiny astenosfery v rayone Vrancha (Karpaty) [The use of correlation between earthquake magnitude and intensity for estimating the depth of the asthenosphere in the Vrancha region (Carpathians) (with English summary)]: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 1, p. 86–91, 1958.

The correlation between magnitude M and intensity I of an earthquake has been found to be $1.5\ M-I=\delta\ (h)$, where $\delta\ (h)$ is a simple function of focal depth h: $\delta\ (h)=-3.0+3.5 \log h$, $0<h<60$–100 km,

$\delta\ (h)=-5.4+3.4 \log h$, 60–$100\ \text{km}<h<640$ km

Thus at a depth of 60 to 100 km the value of $\delta\ (h)$ changes abruptly from 3.2–4.0 to 0.9–1.5. This may be explained by the decrease in the long wave amplitude on the earth's surface due to reflection of seismic rays from underlying foci at the boundary of the crust. It is found that the sudden decrease of $\delta\ (h)$ for all the earthquakes of a given region occurs at a definite depth; for the Carpathians this is found to be 100 km. Some typical records for foci lying above and below the top of the asthenosphere are shown.—*D. B. V.*

173–251. Yevseyev, S. V. O seysmicheskom godografe i stroenii zemnoy kory v rayone Karpat na osnovanii materialov dvukh zemletryaseniy [On seismic traveltime curves and crustal structure in the region of the Carpathians on the basis of data of two earthquakes (in Ukrainian with Russian summary)]: Akad. Nauk Ukraynskoy RSR Geol. Zhur., v. 18, no. 1, p. 68–74, 1958.

Traveltime curves are constructed for two earthquakes from the arrivals of P_n, P^*, $\bar{P}$, S_n, S^*, and $\bar{S}$ at various European stations, and from these the crustal structure in the Carpathian region deduced. The first earthquake was that of February 20, 1951; its epicenter is determined as $\phi=47.9°\pm0.2$, $\lambda=19.2°\pm0.2$; P wave velocity $(v)=7.65$ kmps, $\bar{P}$ wave velocity $(v)=5.48\pm0.2$ kmps, P^* wave velocity about 6.44 kmps, focal depth $(h)=34\pm2$ km, focal time $(t_o)=0^h14^m09.4^s\pm0.4^s$. For the second earthquake, that of October 15, 1953, the epicenter is located at $\phi=42.2°$, $\lambda=26.7°$; $v=5.43\pm0.05$ kmps, $v=7.65\pm0.05$ kmps, $t_o=4^s43^m38.0^s\pm0.5^s$, $h=40\pm2$ km. Average depth of the first layer, calculated from P^* and from $\bar{P}-P^*$ for the first earthquake, is 40 ± 2 km. Average thickness of the second layer, on the basis of data from both earthquakes, is 4 ± 2 km. The values found for these crustal layers agree well with those found for the Alps by Bullard and Gutenberg (40 and 4 km, respectively).—*D. B. V.*

173–252. Riznichenko, Yu. V. Izucheniye stroyeniya zemnoy kory v SSSR metodom glubinnogo seysmicheskogo zondirovaniya [Study of the structure of the earth's crust in the USSR by the method of deep seismic sounding (with German summary)]: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 2, p. 133–140, 1958.

The results of investigations of crustal structure by deep seismic sounding in various parts of Russia are presented, after a brief description of the apparatus, procedure, and method of interpretation of the observations. The thicknesses of various crustal layers are shown diagrammatically for eight sections in the Volga-Ural region, western Turkmen S. S. R., northern Pamir, and northern and southern Tyan'Shan. In regions of Hercynian folding (such as the Tyan'Shan) the mountain roots are related to a thickening in the basaltic layer, in regions of Alpine folding (northern Pamir, western Turkmen S. S. R.) to thickening of the granitic layer. The same relationships have been noted in the Appalachians (Hercynian) and Alps.

Deep seismic sounding investigations can be supplemented by gravity measurements and by determination of foci of weak local earthquakes registered by high frequency seismic apparatus. During the International Geophysical Year the method will be applied to transition zones between continents and oceans and in the Sea of Okhotsk and northwestern Pacific.—*D. B. V.*

173–253. Gamburcev [Gamburtsev], G. A. Die seismische Tiefensondierung [Deep seismic sounding]: Bergakademie, v. 8, no. 4, p. 158–162, 1956.

A German version of the Russian paper (see Geophys. Abs. 160–74).—*D. B. V.*

173–254. Gamburtsev, G. A., Veytsman, P. S., Davydova, N. I., and Tulina, Yu. V. Glubinnoye seysmicheskoye zondirovaniye zemnoy kory na Severnom Tyan'Shane [Deep seismic sounding of the earth's crust on the northern Tyan'Shan Mountains]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 3, p. 13–23, 1956.

According to the results of deep seismic sounding in the northern Tyan'Shan

region it is concluded that the mountain ridges or elevations correspond to rises in the surface of the basaltic layer and to increase of its thickness compared with adjoining depressions. The relationship between the main geotectonic elements and the deep structure of the crust are not necessarily valid for other mountain ranges; they may be related to peculiarities of the geologic development of the Tyan'Shan Mountains.—*S. T. V.*

173–255. Gamburtsev, G. A., and Veytsman, P. S. Osobennosti stroyeniya zemnoy kory v rayone Severnogo Tyan'Shanya po dannym glubinnogo seysmicheskogo zondirovaniya i sopostavleniye s dannymi geologii, seysmologii i gravimetrii [The characteristics of the earth's crustal structure in the region of northern Tyan'Shan according to data from deep seismic sounding and comparison with geologic, seismologic, and gravimetric data]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 3, p. 24–37, 1956.

Deep seismic sounding of the earth's crust in the region of the northern Tyan'Shan mountains showed the existence of a subterranean continuation of the Dzhungarian Alatau Ridge, indicated by the increase in thickness of the basalt layer, together with recent vertical uplift also manifested in the migration of the bed of the Ili River. The comparison of the data obtained by deep seismic sounding with the facts known from seismology shows that the majority of earthquake foci occurring in the Kungey-Transilian Alatau mountain system are located in the basalt in areas where the basalt layer is thicker. Comparison with gravimetric data shows that the greater portion of the negative gravity anomaly which begins near the Ili River depression can be explained by the lowering of the Mohorovičić surface in this region.—*S. T. V.*

173–256. Research Group for Explosion Seismology (Japan). Crustal structure in north-east Japan by explosion-seismic observations: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 229–242, 1956.

Most of the contradictions in the results of independent interpretations of crustal structure from observations of explosions in northeastern Japan probably resulted from the assumption of horizontal structure that was used as the first approximation. Reinterpretation of material from all the past observations by the Research Group for Explosion Seismology shows that the surface layer P_1, having a velocity of 2.51 kmps, is 530 m thick near the Isibuti shot point where it dips eastward about 9°, thins out abruptly at a fault 14 km east of that point, is thin or lacking west of Isibuti but reappears farther west with a thickness of 1 km, is absent near the Kamaisi shot point, and is present south of Isibuti in undetermined shape. A layer that had been considered to be a single one of about 6.0 kmps velocity is found actually to be two layers, P_2 and P_3, having velocities of 5.75 to 5.85 kmps and 6.1 to 6.2 kmps, respectively, and separated by a plane boundary dipping 6° to 11° westward. The P_4 layer has a velocity of 7.5 to 8.0 kmps; assuming it to be horizontal, its depth is 20 to 25 km. This interpretation is confirmed by analysis of four additional smaller blasts made at the east edge of the area studied and agrees fully with the gravity data; if the density difference between P_2 and P_3 is 0.15 to 0.20, agreement is even quantitative, nor is any difficulty found from the geologic point of view.—*D. B. V.*

Akima, T[etsuo] S., and Nagamune, T. Dispersion of seismic surface waves and the structure of continents and oceans. See Geophys. Abs. 173–93.

Hess, H. H. The oceanic crust. See Geophys. Abs. 173–184.

Molodensk[i]y, M. S., and Pariysk[i]y, N. N. Elastic tides and irregularities of the earth's rotation in connection with its structure. See Geophys. Abs. 173–109.

ISOSTASY

173–257. Hsee, K. Jinghwa. Isostasy and a theory for the origin of geosynclines: Am. Jour. Sci., v. 256, no. 5, p. 305–327, 1958.

Assuming that the earth's crust is in isostatic equilibrium, depressions are often formed in response to disturbances of this equilibrium. Geosynclines are regarded as isostatically adjusting (or adjusted) depressions that have received a large sedimentary load, which in turn induces further isostatic subsidence. Any continental or oceanic depression may become a geosyncline provided that an adequate source of sediments is available. A normal geosynclinal cycle is described, and the sedimentary and tectonic histories of southern California and the central Appalachians are reviewed. A crustal model based on Airy's mountain-root hypothesis is used and local isostasy is assumed in this preliminary presentation.—*V. S. N.*

173–258. Jung, Karl. Remarks on the foundation of the conception of isostasy: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 315–318, 1956.

The usual isostatic reductions of gravity values do not correspond strictly to the concept of an exactly hydrostatic state of subcrustal masses, causing secondary effects concerning the shift of equipotentials below the depth of compensation. A reduction to avoid this difficulty called the "perfectly isostatic reduction", can be performed in such a way that the equilibrium state below the crust is unchanged, the potential on the level of compensation being altered only by a constant. This constant can be chosen so that preservation of hydrostatic equilibrium is combined with preservation of masses. It is not possible, however, to fix the removed masses strictly beneath their original place; a removed mass spreads laterally with considerable central condensation. A satisfactory approximation avoiding laborious computation methods can be obtained by reducing in the usual way and replacing the removed mass by a concentrated mass twice as deep as the real compensation. In flat areas there is little difference between the perfectly isostatic reduction and the usual reduction, but rough estimates show remarkable differences above striking crustal features such as volcanic islands and deep-sea trenches.

Advantages of the proposed reduction are that it is founded on a physically well-defined state of hydrostatic equilibrium below the crust and leads to an estimation of the forces tending to reestablish this equilibrium if disturbed; it may be adapted to the concepts of Pratt, Airy, Heiskanen, and others and at least approximately to the regional isostasy of Vening Meinesz; there is no shift of equipotentials below the level of compensation; the layer between the geoid and co-geoid may be regarded as compensated, so that the effects of this layer and its compensation cancel each other. Tables and contour maps should be worked out for several kinds of perfectly isostatic reductions or for the

differences between these and the corresponding usual reductions. It is not necessary to reduce all gravity values in the proposed manner; but perfectly isostatic reductions should be computed for especially interesting regions and compared with the usual anomalies.—*D. B. V.*

Egyed, László. The equilibrium of the earth's crust. See Geophys. Abs. 173–183.

Kääriäinen, Erkki. On the recent uplift of the earth's crust in Finland. See Geophys. Abs. 173–186.

ISOTOPE GEOLOGY

173–259. Wanless, R. K. Application of isotopic studies to geological problems: Canadian Mining Jour., v. 78, no. 4, p. 133–136, 1957.

A review of the natural processes responsible for isotopic variations, the techniques used in determination of isotopic abundances, and of current isotope studies being made by the Geological Survey of Canada.—*V. S. N.*

173–260. Damon, Paul E., and Kulp, J. Laurence. Inert gases and the evolution of the atmosphere: Geochim. et Cosmochim. Acta, v. 13, no. 4, p. 280–292, 1958.

The origin of the present isotopic composition of the inert gases in the atmosphere is reviewed. Using a new value (1.0 T/cm^2 sec) for the maximum rate of tritium, and hence helium-3, production in the atmosphere, the present rate of escape of helium-4 from the crust is calculated as about 7×10^{30} atoms per year and assuming no leakage from the mantle, the corresponding rate of escape of argon-40 as 1.5×10^{30} atoms per yr. This rate is far too small to account for the quantity of argon-40 in the atmosphere. Most of the argon-40, presumably accompanied by some nitrogen and water, must have been introduced into the atmosphere in the first billion years of earth history from the mantle and crust.—*D. B. V.*

173–261. Arnold, James R., and Al-Salih, H. Ali. Beryllium-7 produced by cosmic rays: Science, v. 121, no. 3144, p. 451–453, 1955.

Reports the discovery (in rainwater and snow) of the cosmic-ray induced radioactive isotope beryllium-7, resulting from high energy interactions between nitrogen and oxygen. The non-volatile molecule beryllium oxide will diffuse in the atmosphere until it encounters a dust particle to which it will adhere. From then on its history is that of atmospheric dust; therefore, it is apparent that beryllium-7 (which is easy to detect in spite of its low production rate of 0.035 atom per sec per cm^2 because it occurs substantially carrier-free) could be used to study atmospheric processes.—*D. B. V.*

173–262. Thor, Rama, and Zutshi, P. K. Annual deposition of cosmic ray produced Be^7 at equatorial latitudes: Tellus, v. 10, no. 1, p. 99–103, 1958.

The concentration of cosmic ray produced Be^7 in rain water has been measured at two stations in the equatorial latitudes. Its rate of deposition at the earth's surface has been estimated to be about 5×10^5 atoms cm^{-2}yr^{-1} and the deposited quantity seems to be independent of latitude.—*Authors' abstract*

173–263. Silverman, Sol R., and Epstein, Samuel. Carbon isotopic compositions of petroleums and other sedimentary organic materials: Am. Assoc. Petroleum Geologists Bull., v. 42, no. 5, p. 998–1012, 1958.

Carbon isotope analyses of petroleums, modern plant constituents, and other sedimentary organic materials indicate that the range of C^{13}/C^{12} ratios in organic carbon is about 4.5 percent. The range of variation in petroleums alone is about one percent. Ratios of marine organisms average about 10 per mil higher than non-marine organisms; petroleums of marine origin are correspondingly higher in C^{13} content than non-marine petroleums. Petroleums have lower C^{13}/C^{12} ratios than their biologic sources have. The lipid fractions of plants, however, are isotopically lighter than the whole plants, so that isotope fractionation is not necessary if petroleum is derived from lipid materials. Analyses of soluble organic matter in Recent sediments imply that isotope fractionation may be involved and transformation of non-lipid materials, therefore, may occur during petroleum formation.

The C^{13}/C^{12} ratio of the aromatic-enriched fraction of a petroleum does not differ by more than one per mil from the ratio of the paraffinic-naphthenic fraction. This indicates that changes in chemical composition alone are not responsible for the 10-per-mil range of isotopic composition noted for petroleums. Natural gases from petroliferous areas have considerably lower C^{13}/C^{12} ratios than associated petroleums. In view of the narrow range of isotopic composition in petroleums, gas formation does not appear to be an important natural mechanism for depleting oil fields. The isotope ratios of organic carbon in ancient sediments fall within the isotope ratio range of petroleums.—*Authors' abstract*

173–264. Keeling, Charles D. The concentration and isotopic abundances of atmospheric carbon dioxide in rural areas: Geochim. et Cosmochim. Acta, v. 13, no. 4, p. 322–334, 1958.

Fifty samples of rural air collected near the Pacific coast of North America have been analysed for carbon dioxide reporting, in addition to concentration in air, the isotopic abundances of C^{13} and O^{18}. A correlation observed for all samples between C^{13} isotope abundance and concentration in air can be explained by assuming an initial composition for atmospheric carbon dioxide of 0.031 volume percent in air, C^{13}/C^{12} ratio −7.0 per mil., to which is added carbon dioxide of plant origin with a ratio of approximately −23 per mil. Minimum concentration and associated carbon isotope ratios at different stations show very little variation (0.0307–0.0316 percent, −6.7 to −7.4 per mil.) and are believed to be representative of Pacific maritime air. Oxygen isotope abundances are approximately the same as for carbon dioxide in chemical equilibrium with average ocean water, but individual samples show variations which generally do not correlate with changes in concentration in air and are as yet unexplained.—*Author's abstract*

173–265. Hoering, T. C., and Moore, H. E. The isotopic composition of nitrogen in natural gases and associated crude oils: Geochim. et Cosmochim. Acta, v. 13, no. 4, p. 225–232, 1958.

Measurement of the $^{15}N/^{14}N$ ratio of the nitrogen from a number of samples of natural gas and crude oil show that wide variations exist. A systematic variation in the $^{15}N/^{14}N$ ratio exists across a natural gas field. Experiments on the flow of nitrogen through porous sandstone indicate that two processes

could account for the fractionation of the nitrogen isotopes in natural gas, namely effusive flow and surface diffusion.—*Authors' abstract*

173–266. Holmes, Arthur. The ejectamenta of Katwe crater, South-West Uganda: Koninkl. Nederland. Geol.-Mijnb. Genootschap, geol. ser., pt. 16, p. 139–166, 1956.

In the course of this petrochemical study of the ejectamenta of Katwe crater, Uganda, Holmes cites unpublished determinations (by Baertschi) of the relative oxygen (O^{18}/O^{16}) and carbon (C^{13}/C^{12}) isotope abundances measured on nine carbonate rocks from different places in Africa; the carbon dioxide in the travertine from the Katwe crater lake is shown to be of juvenile origin.—*D. B. V.*

173–267. Marquez, L., Costa, N. L., and Almeida, I. G. The formation of ^{22}Na from atmospheric argon by cosmic rays: Nuovo Cimento, v. 6, no. 6, p. 1292–1295, 1957.

Naturally occurring sodium-22 has been isolated from fresh rain water at Rio de Janiero and its average absolute activity found to be 0.017 disintegrations per minute per liter. Of all the radioisotopes so far found that are produced by cosmic rays, this is the most long-lived, with a half-life of 2.6 years.—*D. B. V.*

173–268. Hulston, J. R., and Shilton, B. W. Sulphur isotopic variations in nature. Part 4—Measurement of sulphur isotopic ratio by mass spectrometry: New Zealand Jour. Sci., v. 1, no. 1, p. 91–102, 1958.

A description of a mass spectrometer using double collection and rapid sample switching, giving details of its use for sulfur isotope measurements. Isotopic ratios of gas samples can be measured with an accuracy of 0.1 to 0.2 percent; standard deviation of comparison measurements is 0.2 percent. Comparison of the New Zealand sulfur standard (Merck sulfur) with standards used by other workers shows good agreement.—*D. B. V.*

173–269. Rafter, T. A., Wilson, S. H., and Shilton, B. W. Sulfur isotopic variations in nature. Part 5—Sulphur isotopic variations in New Zealand geothermal bore waters: New Zealand Jour. Sci., v. 1, no. 1, p. 103–126, 1958.

The discharge from 11 geothermal bores at Wairakei, New Zealand has been examined for sulfur isotope variations. The sulfide is found to be depleted in ΔS^{34} with respect to sulfate by 1.7 percent. If sulfur isotopic equilibrium exists in the hot chloride water underlying Wairakei, it can be shown from partition function calculations that the equilibrium temperature corresponding to the measured values would be 370±70° C. The average ΔS^{34} value for eight bore discharges (−9.6 percent) is higher than what would be expected if the sulfur were entirely of magmatic origin; at the White Island fumaroles the average ΔS^{34} value is −17.5 percent. This difference could be explained partly by loss of hydrogen sulfide from the hot chloride water after formation of the sulfate, or to a difference in character of the magma underlying Wairakei. Chemical evidence suggests that there has been considerable gas loss. The sulfur isotope evidence supports the geochemical evidence that there is a fairly uniform body of hot water beneath Wairakei and that mixing of ground water with magmatic steam does not occur under Wairakei but nearer to Lake Taupo.—*D. B. V.*

MAGNETIC FIELD OF THE EARTH

173–270. Alfvén, H[annes]. On the theory of magnetic storms and auroras: Tellus, v. 10, no. 1, p. 104–116, 1958.

It is shown that the fundamental assumption in the Chapman-Ferraro theory of magnetic storms, a non-magnetized beam, is in conflict with cosmic ray evidence. The discharge mechanism during a magnetic storm is analyzed. When a magnetized beam enters the earth's magnetic field it is heated due to the compression. In the hot plasma the earth will act as a "probe" so that it gets a negative charge in relation to the plasma. As a result of ambipolar diffusion to the earth, the ionosphere in the auroral zones will be bombarded by high energy protons and electrons. It is shown that a mechanism of this type is not subject to the objections that have been raised by Cowling and Chapman. See also Geophys. Abs. 147–13125.—*D. B. V.*

173–271. Bureau, Jean-Louis. Confrontation entre la théorie du nuage ionisé de Chapman et Ferraro et l'enregistrement du début d'un orage magnétique [Chapman and Ferraro's theory of the ionized cloud in the light of registration of the commencement of a magnetic storm]: Acad. Sci. Paris Comptes Rendus, v. 244, no. 10, p. 1396–1398, 1957.

The commencement of the magnetic storm of October 21, 1952 is interpreted according to Chapman and Ferraro's ionized cloud theory of the geomagnetic field, calculating the progress of the cloud front from the magnetic records. The effect is perceptible at a distance of 20 or 30 earth's radii; at the time t=20 sec, or at 13 radii, velocities are of the order of 0.5 radii or 3×10^8 cm per sec, close to the observed velocities of protons in aurora borealis. At the time t=5 sec, the velocities are more than 1.5 radii or 10^9 cm per sec, which is near the velocity of the cloud before it is affected by the geomagnetic field, generally taken to be 10^8 cm per sec.—*D. B. V.*

173.272. Barta, Gy[örgy]. Report on the geomagnetic and telluric researches carried out in Hungary during the period of 1954–57: Acta Tech. Acad. Sci. Hungaricae, v. 18, no. 1–2, p. 161–166, 1957.

Geomagnetic research in Hungary during 1954 to 1957 included observations at the Budakeszi observatory up to October 1955 and the beginning of observations at the Tihany observatory in November 1954, with a year of overlap between the two. Normal speed recording of the magnetic elements will be supplemented during the geophysical year by high speed recording of magnetic elements and earth currents. A reconnaissance magnetic survey of the Great Hungarian Plain with station interval of 1.5 km was completed for the area between the Danube, the northern highlands, and the eastern and southern frontiers. Detailed measurements were made at several areas for ore exploration purposes. Experimental measurements of earth currents, mainly for practical purposes, have been made since 1952 and the relation to magnetic variations has been studied. Theoretical research included studies of geomagnetic secular variation, of the internal constitution of the earth, and calculation of various disturbing bodies from magnetic anomalies.—*D. B. V.*

173-273. Kraiński, Waldemar. Note on the method of calculating QHM magnetometer measurements: Acta Geophys. Polonica, v. 5, no. 2, p. 116–117, 1957.

The equation usually used to calculate the horizontal component H from QHM magnetometer measurements is simplified to $\log H = C - \log \sin(\varphi + \varphi_0) + c_1 t$, where φ is the angle of deflection of the magnet, φ_0 can be calculated for each instrument from the values of C and c_2, t is temperature, and C, c_1, and c_2 are constants of the instrument. A plane slide rule is presented for such calculations.—*D. B. V.*

173-274. Fanselau, Gerhard. Über die Möglichkeit der absoluten Bestimmung der geomagnetischen Vertikalintensität Z auf magnetometrischem Wege [On the possibility of the absolute determination of the geomagnetic vertical intensity Z magnetometrically]: Freiberger Forschungshefte C 38 Geophysik, p. 7–18, 1957.

A description of a procedure developed at the Niemegk magnetic observatory for absolute determination of vertical intensity Z, using a field balance with band-suspension.—*D. B. V.*

173-275. Richard, Martin, and Wiese, Horst. Die Neubestimmung der absoluten erdmagnetischen Feldgrössen am Adolf-Schmidt-Observatorium für Erdmagnetismus in Niemegk [The new determination of the absolute geomagnetic field values at the Adolf Schmidt Geomagnetic Observatory at Niemegk]: Geophys. Inst. Potsdam Abh., no. 13, 70 p., 1954.

This is a detailed report on absolute determinations of geomagnetic elements, particularly H, made during 1950–1954 at the Niemegk Observatory. The horizontal component is determined by the Gauss-Lamont method and the Schmidt method, with an accuracy of ± 1.3 γ. The instruments, determination of their constants, error, and comparison measurements with other observatories are described fully. The instruments and procedures used in determining D and I are treated briefly.—*S. T. V.*

173-276. Przybyszewski, Eugeniusz. Porównanie magetometrów La Coura Obserwatorium Geofizycznego na Helu, Obserwatorium Geofizycznego w Świdrze i Uniwersytetu Warszawskiego [Comparison of La Cour magnetometers of the geophysical observatory on the Hel peninsula, the geophysical observatory in Świder, and Warsaw University (with English summary)]: Acta Geophys. Polonica, v. 6, no. 1, p. 49–76, 1958.

The results of comparison of the La Cour magnetometers (seven QHM and three BMZ) of the Hel and Świder observatories and Warsaw University in Poland are tabulated and discussed.—*D. B. V.*

173-277. Małkowski, Zdzisław. Porównanie wskazán magnetometru *BMZ* 86 z bazami obserwatoriów w Niemegk i w Świdrze [Comparison of the BMZ-86 magnetometer with base-lines of the observatories in Niemegk and Świder (with English summary)]: Acta Geophys. Polonica, v. 5, no. 3, p. 216–226, 1957.

The results of measurements of the geomagnetic vertical component made with a BMZ-86 magnetometer at Niemegk in November 1956 and at Świder

in January 1957 are presented. The results of 16 series of measurements (158 individual measurements) in Niemegk gave a Z-component value 31.8±0.3γ higher in relation to the base line of that observatory; the results of eight series of measurements (80 individual measurements) in Świder gave a Z-component value 24.9±0.9γ higher in relation to the base line of the Świder observatory. Thus the difference between both bases during this time was 7±1γ. Because only one instrument was available for use, because of the two-month interval between measurements at Niemegk and at Świder, and because of the provisional nature of the Świder base line value, the results are considered only a preliminary confirmation of the order of difference between the base lines of the two observatories.—*D. B. V.*

173–278. Kuboki, Tadao, and Kurusu, Kikuo. Intercomparison observations at Kakioka and Memambetsu by means of QHM magnetometers during 1952–1953: Kakioka Magnetic Observatory Mem., v. 7, no. 2, p. 1–18, 1956.

After a brief description of the QHM magnetometer and discussion of possible sources of observational error, the results of intercomparison observations with Cheltenhan conducted at Kakioka and Memambetsu in December 1952 to March 1953 by means of three QHM instruments (No. 50, 51, and 52) are tabulated, summarized, and discussed. The observational errors are approximately those expected. The differences QHM-Kakioka as well as QHM-Memambetsu show rather systematic values depending on the torsional angles, probably because the constant of the quartz fiber varies slightly with torsion.—*D. B. V.*

173–279. Imamiti, Syuiti. Secular variation of the magnetic declination in Japan: Kakioka Magnetic Observatory Mem., v. 7, no. 2, p. 49–55, 1956.

This is an expansion of an earlier (1938) study by Shinozaki of secular variation of magnetic declination in Japan, based on data for the 17th and early 18th century; most of the observations in those days were made from wooden ships using compasses whose precision must have been about ±30′. The data are reduced to the values at Kakioka and from these values the secular variation in Japan is computed. The extreme value of east declination (about 8°) occurred a little after the middle of the 17th century. At the present rate of change the extreme value of west declination, about 7°–8°, will be in the year 2060 or 2070. If this variation is cyclic its period and amplitude are about 800 years and 15′, respectively. This period is nearly twice as long as that calculated for Europe, and the amplitude is only about half as great.—*D. B. V.*

173–280. Whithan, K[enneth], and Loomer, E. I. An investigation of magnetic pulsations at Canadian magnetic observatories: Dominion Observatory Ottawa Pubs., v. 19, no. 7, p. 265–279, 1958.

More than 1,000 pulsations, with approximately constant periods and ranges exceeding three gammas, have been studied using Meanook and Agincourt standard run magnetograms for the years 1951 to 1954. This investigation confirms the existence of two separate classes of pulsations, differing in form, time of diurnal occurrence, and mean period. Some additional characteristics reported earlier from Scandinavia are confirmed, but it is now thought that the narrow band Rolf micropulsations are not infrequent ~1,200 kms south of

the auroral zone in Canada. Very few regular pulsations were observed on magnetograms from stations north of the auroral zone.

Although magnetohydrodynamic waves in the upper parts of the ionosphere provide a possible periodic explanation, the different times of occurrence of the classes in Scandinavia and Canada, and even across Canada, the relationship of the primary sources of pulsations to magnetic disturbance measured by *K*-indices, and the southern geomagnetic extension in Canada of observable pulsations remain unexplained. Screening effects in the lower ionosphere are considered and provide one explanation of the observed amplitude-period trend.—*Authors' abstract*

173–281. Duffus, H. J., and Shand, J. A. Some observations of geomagnetic micropulsations: Canadian Jour. Physics, v. 36, no. 4, p. 508–526, 1958.

New observations of diurnal variation, direction, frequency spectrum, and geographical distribution of geomagnetic micropulsations (*Pc* and *Pt*) made at Victoria, British Columbia and Halifax, Nova Scotia show that frequency and probability of occurrence vary with local solar time and latitude and that micropulsations are detectable over only a portion of the earth's surface at a given instant. Related signals were only occasionally observed at the two stations, 60° of longitude apart. The difference in phase characteristics of such related signals, together with differences in directional characteristics reported by other observatories, put serious strain on recent theories of the outer atmosphere origin of micropulsations. The distinction between *Pc* and *Pt* remains, however, and careful separation of these two types may hold the key to their origin.—*D. B. V.*

173–282. Yumura, Tetsuo. On the sudden commencements in geomagnetic storms. Part II—The local time variations: Kakioka Magnetic Observatory Mem., v. 7, no. 2, p. 31–48, 1956.

The local time variations of sudden commencements of 396 magnetic storms recorded at Kakioka for the period 1924–1951 have been analyzed. First the maximum frequency of the direction angles (ϕ) of horizontal vectors is determined to be 16° E of (magnetic) N; of their magnitudes (ΔF) to be 13.7γ; and of the ratios of vertical to horizontal changes ($\Delta Z/\Delta F$) to be 0.55. Statistical treatment of these quantities of *SCs* shows that the local time effect appears distinctly in their daily variation, especially of ϕ and $\Delta Z/\Delta F$. The equivalent current arrow diagram based on the results show the possible flow in the upper atmosphere over Kakioka that could cause the daily variation of horizontal vectors of *SCs*. It is suggested that the ultimate origin might be in ionospheric shielding effects. See also Geophys. Abs. 158–48.—*D. B. V.*

173–283. Lisowski, Bolesław. On non-cyclic variations of magnetic declination in Świder during the years 1921–1936: Acta Geophys. Polonica, v. 5, no. 3, p. 210–215, 1957.

The results of investigations on non-cyclic variations of magnetic declination in Świder observatory, Poland in the years 1921–1936 are tabulated. Four tables list mean non-cyclic data for quiet days, analogous data for disturbed days, mean monthly corrected values for solar diurnal variations of declination on quiet days, and similar data for disturbed days.—*D. B. V.*

173–284. Kalinowska, Zofia. Burze magnetyczne, zanotowane *w* roku 1957 w Obserwatorium Geofizycznym w Świdrze [Magnetic storms registered in the year 1957 at the geophysical observatory in Świder (with English summary)]: Acta Geophys. Polonica, v. 6, no. 1, p. 86–88, 1958.

Magnetic storms recorded in 1957 at Świder observatory in Poland are listed, giving time of beginning and ending, sudden commencement in *D*, *H*, and *Z*, maximum activity, and amplitude of *D*, *H*, and *Z*. Magnetic storms were most frequent in the third quarter of the year, especially in September; the strongest were those of January 21, June 30, September 4, and September 29.—*D. B. V.*

MAGNETIC PROPERTIES AND PALEOMAGNETISM

173–285. Collinson, D. W., Creer, K. M., Irving, E., and Runcorn, S. K[eith]. The measurement of the permanent magnetization of rocks: Royal Soc. London Philos. Trans., v. 250, no. 974, ser. A, p. 73–82, 1957.

This is a short instruction manual on the design and operation of astatic magnetometers used in the measurement of permanent magnetization of rocks.—*J. R. B.*

173–286. Howell, Lynn G., Martinez, Joseph D., and Statham, E. H. Some observations on rock magnetism: Geophysics, v. 23, no. 2, p. 285–298, 1958.

In general the plane of maximum magnetic susceptibility lies in the bedding plane for sediments and in the plane of foliation for metamorphic rocks; in the latter there is also a tendency for the remanent vector to lie in the plane of foliation. The question whether, in the case of chemical deposits, hematite crystal growth is controlled by the magnetic field has been investigated by study of several formations. The remanent vector of the Clinton ore is found to lie close to the plane of maximum susceptibility but unfortunately this also is the bedding plane. Several other formations show a direction of magnetization close to the bedding plane. Measurements of magnetization and susceptibility anistropy of samples cooled below the transition temperature for hematite yielded no conclusive results other than indications of the presence of hematite in some cases. In the Precambrian Hazel formation, a slightly metamorphosed red bed, the planes of maximum susceptibility dip at various angles; a system of microfractures containing magnetic material is suggested in explanation. The position calculated for the north magnetic pole in Clinton time is lat 35° S, long 42° W; for the Hazel formation, two sets of pole positions are calculated: from flat-lying beds, north pole at lat 49° N, long 175° W, south pole at lat 49° S, long 5° E, and from dipping beds, north pole at lat 60° N, long 151° E, south pole at lat 60° S, long 29° W.—*D. B. V.*

173–287. Kalashnikov, A. G. O raspredelenii ostatochnoy namagnichennosti v kubakh i tsilindrakh iz gornykh porod [On the distribution of the the remanent magnetization in cubes and cylinders of rock]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 4, p. 550–553, 1958.

Cubic and cylindrical samples were made of clay with the addition of 57 percent (by volume) of powdered magnetite. The susceptibility of this mixture was about 0.12. The cubes were 7 cm on edge; the radii of the cylinders 4 cm, their height 6 cm. These specimens were magnetized in a homogeneous magnetic

field having a constant intensity of 150 oersteds. The direction of the edges of the cubes and of the axes of the cylinders coincided with the direction of the magnetizing field. The specimens were cut into cubes 9 mm on edge and the remanent magnetism of these small cubes investigated. It was found that only the specimens taken from the center portion of the initial specimens preserved the direction of the initial magnetizing field; all the others showed deviations up to 15°. This fact must be kept in mind in paleomagnetic studies.—*S. T. V.*

173–288. Reimer, L[udwig]. Magnetische Eigenschaften dünner ferromagnetischer Schichten [Magnetic properties of thin ferromagnetic layers]: Zeitschr. Geophysik, v. 25, no. 1, p. 53–64, 1958.

This is a summary of Reimer's experimental work on the magnetic properties of thin films prepared by evaporation and electrolytical deposition. When the film thickness is smaller than the thickness of a domain wall, the film contains no walls, thus leading to an increase of coercivity with decreasing film thickness. In films smaller than 100 Å the magnetic saturation decreases. In this range of thickness Néel has shown that reversals of magnetization may be due to thermally induced fluctuations of the directions of magnetization, thus explaining thermoremanent magnetization of lavas in an opposite direction to the earth's magnetic field found by Nagata. In lavas the ferromagnetic compound exists in the form of small particles; in thin films we have the same magnetic anomalies as in small particles. Therefore, the measurement of thin films can also give information about the properties of small ferromagnetic particles. The variation of the form of hysteresis loops with decreasing film thickness is determined, in order to get an experimental confirmation of the magnetization reversal by thermally induced fluctuations proposed by Néel.—*I. Z.*

173–289. Green, R., and Irving, E. The paleomagnetism of the Cainozoic basalts from Australia: Royal Soc. Victoria Proc., v. 70, pt. 1, p. 1–17, 1958.

The magnetic properties of the Cainozoic volcanics from their type area in Victoria are examined in detail to give the broad picture of the behaviour of the Earth's magnetic field as it existed at the time of extrusion of these volcanics. On the basis of the direction of magnetization of stably magnetized samples, a clear-cut division is found to exist between the Older Volcanics of Gippsland and the Newer Volcanics of the Western District and, since such a division should be found by sufficient sampling to exist for all other Cainozoic volcanics, the possibility of this new method for stratigraphical correlation is illustrated by a few paleomagnetic measurements of volcanics from elsewhere in eastern Australia.

Numerous specimens from both the Older and Newer Volcanics are found with the direction of magnetization reversed, which is important in geophysical prospecting and may be of value for detailed geological mapping.

The plausible dipole assumption for the steady-state condition of the Earth's magnetic field is used in conjunction with the palaeomagnetic measurements to advance the idea of limited polar wandering during the Cainozoic.—*Authors' abstract*

173–290. Irving, E., and Green, R. Polar movement relative to Australia: Royal Astron. Soc. Geophys. Jour., v. 1, no. 1, p. 64–72, 1958.

From paleomagnetic measurements on some Australian rocks the movements

of the geomagnetic pole relative to Australia during and since the Upper Proterozoic are obtained in broad outline. The path of movement is known in some detail from Carboniferous to Recent time, less certainly before. During Upper Proterozoic time the mean geomagnetic south pole probably lay near Australia; by Cambrian time it had moved to the region of what is now South Africa; then it passed southwards into the Antarctic Ocean by Silurian and early Devonian times. In Upper Carboniferous and Permian it lay in the Tasman Sea, then it moved slowly southward, reaching the present geographic pole towards the end of the Teritary. Except in later Cenozoic times the poles determined from Australian data do not coincide with equivalent results from Europe, North America, Africa, and India. The contrast is greatest in Upper Paleozoic and early Mesozoic (50° to 90° of arc difference), far greater than any experimental error. It is difficult to explain such discrepancies without admitting continental drift.—*D. B. V.*

173–291. Nairn, A. E. M. Observations paléomagnétiques en France: roches permiennes [Paleomagnetic observations in France: Permian rocks]: Soc. géol. France Bull., v. 7, no. 6, p. 721–727, 1957 (1958).

The mean direction of remanent magnetization has been determined for a number of samples of three Permian rocks from France. For the Saxonian(?) Nideck porphyry from the Vosges the declination is S 13° W and inclination −7°, indicating a pole at long 168° E, lat 43° N; for a Saxonian red sandstone from Montcenis in the Morvan the declination is S 17° W and inclination +6°, indicating a pole at long 162° E, lat 38° N; and for an Autunian (lower Rotliegende) red sandstone at Saint Wendel in the Saar the declination is S 1° W and inclination −9°, indicating a pole at long 185° E, lat 45° N. These poles all agree well with that determined for the Exeter basalt in England, but diverge 40° from those determined from American measurements; this may be taken as evidence of continental drift.—*D. B. V.*

173–292. Creer, K. M. The natural remanent magnetization of certain stable rocks from Great Britain: Royal Soc. London Philos. Trans., v. 250, no. 974, ser. A, p. 111–129, 1957.

The remanent magnetization of the trachytic and basaltic Permian lavas of Devon varies from S 6–12° W and inclination from 25° down to 27° up. The direction of remanent magnetization of flat-lying sandstone rocks is S 16° W, 4° up with a circle of confidence of 5°. Dipping or folded Old Red Sandstone rocks showed anomalous magnetizations as if a secondary component had been acquired after folding. The Cambrian sandstone of South Wales has a mean direction of magnetization of S 7° W, inclination 39° down with circle of confidence of 8°. The Precambrian Wentnor series in Wales shows a mean direction of N 66° W, inclination 29° up with a 12° circle of confidence. Two groups of rocks are represented, one with southeast declinations and inclination down and the other with northwest declinations and inclination up. These directions compare favorably with those of the upper Torridonian rocks of Scotland and suggest that they may be of the same age.—*J. R. B.*

173–293. Irving, E. The origin of the palaeomagnetism of the Torridonian standstone of northwest Scotland: Royal Soc. London Philos. Trans., v. 250, no. 974, ser. A, p. 100–110, 1957.

Study of the iron oxide minerals in the Torridonian sandstone shows that the thermal remanent magnetization is due to the presence of detrital specularite

particles that contain a small inclusion of magnetite. These grains retained their original thermal remanent magnetization; during deposition they became aligned approximately parallel to the geomagnetic field.—*J. R. B.*

173–294. Irving, E., and Runcorn, S. K[eith]. Analysis of the palaeomagnetism of the Torridonian sandstone series of northwest Scotland, 1: Royal Soc. London Philos. Trans., v. 250, no. 974, ser. A, p. 83–99, 1957.

Measurement of about 400 specimens of the Torridonian sandstone in northwestern Scotland shows that the lower (Diabaig) group is magnetized in a direction of N. 53° W. with an inclination of 34° down, with a circle of confidence of 7°. The upper (Aultea) and middle (Applecross) groups show magnetizations alternating between S. 51° E., inclination 51° down, and N. 66° W., inclination 28° up, with circles of confidence of 5° and 9° respectively. About ten percent of the rocks show directions oblique to these. The lower 2,000 feet of the Applecross group has been sampled at 18 places over a distance of approximately 36 miles and in all cases the direction of magnetization is SE down, indicating that this horizon is uniformly magnetized over this distance. All of the classic criteria show that the magnetizations are attributed to reversals of the geomagnetic field rather than to spontaneous reversals of magnetization.—*J. R. B.*

173–295. Creer, K. M. The remanent magnetization of unstable Keuper marls: Royal Soc. London Philos. Trans., v. 250, no. 974, ser. A, p. 130–143, 1957.

The natural remanent magnetization of the unstable Keuper marls has been found by experiment to consist of three components: a primary component created on or soon after deposition in the same direction as that of the stable Keuper sandstone and marls; a secondary component in the direction of the geocentric axial dipole field; and a temporary component built up by the geomagnetic field during the time between collection and measurement of the sample. The temporary and secondary components of magnetization appear to be isothermal and due to the red hematitic cement. This is consistent with Week's theory that the magnetization of small single domain particles would be unstable if the diameter is less than 0.15 μ.—*J. R. B.*

173–296. Creer, K. M., Irving, E., and Runcorn, S. K[eith]. Geophysical interpretation of palaeomagnetic directions from Great Britain: Royal Soc. London Philos. Trans., v. 250, no. 974, ser. A, p. 144–156, 1957.

A review of the various paleomagnetic data for British and American rocks suggests that there has been slow migration of the poles and that since Jurassic time there has been a relative motion of several thousand miles of North America away from Europe. The data also suggest that there have been frequent reversals of the geomagnetic field since late Precambrian time.—*J. R. B.*

173–297. Kutscher, Fritz, and Angenheister, Gustav. Angewandte erdmagnetische Messungen in Hessen. 4. Gesteinsphysikalische Untersuchungen an den Kernproben der Bohrung Weyer 1 (Lahnmulde, Hessen) [Applied geomagnetic measurements in Hesse. 4. Investigations of the physical properties of rock on the core samples from the Weyer 1 borehole (Lahnmulde, Hesse)]: Hesse Landesamt für Bodenforschung zu Wiesbaden Notizbl., v. 84, p. 385–402, 1956.

A magnetic survey conducted in 1938–1942 in the iron ore-bearing Lahn basin in Hesse, Germany showed a broad, almost circular anomaly east of Weyer. In view of the fact that the susceptibility of the hematite ore varies from 2×10^{-4} to 300×10^{-4} cgs units, it was thought that the source of the anomaly was not hematite but possibly a layer of magnetite; however, the Weyer 1 borehole, over 500 m deep, did not reach such a layer. At 178 m, a diabase intrusion almost 110 m thick was encountered and its magnetic properties were investigated both in the field and in the laboratory. Susceptibility measurements in the field showed striking variations within the diabase, with the strongest intensity of magnetization concentrated at the top of the body; bu at most the diabase can account for only about 10 percent of the observed anomaly.

Laboratory measurements made on core samples from this and from another diabase at Waldhausen for comparison purposes show that in the weakly magnetized portions the induced magnetization is stronger than the remanent; even when the latter is as strong (as when the total magnetization is of the order of 100 or several hundred γ) the form of the anomaly is still influenced mainly by the induced magnetization, because the remanent magnetization is not homogeneous. A general correlation exists between susceptibility, artificial thermoremanence, saturation magnetization, and saturation remanence; these values are plotted graphically against depth for both diabase bodies. The saturation remanence is about 50 times greater than the artificial remanence, and the latter about 5 times greater than the natural remanence. The saturation thermoremanence is of the same order of magnitude as the usual saturation magnetization and is reached at about the same field strength. It is concluded that the magnetic behavior of diabase is quite distinct from that of basalts and magnetic hematite ore.—*B. T. E., D. B. V.*

173–298. Bhimasankaram, V. L. S., and Rao, B. S. R. Manganese ore of South-India and its magnetic properties: Geophys. Prosp., v. 6, no. 1, p. 11–24, 1958.

An investigation of magnetic properties of samples collected from the Kodur manganese belt shows that in general the magnetized concentrations of manganmagnetite and vredenburgite minerals produce the irregular anomalies found in magnetic surveys. The minerals exhibit ferromagnetic properties. Powdered samples with grain size of 0.5 mm and packing density of 1 gm per cm^3 give susceptibilities ranging from 5 to $5{,}000\times10^{-6}$ cgs and high values of

coercive force and remanent magnetization. The susceptibility in a field of 0.35 Oe shows a linear dependence of percentage of normative $(Mn, Fe)_3 O_4$ as calculated from the ferromagnetic constituents determined by chemical analysis. The predominant manganese minerals in the ore deposits, psilomelane and pyrolusite, have low susceptibilities. It is, therefore, concluded that the magnetic character of the samples and the associated magnetic anomolies depend not on the amounts of commercially important manganese and iron but on relatively small concentrations of minerals such as manganmagnetite and vredenburgite.—*G. D. B.*

173–299. Bossolasco, Mario. Contributo al paleomagnetismo in Italia [Contribution to paleomagnetism in Italy]: Geofisica Pura e Appl., v. 39, p. 109–119, 1958.

When the intensity of remanent magnetization of a body is greater than that of the induced, as in the case of basalt and andesite flows and some magnetic ore bodies, the axis of magnetic polarization and also the direction of remanent magnetization for paleomagnetic purposes can be determined by magnetic surveys. An advantage of this method is that it can be used on bodies that are buried. The directions of magnetization of eleven individual lava flows at Stromboli determined in this way range from 0° to 45° east of north, reflecting secular variation of declination during the Quaternary. (Six of these show reversed magnetization, which might be explained by internal processes during cooling.) These directions can be correlated with pole positions found by Nagata and others for Japanese lavas (see Geophys. Abs. 171–269). The same principle can be applied to magnetic ore bodies, if a mass of ferromagnetic minerals has stayed continuous and compact during its formation and has not been altered subsequently. The magnetization of the Pàmera magnetite deposit in Val Sugana is substantially that of the present magnetic field; at the Traversella deposit in Piedmont the magnetization trends about 9° east of the present geographic pole; therefore, this deposit is somewhat older than the Pàmera; and in the Silurian magnetite deposit near Raccuja the direction of magnetization has a mean direction of 116° E.—*D. B. V.*

Schreiner, G. D. L. Age of a Pilansberg dike of paleomagnetic significance. See Geophys. Abs. 173–11.

MAGNETIC EXPLORATION

173–300. Wahl, W. George. Magnetic prospecting for iron ores, *in* Snelgrove, A. K. and others, Geological Exploration: Michigan Coll. Mining Technology, Inst. Lake Superior Geol., p. 49–53, 1957.

Field and interpretative methods and instrument modifications to speed up the mapping of magnetic data in areas of iron ore deposits are discussed. Instruments described are the compass, dip needle, Schmidt-type magnetometer, and airborne magnetometer.—*V. S. N.*

173–301. Zmuda, A[lfred] J. Extrapolation of scalar magnetic intensity along a radius from the center of the earth: Am. Geophys. Union Trans., v. 39, no. 3, p. 490, 1958.

The scalar magnetic intensity F may be extrapolated along the extension of a radius of the earth by use of the formula $F(h)=F_o e^{-\tau h}$, where F_o is the value of F on the surface $h=o$, and τ is a single value assumed adequately to charac-

terize the variation with altitude. A value of τ may be computed from knowledge of F at two points along the radius.—*R. G. H.*

173–302.—Mácha-Zeiss, Arnošt. Grafické vyhodnocování geomagetických anomalií pro užitou geofysiku [Graphical evaluation of magnetic anomalies in applied geophysics (with English and Russian summaries)]: Československá Akad. Věd Geofys. Ústav Práce, Geofys. Sborník, no. 18, 19 p., 1954.

A description of a graphic method of interpreting local magnetic anomalies is given. The depth of the apex, inclination, and horizontal displacement of the anomalous maximum from its highest center are ascertained; where susceptibility is known the thickness can also be determined. In this paper only the case of a plate at unlimited depth is treated. The resulting graph is valid for all anomalies irrespective of latitude, except that the sign must be changed for the southern hemisphere. The following must be known about the anomaly: location and terrain; trend with respect to magnetic north; exact measurement of Z at the maximum and around the periphery; susceptibility (if thickness is to be determined); geomagnetic inclination and intensity. For the method to be satisfactory the depth of the body must be greater than its thickness and magetization must be that normally produced by the geomagnetic field. Two examples are cited. In the case of the Kursk anomaly in the U. S. S. R., difficulties are caused by the unfavorable ratio of thickness to depth and abnormal magnetic intensity. The second case concerns the anomalies over lamprophyre dikes.—*D. B. V.*

173–303. Milstein, Mark. New method indicates productive area: World Oil, v. 143, no. 6, p. 113–115, 1956.

Magnetic characteristics of sedimentary rocks are said to be sufficient to create measurable contrasts which can be evaluated; these small differences reflecting the influence of localized features are the basis of a new method of interpretation of observations made with conventional magnetic devices. Instead of assuming a unique magnetic field, the observational curve is split up into magnetically uniform "domains"; all existing randomly magnetized matter belongs to various "domains". A reconnaissance survey of the Hainesville salt dome in Texas is presented as a demonstration of the validity of the "domain" principle, which brings out directly the relationships between the stratigraphy and magnetic values. Four areas regarded as promising are recommended for drilling to test the effectiveness of the new method.—*L. C. P., D. B. V.*

173–304. Wasserman, Gilbert. Magnetic survey of the Staten Island serpentinite: Staten Island Inst. Arts and Sci. Proc., v. 18, no. 1, p. 3–19, 1956.

A magnetic survey of the Staten Island serpentinite contributes to the support of many hypotheses explaining the structure of the body. High magnetic intensities, along the eastern edge of the mass, do not refute any of the theories yet advanced. Low magnetic intensities in the central part of the mass tend to concur with Britton's theory that a thin layer of serpentine overlies a different but unidentified rock in this part. Other phenomena which could produce the same pattern of intensities are a deposit of magnetite, changes in polarization of the mass, or changes in the composition of the rock masses concerned. Measurements on oriented specimens of the serpentine show an

average magnetic susceptibility of $.6\times10^{-3}$ cgs units and a remanent magnetization of 1.02×10^{-3} cgs units intensity, 218° azimuth and 74° inclination.—*V. S. N.*

173–305. López Arroyo, Alfonso. Estudio geofísico de la falla de Ste. Genevieve [Geophysical study of the St. Genevieve fault]: Rev. Geofísica, v. 15, no. 60, p. 387–434, 1956.

The first part of this paper is a critical review of theories of rock fracture, with particular attention to fracture in anisotropic media and the behavior of crustal blocks. Then the results of a magnetic survey of the St. Genevieve fault zone in Missouri are reported and interpreted. The fault zone is found to consist of a number of fault lines with small vertical displacement, dipping approximately vertically. The susceptibility of the Precambrian basement is found to be high but not as high as reported by other authors in other parts of the Ozarks. An important feature is the presence of basic intrusions along the faults. Movement appears to have occurred in two main phases, one at the end of the Devonian with mainly horizontal displacement, the other in post-Pennsylvanian time producing reverse faults. Both phases of movement were influenced by the presence of a fracture zone in the basement. For the Ozarks in general, the principal directions of fracture are roughly parallel to the borders of the dome and constitute a double system of coupled faults with horizontal displacement, with basic intrusives and mineralization along the fault planes. Recent seismic activity is related to these northwest-southeast and northeast-southwest fracture systems, with greater activity on those near the eastern edge than toward the interior. (This paper is a Spanish version of a master's thesis presented at the University of St. Louis.)—*D. B. V.*

173–306. Meen, V. B[en]. Merewether Crater—a possible meteor crater: Geol. Assoc. Canada Proc., v. 9, p. 49–67, 1957.

Merewether Crater near Hebron, Labrador, is a nearly circular lake-filled depression in ground moraine sloping uniformly at about 35° to a remarkably symmetrical lake bottom. The crater, top and bottom, is slightly elongated in a direction transverse to the movement of the ice and to the strike of the schists and gneisses underlying the valley. The proportion of depth (maximum 160 ft) to diameter (average 650 ft) is large in comparison with other lakes in the area with the exception of two nearby smaller lakes of similar proportions. Only a semblance of rim can be distinguished but it is highest at the end of the longest diagonal and a magnetometer survey showed a slight positive anomaly at this highest point. Using Baldwin's equation, which relates diameter and depth of craters in cases of terrestrial or lunar explosion, and meteoric impact, $D=0.1088d^2+0.6917d+0.75$ where D=log diameter in feet, and d=log depth in feet; the agreement is excellent in this case where $D(2.81)=2.79$.

The sum of evidence at Merewether Crater is in favor of a meteoric origin. There is no evidence for volcanic activity, origin by sapping or glacial kettle, or by underground solution.—*V. S. N.*

173–307. Hellbardt, G[unter]. Über die Grenzempfindlichkeit des astatischen Spulenmagnetometers [On the sensitivity limit of the astatic coil magnetometer]: Zeitschr. Geophysik, v. 25, no. 1, p. 34–52, 1958.

The possibility of building a coil-magnetometer after Durschner with better sensitivity is discussed. There is evidence that the magnetometer could be

improved by the use of better coils with a more homogeneous magnetic field inside the coil than that of a Helmholtz coil. The lower limit of measurable magnetization will be 10^{-6} Gauss for this type of magnetometer.—*I. Z.*

173–308. Schmidt, Herbert. Die Nullpunktsstabilität von Förstersonden [The zero-point stability of fluxgate total field magnetometers]: Freiberger Forschungshefte C 22, p. 20–28, 1956.

This is a discussion of the sources of zero-point error inherent in the apparatus and techniques of fluxgate total field magnetometers, giving methods of decreasing or completely eliminating these errors.—*D. B. V.*

173–309. Mumme, I. A. Ground magnetometer investigations—Glenorchy–Kalabity area: South Australia Dept. Mines Mining Rev., no. 104, p. 94–98, 1956 (1957).

Ground magnetometer surveys were made in the area of North Billeroo Dam and Alconie Dam to determine the cause of magnetic anomalies located by an airborne survey. Results indicate that the anomalies represent a magnetite-bearing mica-phyllite and schist in the same geological horizon as the Billeroo iron ore deposits and suggest the possibility of economic iron ore deposits at shallow depth under the alluvium and glaciofluvial beds.—*V. S. N.*

Knapman, W. H. Gravity and magnetic traverses in the far northwest of South Australia. See Geophys. Abs. 173–204.

173–310. Hoge, E. Symposium sur les mouvements récents du sol belge et les enseignements qu'ils apportent. 2.—Synthèse du magnétisme terrestre en Belgique [Symposium on recent movements of the ground in Belgium and the information they convey. 2.—Synthesis of terrestrial magnetism in Belgium]: Cong. nat. Sci. (Belgium), 3d, Brussels, v. 4, p. 39–41, 1950 (1954).

Successive magnetic surveys in Belgium, between 1904 and 1937–1938, have resulted in several maps including a detailed map of the Spa-Hautes Fagnes region. Highs occur in the vicinity of Spa, along the axis of the Ardennes dome, and in the Bilsen region (corresponding to the east end of the axis of the Brabant anticline). A low occurs in the vicinity of Hasselt, and strong positive and negative anomalies are found in the Paliseul–Libramont–Bastogne region. Other local anomalies occur at different points. The magnetic anomalies correspond in a general way to gravity anomalies of opposite sign. Comparison with precise levellings shows that regions of recent uplift generally coincide with positive magnetic anomalies. See also Geophys. Abs. 173–205 and 185.—*D. B. V.*

173–311. Norinelli, Armando, and Sogaro, Lorenzo. Nuovi dati geofisici sul distretto eruttivo euganeo-berico-lessineo. Parte seconda: Dati magnetici [New geophysical data on the Euganeo-Berico-Lessineo igneous area. Part 2. Magnetic data (with English summary)]: Boll. Geodesia e Sci. aff., v. 15, no. 4, p. 517–530, 1956.

A magnetic survey was made in 1952 and 1953 of an area of about 8,500 km^2 in northern Italy bounded by the Po, the Venetian lagoon, the parallel of Bassano, and the meridian through Sirmione, which includes the Euganeo-Berico-Lessineo igneous complex. A Schmidt balance was used to measure the

vertical geomagnetic component at 368 stations; mean density was one station per 23 km², with greatest density in the Euganeo-Berico vicinity. For each station the latitude, longitude, observed *Z*, normal *Z*, and *Z* anomaly are tabulated, and the results are compiled in a magnetic map. See also Geophys. Abs. 173–209.—*D. B. V.*

Bossolasco, Mario. Contribution to paleomagnetism in Italy. See Geophys. Abs. 173–299.

173–312. Yumura, Tetsuo. Distribution of the earth's magnetic field in Akita Prefecture (2d report).—Report of the detailed observation over the Asahigawa oil-field (in Japanese with English summary): Kakioka Magnetic Observatory Mem., v. 7, no. 2, p. 119–129, 1956.

Results of a detailed geomagnetic survey of the Asahigawa oil field in Akita Prefecture, Japan, are presented, with a magnetic map and tables of data for the 423 stations occupied. Anomalies are more pronounced in the northern and eastern parts of the area. Five anticlinal and four synclinal axes, cut by two faults, are inferred from the magnetic data.—*D. B. V.*

173–313. Yumura, T[etsuo]. Magnetic properties of Volcano Sakurajima (in Japanese with English summary): Quart. Jour. Seismology, v. 21, no. 2, p. 13–23, 1956.

The average magnetic properties of Volcano Sakurajima, Japan, as determined by a magnetic survey in 1944 are presented. The observed anomaly is equivalent to that produced by an ellipsoid of rotation whose horizontal radius is about 4 km, vertical radius about 2 to 3 km, and average magnetic susceptibility about 5 to 7×10^{-3} cgs. The direction of magnetization is northward and upward. If the source of eruptions is less than 2 km below sea level, it might be possible to predict activity from even simple magnetic observations, but if the depth of origin is greater, the magnetic effects due to eruptions may be more difficult to determine. Prediction might be possible by means of a combination of detailed magnetic observations with other geophysical observations.—*D. B. V.*

173–314. Kobets, N. V., and Komarov, B. V. Nekotorye voprosy metodiki poiskov korennykh mestorozhdeniy almazov na osnove aerometodov [Some questions of methods of prospecting for primary diamond deposits by means of airborne methods]: Akad. Nauk SSSR Izv. Ser. geol., no. 2, p. 85–93, 1958.

A report on the use of airborne photographic and magnetic methods in the search for kimberlite bodies in central Siberia. A team consisting of a geologist, geobotanist, and geophysicist with M–2 magnetometer proved very effective; the work of each reinforced that of the others. Kimberlite bodies too small or too weakly magnetic to be detected by the magnetometer survey often could be picked up on air photos, whereas others that did not show in the photographs were revealed by the magnetic data; thus, the two methods confirmed and complemented one another. This combination is obligatory in regions such as the one mentioned. It is concluded that the combined airborne methods might be useful in prospecting for other types of mineral deposits as well as for geologic mapping and engineering surveys.—*D. B. V.*

MICROSEISMS

173–315. Donn, William L. Microseisms: Their nature and geologic application: New York Acad. Sci. Trans., ser. 2, v. 20, no. 2, p. 152–153, 1957.

The nature and origin of microseisms are reviewed. Present data suggest that microseisms travel with little attenuation in coherent layers of the crust with the layers acting as wave guides for microseism energy. It is apparent that a continent–ocean margin or island arc–ocean margin acts as a barrier to microseisms, but that propagation is fairly efficient within each unit. In general, the study of the propagation of microseisms seems to reveal gross structural trends in the earth's crust, and a systematic study of the data may reveal regions worth investigating by a more refined technique.—*V. S. N.*

173–316. Gilmore, Marion H. Microseisms used in hurricane forecasting: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 205–215, 1956.

On empirical evidence several relationships between severe tropical storms and amplitude of microseisms have been formulated. The fundamental relationship is that a tropical disturbance generates microseisms and when it is within range of a microseismic station the amplitude of the microseims recorded at that station will reflect changes in intensity and or distance from the station. Basic working hypotheses that apply to all storms within range of one or more properly located stations are as follows: when a hurricane of constant intensity approaches a station, the amplitude of microseisms will increase, and when it draws away, the amplitude will decrease; when a hurricane is between two stations, the amplitude will increase at the station it is approaching while decreasing at the other; when a hurricane changes in position and intensity at the same time as the trend at a single station it is more difficult to analyze, but this confusion can be resolved in most cases if the storm is within range of three or more properly located stations. Microseisms thus may be used by forecasters of tropical storms in four ways; to aid early detection, to indicate their intensity, to indicate changes in intensity, and to aid in location. Each of these functions is dependent on the requirement that the microseisms at a station must be generated only by the storm being tracked. The discussion is illustrated by numerous examples of actual storms.—*D. B. V.*

173–317. Zatopek, A[lois]. Sur les microséismes de Praha [On the microseisms at Praha]: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 183–191, 1956.

Study of microseisms at Praha [Prague] for the period January 1, 1948 to May 31, 1954 shows that microseisms there are most often recorded in the form of groups of sinusoidal oscillations having periods between 3 and 9 sec with the maximum frequency near 4.5 sec. Amplitudes, generally largest in the north component, never exceed 3 microns. Records obtained with the two torsion instruments also show microseisms of two-sec period, probably local in origin as they never appear in the seismograms of the horizontal Weichert instrument. The general character of the microseisms at Praha as a function of weather shows a surprising resemblance to those at DeBilt, Jena, Strasbourg, and Uppsala rather than correlating with the Mediterranean (Rome) and Adriatic (Trieste) regions as was expected. Critical areas affecting genera-

tion and evolution of the microseisms are southern and southwestern Iceland, the sea between Iceland, Scotland, and Scandinavia, and the northern Baltic Sea; rapid movement of cyclonic depressions across these areas produces maximum amplitudes at Praha, although slowly moving centers have no observable effect. Extreme northern Norway is the only other region where cyclones have any effect. The effect of fronts is harder to evaluate. In many cases the eastward passage of a front across the Baltic Sea definitely produces a considerable increase in amplitude at Praha, probably due to standing waves in the Baltic. Some of the 4- to 5-sec microseisms may be attributed to the surf effect on the Norwegian coast under the influence of strong west or northwest winds. Those with periods greater than 5 sec are attributed to intense or extensive lows near Iceland. A diurnal variation is noted, having a minimum near midnight and a maximum between 12^h and 18^h. In this study the methods of graphic statistics offered many advantages in correlating microseisms and meteorological agencies.—*D. B. V.*

173–318. Rothé, J[ean]-P[ierre]. Étude du movement microséismique à Strasbourg [Study of microseismic movement at Strasbourg]: Pontificiae Acad. Sci. Scripta var., no. 12, p. 19–61, 1952.

In the first part of this paper Rothé reviews Lacoste's work on microseisms at Strasbourg, which attributed the particularly strong activity there to the favorable location on thick Quaternary alluvium in the center of the Rhine graben, and pointed out the relation of the microseisms to the passage of low pressure areas over certain parts of the ocean; passage over the continent had no appreciable effect. The peak of activity at Strasbourg was found to occur when low pressure centers approaching the French or English coasts from the Atlantic passed over the following zones (listed in order of decreasing importance): over the North Sea between long 0° and 5° E; over the southwest coast of Ireland at the entrance to the English Channel, about lat 50° N between long 5° and 10° E; over the entrance to the Baltic Sea, about lat 55° N, long 15° E; and over the Gulf of Gascony. Lacoste also noted a relationship to fronts, without specifying whether warm or cold fronts.

In the second part Rothé analyzes in detail a classical example, the microseismic storm of April 5–7, 1947, using the records of DeBilt, Uccle, Paris, Stuttgart, Scoresby Sound, and Rome as well as Strasbourg. He concludes that the storm was produced by a very marked low (less than 970 millibars) that moved rapidly eastward over the eastern Atlantic and northern North Sea; that the principal activity at a station depended on the position of the center of the disturbance; and that a depression of this magnitude seems to be necessary to engender large microseisms. It is also noted that when the center reached a station, microseisms were only local and feeble with periods of about 4 sec.—*B. T. E., D. B. V.*

173–319. Iyer, H. M. A study on the direction of arrival of microseisms at Kew Observatory: Royal Astron. Soc. Geophys. Jour., v. 1, no. 1, p. 32–43, 1958.

A modification of Darbyshire's correlation method to study the direction of arrival of microseisms is used to track three fast-moving cyclonic depressions in the Atlantic during the periods 1951 October, 1952 October, and 1956 December. Good agreement between the calculated and actual bearings of the storm center is obtained when the depression is reasonably far away from coastal regions and has a simple meteorological situation. When the storm

is close to the coast, however, multiple sources of microseisms make tracking unreliable. Filtering the waves and using a narrow band about the spectral peak and using longer records improves the accuracy. In all the cases studied, the microseisms contain an appreciable amount of Love waves. The ratio of intensity of Love waves to Rayleigh waves seems to depend on the position and intensity of the storm center.—*Author's summary*

173–320. Geddes, A. E. M. A survey of the microseisms recorded at Aberdeen in 1955, together with a review of the meteorological conditions under which they may have arisen: Seismol. Soc. America Bull., v. 48, no. 1, p. 65–76, 1958.

A survey of microseisms recorded at Aberdeen, Scotland for 1955 and comparison with meteorological conditions suggests that the standing waves generating the microseisms arose from the interference of two sets of wave systems generated by double low-pressure centers. Single low centers off either the Norwegian or American coast produced little effect at Aberdeen. The principal regions where such microseisms were produced seem to be in the Atlantic north of lat 50° N and off the rocky coast of northwest Scotland. Comparison of the displacements on the EW and NS records supports the hypothesis that microseisms are due to a mixture of Rayleigh and Love waves.—*D. B. V.*

173–321. Chakrabarty, S. K., and Sarker, D. Microseisms associated with norwesters: Seismol. Soc. America Bull., v. 48, no. 2, p. 181–189, 1958.

Records of microseisms associated with norwesters [sic] have been analyzed, the records being taken with three electromagnetic seismographs [at Saugor Observatory, India]. It has been observed that while no appreciable microseisms are recorded when the disturbance is very close to the observatory, prominent microseisms are recorded when the center of disturbance is over the Bay of Bengal and away from the coast. The records indicate that for the production of microseisms a layer of water about 1 km thick under the center of disturbance is necessary, that the microseismic disturbance is transmitted through the ocean bottom, and that a beating of high waves on the steep coast is not necessary. A comparison of the recorded variation of the period and amplitude of the microseisms with the changes in position of the atmospheric disturbance, together with the theoretical results of studies on the propagation of Rayleigh waves, give a good estimate of the structure of the ocean bed as well as of the depth of the continental shelf.—*Authors' abstract*

173–322. Iyer, H. M., and Nanda, J. N. Microseisms at Cochin: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 193–196, 1956.

The three-sec pendulum apparatus recently installed in the Indian National Physical Laboratory at Cochin, India, for recording microseisms is described briefly. Records are made on a commercial tape recorder run at very low speed and analyzed with the tape run at high speed thus bringing the frequency into the sonic range. Preliminary analysis shows a preponderance of 4 to 6 sec periods. A "microseismic counter" developed for quick measurement of average relative intensity of the recorded waves is described and illustrated by a schematic diagram. Work is in progress for finding direction of microseisms by the Darbyshire correlation method. Additional stations are planned

for Trivandrum and Mangalore; the three stations will be used to study direction of microseisms by comparison of average intensities.—*D. B. V.*

173–323. Giorgi, M[aurizio], and Rosini, E. Les microséismes d'origine tyrrhénienne [Microseisms of Tyrrhenian origin]: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 197–202, 1956.

Microseisms originating in the Tyrrhenian Sea have been studied using the seismograph records from observatories of the Istituto Nazionale di Geofisica at Rome, Padua, Bologna, Messina, and Catania, and meteorological data from the weather forecasting service of the Italian air force. Comparison of microseismic activity and weather conditions were systematic and continuous, and all meteorological elements were taken into consideration. A quantitative relationship was established between the period of the microseisms and distance from the disturbance; attention could thus be concentrated on the relationship between short-period (4 to 5 sec at most) microseisms and disturbances affecting the Tyrrhenian Sea and its environs. The fundamental result of the study is establishment of the fact that microseisms of Mediterranean origin are generated in the open sea by centers of high pressure, either stationary or moving. The microseismic storm of April 29–30, 1954 is cited in illustration; in that case, the three meteorological elements most commonly cited as a cause of microseisms (force of wind, conditions of sea, and passage of a cold front) are either absent or inconsistent with the observations, whereas the progress of a high over the Tyrrhenian Sea exactly fits the facts.—*D. B. V.*

173–324. Monakhov, F. I. Opyt izucheniya mikroseysm v SSSR [The study of microseisms in the USSR]: Akad. Nauk SSSR Sovet po Seysmologii, Byull. no. 6, p. 139–145, 1957.

The study of microseisms in the U. S. S. R. was started by Golitsyn, who was the first to attribute their origin to barometric disturbances over the surface of oceans, and continued by Bonchkovskiy. In 1952 systematic studies were begun at a number of stations including the Far East. The meteorological conditions necessary for generating microseisms and their characteristics at certain stations are discussed. Those recorded at Far Eastern stations (Vladivostok, Sakhalin, Kuriles) are generated over the northwest Pacific and far eastern seas. Those at Yalta (Crimea) are mainly related to cyclones and fronts over the Black Sea but may be complicated by microseisms generated over the Atlantic or northern seas; those from the Black Sea have a period of 5 sec, those from the Atlantic of 5 to 8 sec. The most intense microseisms are those produced by typhoons; amplitude of ground displacement may be as much as 50μ. The lag between the passage of a cyclone center at a given point on its trajectory and generation of the vibrations is about 10 v per km (v=velocity of movement of the cyclone in km per hour).—*S. T. V.*

173–325. Lynch, J. [Joseph]. The Great Lakes, a source of two-second frontal microseisms: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 177–182, 1956.

Observations of two-second frontal microseisms originating west of New York and north of North Carolina turned attention to the Great Lakes as the probable source (see Geophys. Abs. 150–13878 and 154–14702). Horizontal and vertical underwater seismometers (the latter described briefly) of four-second free

period were constructed, to be suspended several feet below the water surface. Lake Michigan was chosen for the first trial; so far, only the vertical instrument has been used owing to difficulties in levelling the horizontal instrument. Progressive waves of the right predominant period (3.5 sec) to produce two-second microseisms have been observed and recorded.—*D. B. V.*

RADIOACTIVITY

173–326. Herr, W[ilfrid], Merz, E[rich], Eberhardt, P[eter], and Signer, P. Zur Bestimmung der β-Halbwertszeit des ^{176}Lu durch den Nachweis von radiogenem ^{176}Hf [On the determination of the β-half-life of lutetium-176 by the detection of radiogenic hafnium-176]: Zeitschr. Naturforschung, v. 13a, no. 3, p. 268–273, 1958.

The lutetium and hafnium contents of different rare earth minerals (two gadolinites, one euxenite, one thortveitite, and one blomstrandite) were measured and the isotopic abundance of hafnium determined. Radiogenic hafnium-176 was found for the first time in one of the gadolinites. The Pb^{206}/Pb^{207} age was calculated for this mineral as $(810\pm70)\times10^6$ yrs. Assuming that *K*-capture is negligible compared to β-decay in lutetium-176, its half-life is calculated from these measurements as $(2.7\pm0.35)\times10^{10}$ yrs. The possibility of using the natural β-radioactivity of lutetium-176 as a dating method is confirmed.—*D. B. V.*

Herr, W[ilfrid], and Merz, E[rich]. On the determination of the half-life of Re^{187}. Further datings by the rhenium-osmium method. See Geophys. Abs. 173–14.

173–327. Kogan, P. M. Nekotoryye integral'nyye zakonomernosti raspredeleniya gamma-polya v sloistykh sredakh [Certain integral regularities in distribtuion of the gamma-field in stratified media]: Akad. Nauk SSSR Izv. Ser. geofiz., no. 2, p. 225–234, 1958.

On the basis of simple assumptions concerning the mechanism of mutual interaction between the γ-radiation and the medium the characteristics of the trajectories of the γ-quanta are established and the properties of integral parameters of the γ-field produced by a point source in stratified media are derived. Formulas are given for computing the integral parameters of the γ-field of a point source, a three-dimensional source and plane source in a stratified medium, in accordance with the known spectral and angular characteristics of the γ-field produced by a point source in a homogeneous medium. The results obtained for the γ-radiation can be extended to some secondary effects produced by the propagation of the γ-radiation through the medium. The established regularities can be used for the solution of different problems of exploration geophysics, such as γ-ray logging or airborne gamma surveying.—*Author's summary, S. T. V.*

173–328. Aswathanarayana, U. Transfer of radioactive matter through rocks by diffusion: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 137–149, 1956.

An attempt is made to apply the physical principles of diffusion in spherical shells to investigate the effect of a batholithic intrusion on the radioactivity distribution patterns in the intruded rocks. Starting with fundamental laws of diffusion, a mathematical analysis is developed to calculate the quantity

of radioactive matter added to any unit area of cross-section in the spherical shell. Three cases are treated: first that of a batholith providing a continuous supply of radioactive elements to be diffused into the surrounding rocks, which have an initially uniform distribution of radioactive matter; the second case is similar but takes into account the diffusional history of radioactive ions; and the third assumes an initially variable distribution of radioactive matter in the country rock. The last corresponds best to conditions in nature but is an approximation at best, for several factors should be taken into account on which we have virtually no data. The existence of thermal gradients and decay of radioactive elements during diffusion should also be considered. Systematic work on this subject, therefore, requires more data on the consolidational history of a batholith, adduced from geological thermometry; on diffusion constants of radioactive elements through various rock types; on radioactive content of batholithic material; on the dimensional relationship between batholith and intruded rocks; and on temperature gradient in the country rock due to the batholith and its effect on the diffusion constants.—*D. B. V.*

173–329. Adams, John A. S., Richardson, Hasper E., and Templeton, Charles C. Determinations of thorium and uranium in sedimentary rocks by two independent methods: Geochim. et Cosmochim. Acta, v. 13, no. 4, p. 270–279, 1958.

Two independent methods for the determination of uranium and thorium-uranium ratios are described, one based on γ-ray spectral analysis and the other on total α-activity and fluorometric uranium determinations, and then applied to 4 standard samples and 18 sedimentary rocks (6 limestones, 8 shales, 2 bauxites, 1 underclay, 1 bentonite). By applying both methods to the same sample it is possible to determine if secular radioactive equilibrium exists; where it exists both methods agree to within experimental errors. The observed thorium-uranium ratio in sedimentary rocks ranges from less than 0.02 to over 20; the two methods presented are capable of measuring this ratio to well within ± 1 over most of this range.—*D. B. V.*

173–330. Murray, Elaine G., and Adams, John A. S. Thorium, uranium and potassium in some sandstones: Geochim. et Cosmochim. Acta, v. 13, no. 4, p. 260–269, 1958.

Determination of the thorium, uranium, and potassium concentrations in 19 sands and sandstones by γ-ray spectrometry, fluorometric uranium analysis, and α-counting provides some independent and experimental comparisons for the average thorium and uranium content of sandstones calculated from geochemical balances. It is found that the thorium and uranium in many common orthoquartzites are contained almost entirely in the quartz grains, the heavy minerals like zircon and monazite playing very minor roles except in placer sands; that in these quartz grains there is an average and rather uniform concentration of 1.7 ± 0.1 parts per million of thorium and 0.45 ± 0.05 parts per million of uranium, giving an average thorium-uranium ratio of 3.8 ± 0.8, which may represent an independent determination of the overall crustal thorium-uranium ratio. It is very difficult to estimate the average thorium and uranium content of sandstones because the importance of placer sands is difficult to assess. The data indicate that in many sedimentary basins the near-shore sand sediments are depleted in thorium and uranium in relation to deeper water shales.—*D. B. V.*

173–331. Kaplan, Grégoire. Sur la présence d'un phosphate d'uranyle dans une granulite de Bretagne [On the presence of a uranyl phosphate in a granulite from Brittany]: Acad. Sci. Paris Comptes Rendus, v. 246, no. 7, p. 1066–1068, 1958.

An abnormally radioactive granulite at Kernevez en Plouray in Morbihan, Brittany, is found to contain a complex fluorescent uranyl phosphate developed on the faces of quartz crystals. By means of nuclear emulsion plates the mineral is shown to emit 119 α particles per cm^2 per sec, corresponding to a uranium content of about 60 percent; the presence of thorium is indicated by long Th C′ (Po-212) tracks. Uranium content of the rock as a whole, measured fluorometrically, is 23 parts per million.—*D. B. V.*

173–332. Aswathanarayana, U. Some statistical aspects of the distribution of radioactivity in the Salem gneisses of Madras State: Bur. central séismol. internat. Pubs., sér. A, Travaux sci., no. 19, p. 151–154, 1956.

The radioactivity of the diopside-hornblende gneisses of the Salem area of Madras State, India, was computed from their β-radiation count. The data are grouped into classes according to number of counts and the frequency distribution determined. Distribution was found to be unimodal; hence, its nature was further investigated by calculating λ (an estimate of the parameter of the Poisson distribution) and graduating the distribution according to the Poisson law and then examining the discrepancy between the observed and calculated frequency by the method of least squares. It was found that when grouped into classes of 30 counts each (ranging from 0–29 to 300 and above) the data satisfactorily fit the Poisson law with $\lambda=4.38$; this may constitute additional evidence that some natural processes favor a Poisson distribution, but as sampling was not done according to any predetermined pattern these results can be considered only tentative.—*D. B. V.*

173–333. Asayama, Tetsuji. On the radioactivity of rocks in Japan and vicinity, I. Radium contents of volcanic rocks: Kyōto Tech. Univ. Faculty Indus. Arts Mem., no. 2–B, p. 53–69, 1953.

A summary of the results of determinations of radium contents of volcanic rocks in Japan and vicinity by Japanese workers. The results of measurements on 20 rocks are tabulated; mean value for liparites and dacites is 1.19×10^{-12} grams of radium per gram of rock, of andesites 0.41×10^{-12} g per g, and of basalts 0.33×10^{-12} g per g. A general increase in radium in proportion to silica has been noted in rocks from central and western Japan but not in those from Hakone volcano or Ooshima Island. A tendency of radium to increase in proportion to potash is more distinct. In some cases a correlation was observed between radium content and order of eruption, suggesting concentration of radium in the residual magma during crystallization; but in other cases there was a decrease or no correlation at all. No definite conclusions can be drawn regarding the relation between texture or crystallinity and radium content; an earlier statement that glassy rocks are more radioactive is now qualified. The "pottery stones" (hydrothermally or pneumatolytically altered liparites or acid tuffs) show a higher radium content than lavas; radioactive elements may have been introduced with the altering solutions. Finally the geographic distribution of radium among and within volcanic zones is summarized.—*D. B. V.*

173–334. Barker, F. B., and Scott, R. C. Uranium and radium in the ground water of the Llano Estacado, Texas and New Mexico: Am. Geophys. Union Trans., v. 39, no. 3, p. 459–466, 1958.

As the Ogallala formation in the Llano Estacado section of the High Plains of Texas and New Mexico is hydrologically and geologically isolated, the uranium and radium concentrations measured in water samples collected from 47 wells and springs in this formation are considered as inherent characteristics of the formation in this area. The uranium concentrations ranged from 0.9 to 12 parts per billion with a mean of 6.2 parts per billion, the radium concentrations from <0.1 to 0.8 micromicrocuries per liter with a median of 0.1 $\mu\mu$c per 1. The uranium concentrations tend to correlate with gross chemical character of the waters in accordance with the expected chemical behavior of uranium. The deficiency in radium in all samples might be explained by ion exchange.—*D. B. V.*

173–335. Okabe, Sigeru. On some relations between atmospheric ions and natural radioactivity: Kyōto Univ. Coll. Sci. Mem., ser. A, v. 28, no. 3, p. 231–252, 1957.

The distribution of alpha-particles in the air near the ground was determined by measurement with a nuclear plate camera. The density of alpha-particles in the lower layer of air was found to be small and the application of the theory of eddy diffusion to these particles is believed to be wrong. A correlation between atmospheric radioactivity and atmospheric ions was found to exist at night but not during the day. The ratio of atmospheric ions ionized by atmospheric radioactive substances to the total number of ions was calculated to range from 0 to 80 percent. The mean correlation coefficient between earth radiation and atmospheric ions was estimated to be 0.62. The percentages of ions formed by earth radiation and by atmospheric radioactivity are presumed to be 60 to 79 percent and 10 to 20 percent respectively.—*V. S. N.*

173–336. Small, S. H., Lillegraven, A., and Storebø, P. B. Natural airborne radioactivity at Kjeller, Norway: Nature, v. 181, no. 4617, p. 1197–1198, 1958.

During the last four months of 1957, radon concentrations of air measured by filters at Kjeller, Norway have varied between about 30 and $1{,}100\times10^{-18}$ curies per cm^3, with an estimated mean of 300×10^{-18}. The observations confirm in general those of other investigators; in particular, rapid increases to maximums under atmospheric conditions of low inversion and low temperature were noted. The explanation is suggested that considerable radon exhalation may be trapped in the cooled air that tends to follow the natural water flow from higher ground around Kjeller. This radon-enriched air then builds up in depth on the valley floor. Very rapid decreases in activity on several occasions were accompanied by simultaneous changes in air temperature and relative humidity.—*D. B. V.*

RADIOACTIVITY SURVEYING AND LOGGING

173–337. Dmitriyev, A. V., and Ionov, V. A. Avtomatizatsiya privedeniya prì aerogammas'emke [Automatic reduction in airborne gamma-surveying]: Razvedka i okhrana nedr, no. 40, p. 31–36, 1958.

Airborne γ-surveying necessitates taking into account the altitude of the airplane at every moment when the readings are being taken. At present the

intensity of the γ-field and the altitude of the airplane are recorded separately and the field readings are reduced to a given altitude by means of a "reducing function", or so-called King's function. A number of automatic correctors for eliminating these calculations are described, with wiring diagrams. Errors introduced by their operation are no greater than those involved in using King's functions. Some precautions for minimizing these errors are suggested.—*S. T. V.*

173–338. Marcuse, Heinz. Uranium search by air in Victoria: Mining and Geol. Jour. [Australia], v. 5, no. 6, p. 10–16, 1955.

A discussion of the equipment and procedure used in an airborne scintillograph survey for radioactive mineral deposits in five areas in Victoria, Australia. The program was to be completed in 1956. Areas of special interest were investigated in further detail by a mobile scintillograph survey on the ground before geological surveying was begun.—*V. S. N.*

173–339. Belin, R. E. A gamma radioactivity survey of some of the geothermal areas of the North Island of New Zealand: New Zealand Jour. Geology and Geophysics, v. 1, no. 1, p. 156–165, 1958.

A preliminary survey of gamma radioactivity of some geothermal areas in the North Island of New Zealand (the results of which are tabulated) showed a wide variation in the radioactivity of soils, pools, and sinters between separate thermal areas, particularly between sulfate and chloride areas. In the Waiora area the average radioactivity of stagnant hot pools was greater than that for hot springs. In some hot pools the variation in gamma radioactivity with depth showed the presence of comparatively active ledges. Sinter deposits around these pools were more radioactive than nearby soils. It is concluded that the radioactivity observed in the pools is controlled by physical and chemical characteristics of the pools and not by the water entering from depth. Radon measurements probably would yield more valuable information about the thermal areas than gamma-activity measurements because the inert gas would be affected only slightly by the characteristics of a given pool.—*D. B. V.*

173–340. Brown, A. A., and Bowers, Brian. The relationship between neutron log deflection and porosity: Canadian Oil and Gas Industries, v. 11, no. 3, p. 59–63, 1958.

It is possible to estimate porosity from the neutron log with improved accuracy by using plots of the logarithm of neutron deflection (neutron deflection being measured from the "100 percent porosity" reference line) versus porosity on a linear scale. These plots are straight lines over a wider range of porosity in comparison to plots of neutron deflection versus the log of porosity.—*V. S. N.*

173–341. Armstrong, F. E. Gamma-ray detector aids oil field surveys: Electronics, v. 31, no. 21, p. 61–63, 1958.

A borehole gamma-ray detector has been constructed for study of petroleum reservoir fluids by means of radioactive isotope tracers. A cluster of five G–M tubes is employed as the sensing element. Transistorized amplifier and power supply circuits, utilizing subminiature components, are contained in plug-in sub-assemblies within the sealed, stainless steel probe. A thermistor shunt in the power supply provides temperature compensation. The output, a square

pulse about 80 μ sec wide and .1 volt amplitude, is fed through a 50-ohm cable to a truck-mounted recorder.—*R. M. M.*

173-342. Fergusson, G. J., and Gibbons, K. M. Radioactivity logging in geothermal bores: New Zealand Dept. Sci. Indus. Research Physical Lab. Rept., no. R. 275, 11 p., 1957.

To obtain logs of natural γ-activity in boreholes of the Wairakei area, it was necessary to design equipment which could withstand bore temperatures up to 270° C and possible wellhead pressures of several hundred pounds per square inch. In the first field trials of this equipment, logs of natural γ-radioactivity obtained for four bores showed reasonable correlation with the geological formations and with measurements of β-radioactivity of selected core samples. Satisfactory operation was obtained up to temperatures of 180° C.—*V. S. N.*

SEISMIC EXPLORATION

173-343. Berryman, L. H., Goupillaud, P. L., and Waters, K. H. Reflections from multiple transition layers. Part 1—Theoretical results: Geophysics, v. 23, no. 2, p. 223–243, 1958.

Continuous velocity logs may be approximated by a series of zones in which the velocity is a linear function of the depth. The reflection response of a series of transition layers may be calculated from an iterative type formula, developed in this paper, which is well suited to digital computer use. This solution takes into account multiple reflections between layers. The reflection output for any input wave shape may be calculated. In this paper a Gram Charlier series pulse having a spectrum peaker at 40 cps is used throughout to facilitate comparison of results.

The dependence of the reflection response of single and double layers on frequency and the reflections for the standard input pulse are illustrated.

It is shown that 1) symmetrical double transition layers give an appreciable reflection output even for a base thickness as low as 10 feet; and 2) the upper layers of a multilayer group may influence considerably the reflection character from the lower layers.—*Authors' abstract.*

173-344. Gurvich, I. I. Opredeleniye effektivnoy skorosti sposobom sovmeshcheniya vstrechnykh godografov otrazhennykh voln [Determination of effective velocities by means of superposition of reciprocal travel time curves of reflected waves]: Moskov. Geol.-Razved. Inst. Trudy, v. 26, p. 196–203, 1954.

A new grapho-analytic procedure of determining the effective velocity of a reflected wave is based on geometric relations that can be established between two travel time curves constructed so that their shot points and the points of the observation are interchanged. From the geometric relations the formula can be derived for V in the very general case. Simplifications are possible when the reflecting horizon is horizontal and parallel to the earth's surface. Use of the formulas is illustrated by examples from surveys made in different parts of northern Russia since 1942.—*S. T. V.*

173–345. Adachi, Ryutaro. Fundamental relations on the seismic prospecting and a method of exploration (General case concerning the reflection method) : Kumamoto Jour. Sci., ser. A, v. 3, no. 1, p. 25–31, 1957.

Some fundamental relationships are derived mathematically between the separation curve $y=y(x)$ and the traveltime curve $t=\phi(x)$ for the form of the separation curve when the traveltime curve is given. Although the latter is accurate and has no approximation or abbreviation, it is difficult in practice to find the functional form of $\phi(x)$; in most cases $y(x)$ must be extrapolated from the numerical values of $\phi(x)$, thus introducing some error.—*V. S. N.*

173–346. Adachi, Ryutaro. A method of exploration on the seismic prospecting (General case concerning the refraction method) : Kumamoto Jour. Sci., ser. A, v. 3, no. 1, p. 20–24, 1957.

An accurate mathematical solution without approximation or abbreviation is found for the form of the separation curve for any traveltime curve for use in the seismic refraction method.—*V. S. N.*

173–347. Adachi, Ryutaro. A method of exploration on the seismic prospecting (When the curvature of travelling-time is small concerning refraction method) : Kumamoto Jour. Sci., ser. A, v. 3, no. 1, p. 1–19, 1957.

A mathematical demonstration that when the curvature of the traveltime curve is small, it is possible to calculate the velocity of the wave in the lower layer and the form of the separation curve, if the velocity of the wave in the first layer and the form of the traveltime curve are known. Two examples are given. In practice, accuracy of the solution depends mainly on accuracy of measurement of travel time.—*V. S. N.*

173–348. Bonini, William E., and Hickok, Eugene A. Seismic-refraction method in ground-water exploration: Mining Engineering, v. 10, no. 4, p. 485–488, 1958.

As a part of an investigation for expanding ground-water facilities, a seismic refraction survey was made of a part of the flood plain of the Passaic River 10 miles west of Newark, N. J., to determine the thickness of the unconsolidated water-bearing deposits above the bedrock. Results were highly successful and although the need for all test wells was not eliminated, the survey defined favorable areas for drilling test wells for aquifer information. A contour map of the bedrock surface is included in the report.—*V. S. N.*

173–349. Melamud, A. Ya. O perekhodnykh protsessakh seysmorazvedochnoy apparature [On transient processes in seismic exploration equipment] : Akad. Nauk SSSR Izv. Ser. geofiz., no. 4, p. 471–485, 1958.

Computations of the operation of an idealized resonant system acted upon by a bell-shaped impulse show the changes produced by transient processes in sensitivity, selectivity, resolving and filtering capacities of seismic apparatus, as well as the relationship between the frequency of the output signal and the characteristics of the input signal and the parameters of the apparatus. The intensity and nature of the effect of the transient processes on the above parameters of the apparatus depend on the ratio of the duration of the input

signal to the duration of the natural processes of the system. In the case where the input signal has a duration of a half period, the characteristic of the apparatus is determined by its dynamic parameters, namely, dynamic sensitivity, resolving and filtering properties. On the other hand, when the input signal has a duration of more than three periods, the apparatus can be characterized by the same parameters as in stationary processes. In the case where the duration of the input signal is about one period, the behavior of the apparatus is again characterized by its dynamic parameters.—*Author's summary, S. T. V.*

173–350. Khudzinskiy, L. L., and Melamud, A. Ya. Stantsiya chastotnogo analiza seysmicheskikh kolebaniy [A station for the frequency analysis of seismic waves] Akad. Nauk SSSR Izv. Ser., geofiz., no. 9, p. 1099–1117, 1957.

A description is given of an apparatus for frequency analysis of seismic waves in the range 10 to 250 cycles per sec that records the wave spectra automatically. This equipment can also be used for the analysis of steady harmonic waves. It is simple in construction and reliable in operation, and can be used in the field. Recording by the method of variable band width directly on the seismogram makes it possible to use ordinary seismic apparatus for the frequency analysis without any essential modifications. The equipment described can be used either as a separate station or as an adjunct to a regular seismic station.—*S. T. V.*

173–351. Buben, Jeri. Un chronographe électronique pour les mesures séismiques [An electronic chronograph for seismic measurements]: Československá Akad. Věd Studia Geophys. et Geod., v. 2, no. 2, p. 141–146, 1958.

A description of an electronic chronograph adapted for measuring variations in propagation time of a wave front in rocks between two points on a fixed base. The apparatus was tested experimentally using hammer blows on a concrete slab. Under optimum conditions the duration of propagation can be measured with an accuracy of $\pm 2 \times 10^{-4}$ sec. Wiring diagrams are given for the chronograph and amplifier.—*D. B. V.*

Jacobs, J. A. Geophysical determinations of thickness of glaciers. See Geophys. Abs. 173–189.

173–352. Masson, Pierre A. A. H., and Agnich, F. J. Seismic survey of Sinai and the Gulf of Suez: Geophysics, v. 23, no. 2, p. 329–342, 1958.

A seismic survey on the Sinai coast along the Gulf of Suez in 1955 and 1956 used a combination of land operations in the littoral plain, bay-type observations in shallow reefy water (using boats adapted locally), and offshore operations using a single boat system (the motor vessel *Sonic*). The offshore results could not be tied in directly to the results of the land survey because of a separating fringe of reefs, a mile wide in places. Details of procedure in each type of survey are described. It is recommended that in prospects of this type the general survey program should begin with a fast marine reconnaissance, thus permitting better orientation of the more expensive land or semi-marine surveys. In the case described it was the semi-marine survey that led to the discovery and detailing of most of the structure, three of which are now pro-

ducing—the Belayim, Ekma, and particularly, the Abu Rudeis. Cost per profile of the single-ship method was 30 to 35 percent of that of the other two methods.—*D. B. V.*

173–353. Clasen, Gerhard. Salzstockrandbestimmungen mit Hilfe gravimetrischer und seismischer Methode [Determinations of the edges of salt domes with the help of gravimetric and seismic methods]: Erdöl u. Kohle, v. 11, no. 1, p. 2–5, 1958.

The use of gravimetric and seismic reflection methods to determine the boundaries of salt domes is illustrated by an example from the Vorhop dome in Germany. It is concluded that the gravity anomalies, particularly the second derivative, give only a rough approximation of the dome and its outline. Their interpretation is improved if they are supplemented by reflection surveys over the outer parts of the dome. The calculation of gravimeter profiles is a help, although the profiles do not give unique determinations. Seismic travel-time measurements are the only solution. Of course a series of preliminary conditions must be shown before unique results are obtained.—*D. B. V.*

173–354. Merriweather, A. S. A seismic refraction–shooting survey off the north coast of Cornwall: Royal Astron. Soc. Geophys. Jour., v. 1, no. 1, p. 73–91, 1958.

A seismic refraction survey along four bearings from a hydrophone laid on the sea bed near Perranporth, Cornwall, shows that the sea bed in this area consists of three layers: a sand or sediment layer 80 to 100 feet thick with a velocity of 4,950 to 5,500 feet per sec; a high velocity rock layer 1,300 feet thick with a velocity of 14,250 feet per sec, and a very thick high velocity layer with a velocity of 18,500 feet per sec. The second layer is correlated on the basis of velocity with schists quarried near Perranporth, indicating a northward extention of the Paleozoic rocks of Devon and Cornwall. Predominant ground wave frequency was found to be about 10 cycles per sec, ground wave attenuation about 12 decibels per distance doubled. The experiments described show that the refraction method gives little information on the upper sediment layer unless it happens to be thick. The minimum range of 250 yards was not small enough to permit resolution of the wave propagated through the sediment; therefore, velocity in this layer is not accurately known. Fair agreement was obtained between the experimental results and existing theories of propagation of explosive sounds over fluid and elastic sea beds; accurate agreement will probably be possible only when new techniques enable determination of the vital parameters of the upper sedimentary layer.—*D. B. V.*

173–355. Ninagawa, Shinji. A well shooting survey in Yoshioka No. 4 at Fukushima District, Hokkaido [in Japanese with English summary]: Geol. Survey Japan Bull., v. 7, no. 8, p. 37–39, 1956.

A well shooting survey was made in Yoshioka No. 4 well in the Fukushima district, Hokkaido, Japan, in September 1955. Slant time, interval velocity, and average velocity were calculated from the records and plotted graphically. Although the relationship of seismic velocity to geology cannot be determined from this single survey, it is hoped that these data will serve as valuable basic material in future marine seismic surveys.—*D. B. V.*

STRENGTH AND PLASTICITY

173–356. Jeffreys, Harold. A modification of Lomnitz's law of creep in rocks: Royal Astron. Soc. Geophys. Jour., v. 1, no. 1, p. 92–95, 1958.

C. Lomnitz has shown that creep of rocks under sustained stress increases logarithmically with time. Data for the variation of latitude and seismic waves indicate that for most of the Earth's shell a term in $t\alpha$, with α about 0.17, is better. This rule is applied in the present paper to the subsidence of a harmonic surface inequality. The indications are that this type of creep will not account for isostatic adjustment within a geological period, and the presumption is that the adjustment is due to a fracture or flow near the elastic limit.—*Author's summary*

173–357. Paterson, M. S. Experimental deformation and faulting in Wombleyan marble: Geol. Soc. America Bull., v. 69, no. 4, p. 465–476, 1958.

In compressive stress-strain tests on a coarse-grained marble at various confining pressures up to 1000 kg cm^{-2}, special attention has been paid to the transition from brittle to ductile behavior. The application of low confining pressures suppresses the longitudinal fractures characteristic of failure at atmospheric pressure, and well-defined shear failures develop. The formation of the localized shear zones accompanies a gradual decrease in the stress needed for continued deformation but does not lead immediately to complete fracture. This behavior may be initiated by a type of plastic instability. Its relevance to geological faulting is discussed, since the shear zones developed in the marble specimen appear to be similar to geological faults.

At confining pressures above about 300 kg cm^{-2}, the stress-strain curves rise continuously without reaching a maximum, and the deformation is distributed throughout the specimen instead of being localized in shear zones or faults. This suggests that there is a depth in the earth's crust below which faulting cannot be expected in this rock.

The stress-strain curves have been analyzed to show the effect of confining pressure on the yield stress and on the stress at the maximum load. A few measurements on a fine-grained limestone are also included in an appendix.

Coloration of the marble by X radiation occurs after deformation at low confining pressures, but the effect becomes more marked at higher confining pressures.—*Author's abstract*

173–358. Budryk, Witold, and others. Symposium. Wpływ wyeksploatowania pokładu na stan naprężeń i odkształcén w górotworze [Effect of underground mining operations on the conditions of stress and deformation of the surrounding rock]: Archiwum Górnictwa i Hutnictwa, v. 3, no. 4, p. 439–520, 1955.

Budryk, Witold. Wstęp [Introduction]: p. 439–443.

Budryk, Witold. Sprężyste własności górotworu [Elastic properties of the rock]: p. 445–453.

Korman, Stanisław. Wartości współczynników sprężystości w górotworze [The values of the elastic coefficients in the rock]: p. 455–472.

Budryk, Witold. Stan naprężeń w górotworze pod wpływen wyeksploatowania pokładu [The stress conditions in the rock as a result of driving a mine tunnel]: p. 473–477.

Litwiniszyn, Jerzy. Wpływ czasu na stan odkształcenia i naprężenia górotworu [Effect of time on the state of deformations and stresses in the rock]: p. 479–491.

Sałustowicz, Antoni. Warunki eksploatacji pokładów odprężonych [The conditions of underground drift workings]: p. 493–499.

Knothe, Stanisław. Obniżenie powierzchni przy częściowym wybraniu pokładu pasami [Subsidence of the earth's surface due to partial excavation of a drift leaving pillars]: p. 501–511.

Budryk, Witold. Wnioski praktyczne [Practical conclusions]: p. 513–520.

The papers in this symposium are concerned with calculations of stresses and deformation of practical significance in underground mining operations.—*D. B. V.*

SUBMARINE GEOLOGY

173–359. Frassetto, Roberto, and Northrop, John. Virgin Islands bathymetric survey: Deep-Sea Research, v. 4, no. 2, p. 138–146, 1957.

The deepest charted passages between the Atlantic Ocean and the Caribbean Sea are the Anegada and Jungfern passages connecting the two seas between the Virgin Islands platform and St. Croix Island. The limiting factor in the exchange of deep water between the Atlantic and the Caribbean is the Jungfern passage sill at 1,072 fathoms. The Virgin Islands basin lying between the two passages is a tectonic anomaly in the typical island arc structure of the West Indies because of its fault-block or intermontane basin type of structure. Soundings show that the basin has a flat floor 2,400 fathoms deep with topography concealed by thick layers of sediments, part of which may be Miocene in age, and is bounded on the north and south by steep sea scarps with slopes of 9 to 43 degrees. The basin has been the center of several medium size earthquakes and numerous minor shocks, apparently associated with the sea scarps.—*V. S. N.*

173–360. Herdman, H. F. D. Recent bathymetric charts and maps of the Southern Ocean and waters around Antarctica: Deep-Sea Research, v. 4, no. 2, p. 130–137, 1957.

Recent bathymetric charts of the Antarctic Ocean area are of two types: those which show contours of a wide area of the ocean floor and those which primarily delineate the coastal areas and some features of the Antarctic continent.

In the latter, contouring has been continued far enough seaward to make it possible to relate features on or adjacent to the continental shelf to the topography of the continent. The U. S. Hydrographic Office's chart no. 2562 (3d ed., 1955); the International Hydrographic Bureau's bathymetric charts south of 46°40′ S (ser. B′ and C′, 1952–1955); the Australian map of Antarctica (2d ed., 1956); and Hans-Peter Kosack's Karte der Antarktis (Geographisch-Kartographische Anstalt, Gotha) are discussed and some comparisons made. Brief mention is made of the work of the International Committee on Nomenclature of the Sea Bottom Features and of the results of recent soundings along the continental shelf of Antarctica.—*V. S. N.*

VOLCANOLOGY

173–361. Scofield, John, and Sisson, Robert F. A new volcano bursts from the Atlantic: Natl. Geog. Mag., v. 113, no. 6, p. 735–757, 1958.

A popularized account of an eruption close off the shore of Fayal in the Azores. Activity began on September 27, 1957 following a week of tremors. In three days the cone rose 150 ft above the sea floor. The new island ("Ilha Nova I") grew to nearly 300 ft in height, then disappeared overnight on October 30–31. Early in November "Ilha Nova II" appeared and grew into a peninsula extending ½ mile beyond the former shore of Fayal. The eruption was still in progress in March 1958. Ash falls caused damage to buildings in nearby villages and crops and other vegetation.—*D. B. V.*

173–362. Cucuzza Silvestri, S[alvatore]. La recente attività dello Stromboli (febbraio-marzo 1954) [The recent activity of Stromboli (February–March, 1954)]: Accad. Gioenia Boll., ser. 4, v. 3, no. 1, p. 26–31, 1955.

The eruption of Stromboli which began on February 1, 1954, and lasted for 41 days was the longest period of lave effusion in the recorded history of the volcano. It was exceptional also in the lack of premonitory or accompanying seismic phenomena; in the absence of explosive activity in the first phases of lava effusion; in the rapid changes of position of the lava ducts in the late stages; and in the unusual basicity of the products.—*D. B. V.*

173–363. Taneda, Sadakatu, and Matumoto, Yukio. The 1953 eruption of volcano Aso, Kyushu, Japan [in Japanese with English abstract]: Geol. Soc. Japan Jour., v. 60, no. 702, p. 106–112, 1954.

Volcano Aso suddenly became active at the end of April 1953 after having been almost dormant since April 1952. Explosions occurred in the Nakadake crater on April 27, 28, 29, and May 4 with a few others in June, July, and September. Each explosion was preceded by slight earthquakes, after a period of seismic repose lasting from 3 to 17 hrs. The pre-eruption repose period was especially marked for the first three explosions. Blocks of somewhat glassy pyroxene-andesite up to 5 tons in weight were ejected, along with blocks of tuff torn from the crater walls. Ash was scattered mostly northward, sometimes falling in and around the villages of Miyaji and Bōchū in the northern part of the "Aso Caldera".—*D. B. V.*

173–364. Tanaka, Y. Character of the volcanic earthquakes and tremors at Miharayama, Oshima (in Japanese with English summary): Quart. Jour. Seismol., v. 22, no. 4, p. 31–39, 1958.

A report of observations of volcanic earthquakes and volcanic tremors associated with Mihara volcano in Japan, made during the period 1938–1957 at Oshima Weather Station, is given. Epicenters of volcanic earthquakes lie north and northeast of the caldera. The earthquake swarms, each with epicenters in a limited area, began very suddenly, calmed down after a few days; no surface volcanic activity such as eruptions or emissions of smoke occurred while the swarms were taking place. Swarms of volcanic tremors are classified as continuous and discontinuous. Duration of each of the latter was about 40 sec; they gradually increased in number day by day, decreased gradually within a half to three months. No surface activity followed this type of tremor. Continuous tremors were followed by surface activity and usually continued during such activity; they began a few hours to several days prior to eruptions or emissions of much smoke. The source of all tremors is probably shallow under the caldera.—*D. B. V.*

Yumura, T[etsuo]. Magnetic properties of Volcano Sakurajima. See Geophys. Abs. 173–313.

Tsuboi, Ch[uji]. Earthquake epicenters, volcanoes and gravity anomalies in and near Japan. See Geophys. Abs. 173–24.

173–365. Vlodavets, V. I., and Piyp, B. I. Katalog deystvuyushchikh vulkanov Kamchatki [Catalog of the active volcanoes of Kamchatka]: Akad. Nauk SSSR Lab. vulkanol., Byull. vulkanol. stantsii, no. 25, p. 5–95, 1957.

Gorshkov, G. S. Katalog deystvuyushchikh vulkanov Kuril'skikh ostrovov [Catalog of the active volcanoes of the Kurile Islands]: ibid, p. 96–178, 1957.

These two papers together constitute a catalog of all 67 of the active volcanoes in Soviet territory. For each of the 28 volcanoes of Kamchatka and the 39 in the Kurile Islands there are given the name (or names), location, height, form, geological character, crater or craters, lava flows, composition of its products (including chemical analyses where available), known eruptions, special features of its activity, type of activity, and bibliographic references.—*D. B. V.*

173–366. Naboko, S. I. Uspekhi Sovetskoy vulkanologii [The progress of Soviet volcanology]: Sovetskaya Geologiya, no. 61, p. 65–86, 1957.

This is a review of the development of volcanology in the U. S. S. R. Activity in this branch of geology has been concentrated on the only region of Russia with active volcanoes, Kamchatka and the Kurile Islands, with a total of 67 active volcanoes. The present article is a summary of studies that have appeared in publications of the Kamchatka volcanological station for the years 1940 to 1957 and the volcanology laboratory of the Russian Academy of Sciences for the years 1947 to 1956.—*S. T. V.*

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