

The Geochemical News

NUMBER 25

December 1960

ANNUAL MEETING OF THE GEOCHEMICAL SOCIETY

The annual meeting of the Geochemical Society was held from October 31 to November 2, 1960, at the Denver-Hilton Hotel in Denver, Colorado, in conjunction with the annual meeting of the Geological Society of America and other associated societies.

The field of geochemistry was particularly well represented in the scientific sessions. Sessions on geochemistry were held Monday morning, October 31 (12 papers), Monday afternoon (12 papers), Tuesday afternoon, November 1 (9 papers), Wednesday morning, November 2 (12 papers), and Wednesday afternoon (12 papers), making a total of 57 papers in the field of geochemistry.

The session of Monday afternoon was devoted to general topics in the field of geochemistry; that of Wednesday morning, to organic geochemistry; and that of Wednesday afternoon, to economic aspects of geochemistry.

Much interest developed in some of the papers read during the first session devoted to geochronology, particularly to a paper by Hart et al. on the use of amphiboles and pyroxenes for K-Ar dating. The session of Tuesday afternoon had as its theme phase studies, both in melts and hydrothermal systems.

The Council of the Geochemical Society met twice: Monday afternoon from 2 to 4, and Wednesday afternoon from 12 to 2. An account of the council meetings will be published in the next issue of the Geochemical News. The president of the Geochemical Society, Prof. T. F. W. Barth, delivered the presidential address on Tuesday morning, at 10:30. It was entitled "Abundances of the Elements, Areal Averages and Geochemical Cycles".

GEOCHEMICAL RESEARCH DURING THE 1959-60 ACTIVITY OF KILAUEA VOLCANO*

by

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Abstract

The 1959-60 activity at Kilauea volcano provided a graphic sequence of summit eruption, flank eruption, and summit collapse. The eruption also has been a unique laboratory for geochemical studies. Varied techniques of sampling lava and gases were used to follow changes in erupted materials. Lava fountain temperatures (1120° to 1190°C) were found to correlate with silica composition of the lava (46.7 to 50.7 percent). A flame spectogram shows strong CuCl bands. Volcanic gases highly diluted by air show oxidized conditions represented by CO₂ (up to 6.3 percent) and SO₂ (up to 1.0 percent) in the high-temperature interior of the newly formed pumice cone (760°C near the surface). SO₂ is oxidized to SO₃ in the iron oxide-rich environment and forms H₂SO₄ at the surface. H₂ (up to 0.1 percent) most probably is produced by decomposition of water in oxidation reactions. Rate of lava extrusion and mean lava-fountain heights are useful for calculating fountain energy and estimating amount of volatiles. The cooling history and attendant physical changes in the lava lake are being studied.

* * * * *

* Publication authorized by the Director, U. S. Geological Survey

Kilauea volcano during its 1959-60 eruption has been a living laboratory providing a rich variety of volcanic phenomena for observation and study. There occurred a progressive sequence of activity as exhibited first in the summit unrest and eruption of November 14 followed by a flank eruption on the east rift zone on January 13, and finally, by many local quakes and collapse in the summit pit crater on February 7 and later.

After several months of increased seismic activity and uptilting in the summit region (Eaton and Richter 1960; and Richter and Eaton, 1960), the eruption broke out first in Kilauea Iki, (Fig. 1). This is a summit crater separated from the main Kilauea caldera by the narrow Byron Ledge and was 225 m deep prior to the eruption. The initial 0.8 km line of fountains broke out half way up the south side of the crater or essentially along the same rift zone as that of Kilauea Iki eruption in 1868. Within 10 hours the line of fountains had died down until only one fountain remained. This fountain persisted with an increasing rate of output (as much as $378 \times 10^3 \text{ m}^3$ per hr) for one week until it had produced a lava lake 102 m deep that swamped its own vent. Pumice and spatter from the fountain also built a pumice cone more than 60 m high on the leeward rim of the crater (Fig. 2). The fountain continued intermittently through 16 additional phases, sometimes filling the lava lake to a depth of more than 122 m, but lava back-flow down the vent lowered the lake again between each phase. On January 20 when the eruption ceased, the lava lake lowered to a depth of about 116 m and started its long process of cooling.

Following this, the seismic activity moved 45 km down the east rift zone to the Puna district, where a graben block more than 1 km wide, which last dropped significantly in 1924, was again dropped about 1 m during the 12 hours preceding the lava outbreak. In the sugar cane fields a line of fountains 1 km long erupted almost parallel to and in the middle of the graben block about 2 miles from the ocean, at a 20 m elevation and about 0.5 km from the town of Kapoho. Within 24 hours the line of active fountains had shortened to about 300 m and proceeded to build spatter ramparts and to send a flow northeastward along the graben block. Within 2 days the flow reached the ocean and began sending up billowing jets of steam and producing glassy rock fragments or "black sand." During the first 24 hours some of the vents along the rift alternately produced glowing lava and billowing steam loaded with rock fragments as brackish groundwater evidently entered the vent. The eruption continued until February 20 and by then had almost wiped out Kapoho, a town of more than 250 inhabitants, partly by burning and burial by flowing lava and partly by burial by pumice with subsequent collapse of buildings. Lava also destroyed half the group of residences and churches in the smaller community of Koae, covered a portion of a beach lots development, and enlarged the island of Hawaii by $2 \times 10^6 \text{ m}^2$ (approximately 495 acres). The fountain had built a spatter and pumice cone about 100 m above its base (Fig. 3), and had produced about $122 \times 10^6 \text{ m}^3$ of lava as compared to the summit eruption of about $97 \times 10^6 \text{ m}^3$.

The eruption of lava from Kilauea volcano had relieved the internal pressure in the summit area so that relatively rapid collapse or downward tilting was evident (Richter and Eaton, 1960). On February 7 the floor of Halemaumau crater in Kilauea caldera began to subside visibly; a central collapse pit sank about 90 m to a depth of 225 m (Fig. 4), or nearly as deep as it was before the 1952 and 1954 eruptions which filled it so it was only 135 m deep. The collapsing of the floor was accompanied by molten lava extruding along the arcuate breaks and flowing slowly into the central collapse pit. The extruded lava apparently had already been largely outgassed as there was relatively little gas emission accompanying its sluggish flow. Probably it was uncongealed lava remaining from the 100 m thick 1952 lava lake. Detumescence of Kilauea may have opened the main vent rift under Halemaumau allowing most of the still molten lava to drain downward and the crater floor to subside. Subsequently, two more collapse pits formed on the sunken floor along a line coinciding with the 1952 eruption rift. The first of these on February 9 was seen to drop about 60 m in 10 seconds and the second on March 11 produced a steam cloud which scattered fine dust 2.5 km distant. During this collapse period of activity many earthquakes were felt in the summit area and around the island. The collapse period was followed by dense emission of carbon and sulfur gases from Halemaumau beginning on June 6 and continuing as of this writing.

Early in 1958 the U.S. Geological Survey had expanded its laboratory facilities at its Hawaiian Volcano Observatory on the rim of Kilauea. The scientific staff was increased and now includes two geologists, two geophysicists, and two geochemists. The geochemical laboratories are equipped to do wet chemical rock analyses, trace element emission spectrography, vacuum fusion of rocks, and mass spectrometric gas analyses. The main purpose of the geochemical laboratories is to carry out "on the spot"

research, follow the course of volcanic activity by means of frequent analyses of gases and lavas, and to develop and test effective sampling techniques.

During the eruption stages described above, the scientific staff made periodic temperature measurements of the lava fountains with optical pyrometers. Temperatures up to 1190°C* were obtained on the Kilauea Iki fountain and up to 1125°C on the Puna fountains. Also samples were collected several times daily from hot falling pumice and from new flows. From the silica analyses at Kilauea Iki, K. J. Murata found a good correlation between percent silica, 46.7 to 50.1, content of olivine, and temperature of the fountain. For Puna, Murata and D. H. Richter extended the correlation to lower temperature and higher silica (47.8 to 50.7 percent with an average about 2 percent higher) and the more advanced stage of crystallization (proxene and plagioclase in addition to olivine).

Between eruptive stages at Kilauea Iki and after the eruption, altered rock and newly deposited minerals from cracks in the pumice cone and lava flow surfaces have been sampled for analysis. Also lava rock has been sampled for trapped gas analysis by vacuum fusion techniques.

At one of the later stages in Puna, two vents intermittently issued illuminated flames of "burning" gases. These gaseous flames were distinct from the luminescent stream of molten wisps of pumice which sometimes accompanied them. Murata was able to obtain spectrograms of the flames and identify strong bands of CuCl and possibly of diatomic sulfur (Murata, in press).

Table I. Comparison of average values (Volume percent of whole sample) of several components of volcanic gases.+

Sample:	O ₂	CO ₂	SO ₂	H ₂ O*	H ₂
1. Air rising from Kilauea Iki crater above eruption rift	19.4	0.07	0.04	0.87	---
2. Gas cloud above fountain (via aircraft)					
Kilauea Iki	19.3	0.05	----	0.64	----
Puna	19.5	0.06	----	0.55	----
3. Early Kilauea Iki vent 14 hours after cessation	19.4	0.11	----	----	0.03
4. Air above molten lava in Kilauea Iki lava lake	19.3	0.09	----	1.4	----
5. Kilauea Iki pumice cone outgassing	5.1	6.3	0.01	----	0.11
	9.2	5.2	----	----	0.09
	14.4	1.6	1.0	----	0.04
	19.5	0.11	1.04	----	----

*/ For pumice cone samples liquid water was not calculated, being largely rainfall.

+/ Preliminary data by Ault and Kojima.

Volcanic fluids have been sampled from various environments and by different methods. Table 1 shows a comparison of certain components for several gas samples collected in evacuated Pyrex bulbs. All samples were greatly diluted by air which probably reacted to some extent with the volcanic constituents. Water vapor, carbon dioxide, and sulfur dioxide are the dominant volcanic constituents. Hydrogen and carbon dioxide show an inverse relation to oxygen abundance for the gases from the pumice cone. The hydrogen appears to come from the thermal dissociation of water and from reactions such as $H_2S + 2H_2O \rightleftharpoons SO_2 + 3H_2$. Oxygen of the air that flushes the cone is depleted

*Uncorrected for departure from "black body" radiation.

by reactions with the cone materials as well as by forming SO_3 through the reaction $\text{SO}_2 + 1/2\text{O}_2 \rightleftharpoons \text{SO}_3$ in the iron oxide-rich environment. The SO_3 immediately combines with H_2O to form H_2SO_4 which rapidly attacks the pumice materials (and sampling equipment as well as clothes and watches) and causes the atmospheric moisture in the vicinity of the cone vents to give an indication of $\text{pH} < 1$.

Sampling volcanic gas clouds from aircraft and collecting gas and lava together in a sample on the ground are fraught with difficulties and were only partly successful. The experience was invaluable, however, in leading to new sampling techniques. Because fumaroles are approachable, sampling from them allows experimentation in preserving the high temperature equilibrium between the various components. Gas collections are made both for analytical and isotopic studies.

Kilauea Iki lake offers an unequalled opportunity to study a lava body throughout its cooling history. As of this writing (June 1960), the temperature of the crust is over 70°C at the surface. A hole 3 cm in diameter and 7 m deep is permitting the determination of temperature gradients and has reached molten lava that is still 1065°C . The thermal history along with rainfall data and magnetic surveys by J. P. Eaton and H. L. Krivoy, and elevation measurements by Richter should increase our knowledge of a cooling basalt body. Thickness and extent are about as precisely known as could be desired. Deeper drilling will be done to follow the liquid-solid interface and test the theoretical curves.

Having continuous fountain-height measurements for Kilauea Iki and accurately known rates of lava output, it is possible to obtain a better estimate of the "gas drive" at the fountain, and hence a ratio of fluids to solids.

The Kilauea Iki eruption yielded enormous rates of single fountain output (up to $1070 \times 10^3 \text{ m}^3$ per hour), produced the greatest known fountain heights (580 m), and gave the highest observed fountain temperatures (1190°C) known for Hawaiian lavas. The eruption has provided a unique opportunity to obtain the most complete record of a dramatic and rapid sequence of summit eruption, flank eruption, and summit collapse in the history of Kilauea.

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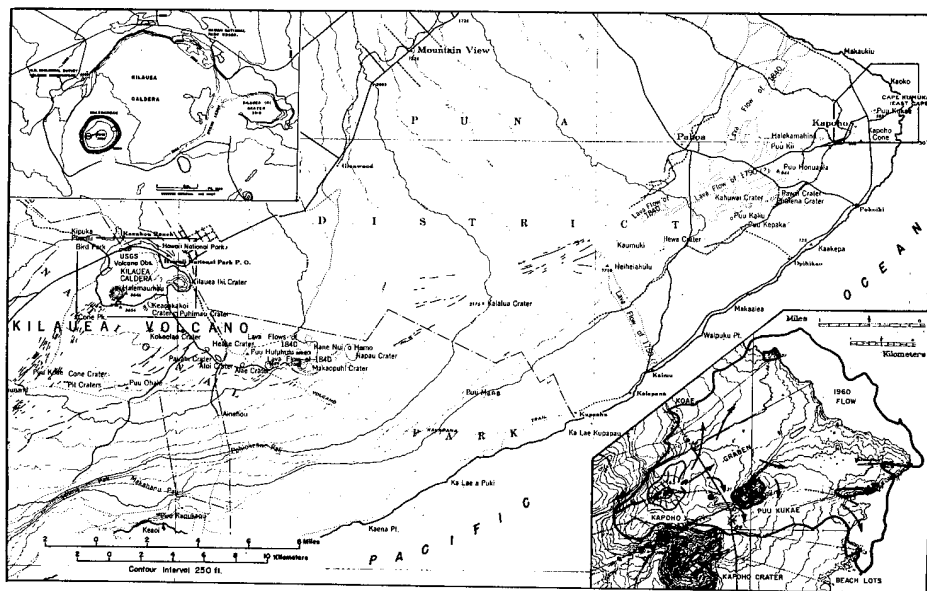


Figure 1. Map of Kilauea volcano caldera and the east rift zone extending to Cape Kumukahi. Insets show the collapse pits in Halemaumau, the lava lake of Kilauea Iki, and the 1960 flank flow at Kapoho.

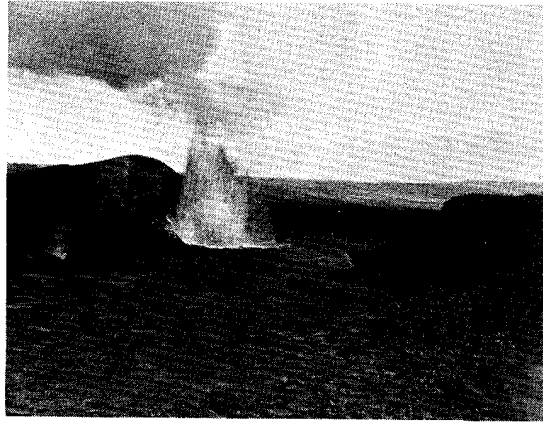


Figure 2. Kilauea Iki in eruption showing newly formed pumice cone to left of fountain. Lava lake is about 100 meters deep and has a surface area of over $0.4 \times 10^6 \text{ m}^2$ (100 acres). Byron Ledge beyond the fountain separates Kilauea Iki Crater from the Kilauea Caldera.

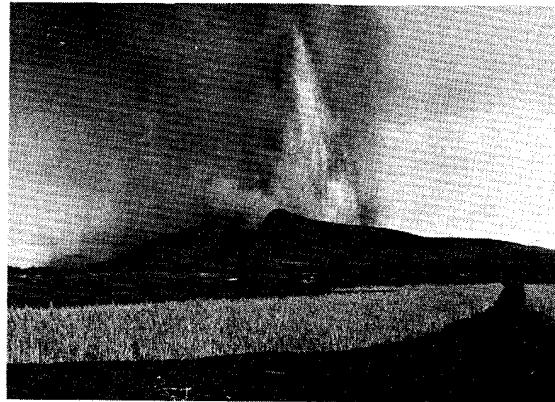


Figure 3. Lava fountain at Kapoho towers over pumice and spatter cone. High fountains produce much pumice and dust. Pumice covered cane road through the battered cane field leads to lava flow.

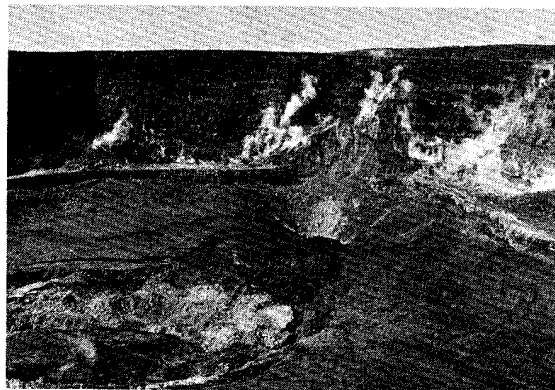


Figure 4. Saucer-like collapse in Halemaumau Crater. The first (central) and second collapse pits extend the crater depth to more than 230 m. Lava oozed out around the arcuate fractures and flowed into the bottom of the central collapse pit. Ledge around crater shows former 120 m depth of Halemaumau.

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MEMORIAL OF JOHN T. LONSDALE

by E. Wm. Heinrich

John T. Lonsdale, director of the Bureau of Economic Geology, University of Texas, Austin, Texas, died on October 5, 1960. Dr. Lonsdale was born November 8, 1895 at Dale, Iowa, and received his BA in 1917 and his MS in 1921, both from the University of Iowa. In 1924 he was awarded his PhD from the University of Virginia. His professional appointments include:

1. Assistant Professor of geology at the University of Virginia and geologist with the Virginia Geological Survey, 1921-1924.
2. Assistant Professor of geology at the University of Oklahoma and geologist with the Oklahoma Geological Survey, 1924-1925.
3. Geologist, Texas Bureau of Economic Geology, 1925-1928.
4. Chairman, Department of Geology, Texas A and M College, 1928-1935.
5. Chairman, Department of Geology, Iowa State College, 1935-1945. Between 1942 and 1945 he was on military duty as a colonel in the U.S. Army.
6. Director, Bureau of Economic Geology, University of Texas, 1945 until his death.

His achievements and publications in the fields of mineralogy and geology were numerous and varied and his work was painstaking and sound. He was a member of many professional and scientific societies, but beyond all these he will be remembered best for his kindnesses, courtesies and help to students and younger members of the geological profession. The writer, who was his student for four years at Iowa State College, can testify that he will not be forgotten as long as any of his friends and students remain alive.

BOOK REVIEWS

CLASSICS IN SCIENCE. 322 pages. Philosophical Library, Inc., New York, 1960. \$6.00.

For those of us who, for reasons of time, are unable to read the original references, this anthology is a wonderful tool for consulting some major contributions in the field of science. It is divided into these four "books": Book I, The Origin and Meaning of Science, with 8 chapters; Book II, The Universe, with 14 chapters; Book III, Matter and Energy, with 11 chapters; and Book IV, Science and Everyday Life, with 10 chapters.

The volume concludes with brief biographical notes on all of the contributors, a bibliography, acknowledgments and an index. The list of contributors selected reads like a Who's Who of Science. Noteworthy among many are Immanuel Kant, Aristotle, Sir Archibald Geikie, Pythagoras, Ptolemy, Copernicus, Galileo Galilei, Isaac Newton, Sir Charles Lyell, A. L. Lavoisier, Lord Rutherford, and Sir Charles Darwin.

This book belongs in the library of every serious student of the development of science.

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NUCLEAR REACTOR MATERIALS, by B.R.T. Frost and M.B. Waldron. 79 pages. Simmons-Boardman Publishing Corp., New York, 1959. \$2.75

The primary purpose of this little monograph is to outline for engineers and physicists who work with reactors the present state of information on reactor materials. It is based on a series of lectures by members of the staff of the Metallurgy Division, A. E. R. E., Harwell, to students of nuclear engineering at Queen Mary College, London.

The six chapters deal respectively with Theoretical metallurgy; Structural materials; Fuel materials; Liquid metals; Ceramics and metal-ceramic mixtures as reactor materials; and Corrosion. A four-page bibliography is followed by a brief index. Of particular interest to geochemists and mineralogists will be Chapter 2, Structural materials, which discusses the metals aluminum, magnesium, beryllium, iron and steel, zirconium, niobium, molybdenum, tantalum, and vanadium. Chapter

3 on fuels summarizes information on uranium, plutonium and thorium. The book is a modern and succinct summary of data on the five categories of materials needed in the construction of reactors: fuel, coolant, can, moderator and structural members.

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LEAD ISOTOPES IN GEOLOGY, by R. D. Russell and R. M. Farquhar. 243 pages. Interscience Publishers, Inc., New York, 1960. \$9.00.

Geochemists and geochronologists will be very pleased to receive this long necessary and awaited volume. It is concerned primarily with the interpretation of lead isotope abundances. Its authors, who have been original workers in the field of absolute age determination methods for several years, are well-known to all students in this field. They state that they have drawn mainly on their own views in preparing the book, but have tried to present and refer to other scientists' results and interpretations.

After an introduction come chapters on the Measurement of lead isotope ratios; the Age of the earth; Dating galenas by means of their isotopic constitutions; Anomalous leads; Case histories; Extensions of the Holmes-Houtermans model; and Methods of lead-uranium-thorium age determination. This general section is followed by four and one-half pages of references and 121 pages of 12 appendices, listing isotope determinations for the entire world on the basis of the laboratory that made the determination. Within each appendix the data are further subdivided into geographical groups.

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U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 400-A. 136 pages. 1960. \$1.00.

U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 400-B. 515 pages. 1960. \$4.25.

These two professional papers apparently represent a new type of Survey release. They are major efforts toward developing suitable means for the prompt publication of new technical findings of both economic and scientific significance. Professional Paper 400-A, which is a synopsis of geological results of research projects undertaken by the Survey in 1960, gives a general cross-section of the manifold activities of the Survey throughout the year. It is impossible here to list all of these investigations, but suffice it to say that the list is long and impressive. The studies are subdivided into the following main categories: Mineral resource investigations; Development of exploration and mapping techniques; Geology applied to engineering and public health problems; Regional geology; Investigations of geologic processes and principles; and Laboratory techniques.

Professional Paper 400-B, entitled Short Papers in the Geological Sciences, includes an almost overpowering 232 contributions which are grouped under the following headings: Geology of metalliferous deposits; Geology of light metals and industrial minerals; Geology of fuels; Exploration and mapping techniques; Geology applied to engineering and public health; Geology of Eastern United States; Geology of Western Conterminous United States; Geology of Alaska; Geology of Hawaii, Puerto Rico, Pacific Islands, and Antarctica; Paleontology, geomorphology, and plant ecology; Geophysics; Mineralogy, geochemistry, and petrology; and Analytical and petrographic methods.

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CALENDAR

Dec.

- 11-14 Winter meeting, Amer. Nuclear Soc., Mark Hopkins Hotel, San Francisco, Calif. Contact Octave J. DiTemple, executive secretary, ANS, 86 E. Randolph St., Chicago 1, Ill.
- 12-14 National Conference on Water Pollution, Public Health Service, Wash., D.C.
- 12-16 Exhibit and Conference, Atomic Industrial Forum, Fairmont Hotel and Masonic Memorial Bldg., San Francisco, Calif. Contact Daniel J. Scherer, 3 E. 54th St., New York 22.

Feb., 1961

- Light Metal Industry Symposium, Nat'l. Metallurgical Lab., Jamshedpur, India.
- 10 12th Ann. Symposium on Highway Geology, Univ. of Tennessee, Knoxville. Contact R.A. Laurence, USGS, Room 11, P.O. Bldg., Knoxville 2, Tenn.

Mar., 1961

- 20-24 7th Nuclear Congress, Chicago, Ill.

Apr., 1961

- 26-27 High Temperature Materials Conference, Cleveland Section, AIME, Hotel Pick-Carter, Cleveland.

ION EXCHANGE COLUMN

The Tenth Pacific Science Congress will be held under the sponsorship of the Pacific Science Association at the University of Hawaii, Honolulu, Hawaii, U.S.A., from August 21 to September 6, 1961. The chairman of the Program Committee is David I. Blumenstock, U.S. Weather Bureau, Federal Building, Honolulu 13, Hawaii. Of particular interest to workers in the earth sciences will be the following section and divisions:

Section of Geophysical Sciences.

Organizer: Dr. L. V. Berkner, Associated Universities, Inc., 10 Columbus Circle, New York 19.

Division of Solid Earth Sciences.

Organizer: Dr. Gordon A. Macdonald, Dept. of Geology and Geophysics, University of Hawaii, Honolulu 14, Hawaii.

Division of Oceanography.

Organizers: Dr. Walter H. Munk, Scripps Institution of Oceanography, University of California, La Jolla, California; Mr. Thomas S. Austin, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Honolulu, Hawaii.

Those who wish to present scientific papers should submit a summary of the proposed paper to the appropriate division organizer no later than March 31, 1961. These summaries must be typed and double-spaced; must be submitted in duplicate; must be 300 to 1,000 words long; must carry the title of the paper and the name, address, title and affiliation of the author; and must indicate the amount of time needed for presentation or state whether the paper is merely to be read by title. Five to 15 minutes will be allowed for presentation of contributed papers.

The Swiss monograph on Syngeneses and Epigeneses in petrology and the study of mineral deposits by G. C. Amstutz (Schweiz. Min. Petr. Mitt. Vol. 39, pp. 1-84), has been translated into English and is available as Technical Publication AEC-tr-4219, from the Office of Technical Services, Department of Commerce, Washington 25, D.C.

A noteworthy publication which was available at the time of the annual meeting of the Geochemical Society is the 50th Anniversary Issue of The Mines Magazine, October 1960, Vol. 50, No. 10, published by the Colorado School of Mines Alumni Association of Golden, Colorado. Papers of

interest appearing in this number are "Gold Forms in Ores" and "Cripple Creek-Victor, Colorado District".

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