GEOLOGICAL SURVEY CIRCULAR 621

U.S. Geological Survey Heavy Metals Program Progress Report 1968— Field Studies

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Washington 1969

United States Department of the Interior
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Geological Survey
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Free on application to the U.S. Geological Survey, Washington, D.C. 20242

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INTRODUCTION

The Heavy Metals program of the U.S. Geological Survey and the U.S. Bureau of Mines began in mid-1966 and thus at the end of calendar year 1968 was halfway through its third year. This progress report summarizes field studies carried out under the Geological Survey's part of the program during 1968. Topical studies for 1968 are summarized in U.S. Geological Survey Circular 622. Background of the program and results during 1966 and 1967 were reported in U.S. Geological Survey Circular 560 and will not be further discussed herein.

ORGANIZATION

In 1968, about 260 employees of the Geological Survey participated directly in the program. This number includes about 140 geologists, 30 chemists, and 10 geophysicists of the Geologic Division and eight professional employees (hydrologists and chemists) of the Water Resources Division. Another 135 or so were involved in analytical laboratories and publications.

In addition to Geological Survey personnel, scientists from the university community took part in the program through research contracts and grants. In 1968, 19 contracts were in effect at 16 universities. Contract research in the marine field was carried out at the University of Alaska, University of California (Scripps Institution of Oceanography), Duke University, Louisiana State University, University of Oregon, Oregon State University, University of Southern California, Stanford University, Texas Agricultural and Mechanical University, and University of Washington; and land-based research was done at the University of Alaska, University of California (Berkeley), University of Colorado, Colorado School of Mines, Colorado State University, University of Maryland, Oregon State University, South Dakota School of Mines and Technology, and University of Texas.

Contract research also was done by Tracerlab, Inc., a commercial research laboratory.

PROJECTS UNDERWAY

At the end of 1968, the program included 137 projects in about 25 States. Land-based projects totaled 116; those in the marine field, 21. About 96 projects were district- or region-oriented field studies and 41 were dominantly topically oriented field or laboratory studies. Geological Survey personnel accounted for 118 projects, and contract personnel for 19. Distribution of effort was approximately as follows:

	Percent
Land-based district or regional studies	43
Topical field or laboratory studies	25
Marine studies	14.5
Contract research, marine	6
Contract research, land	2.5
Other contracts	9
	100.0

ANALYTICAL SUPPORT

Extensive chemical, spectrographic, and other analytical support was provided for the program. A substantial part of the analytical work was done in 15 to 20 truck-mounted mobile laboratories.

In 1968, about 110,000 samples were processed. Analytical work consisted of 58,000 analyses for gold, 755 analyses of platinum metals (platinum, palladium, and rhodium), 21,000 analyses for mercury, and 72,000 analyses for other elements (antimony, arsenic, beryllium, bismuth, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, silver, tellurium, tungsten, uranium, vanadium, and zinc). Semiquantitative spectrographic analyses for 30 elements each were made on 55,000 samples, and 120 complete spectrographic analyses were made to determine the trace element content of gold. Neutron-activation analyses for gold were made on 298 samples. A total of about 152,000 chemical determinations and 1,500,000 spectrographic determinations were made.

GEOLOGIC DRILLING

Geologic core and noncore drilling to obtain information on the third dimension was done under contract in eight areas, as follows:

1. Iron Canyon, 10 miles southwest of Battle Mountain, Nev. Two core-drill holes, started in April 1967, completed in June 1968.
2. Tenabo-Gold Acres, east side of Shoshone Range 30 miles southeast of Battle Mountain, Nev. Five core-drill holes, started in July 1967, completed in July 1968.
3. Roubaix and Rochford districts, northern Black Hills, S. Dak. Two core-drill holes, started in July, completed in September.
4. Ragged Top area, northern Black Hills, S. Dak. Two core-drill holes, started in July, completed in September.
5. Goldfield district, Nev. Two core-drill holes, started in July, completed in December.
6. Virginia City (Comstock Lode) district, Nev. Five core-drill holes, started in August, drilling still in progress at year's end.
7. San Juan Ridge, Nevada County, Calif. Four rotary-drill holes and some core drilling, started in July, drilling still in progress at year's end.
8. Badger Hill-North Columbia area, Nevada County, Calif. Six churn-drill holes, started in September, completed in December.

GEOPHYSICAL SUPPORT

A wide variety of geophysical support was provided to various projects. These geophysical investigations are summarized here; details on individual projects are included in the project descriptions.

AIRBORNE SURVEYS

Aeromagnetic surveys with flight lines spaced 1 mile apart were done in the Barker and Neihart quadrangles southeast of Great Falls in central Montana (420 square miles), in the Great Salt Lake Desert between Bingham and Wendover in Utah (6,480 sq mi), in the Virgin Basin south of Lake Mead in northwestern Arizona (2,200 sq mi), in the Crown King area of the Bradshaw Mountains south of Prescott in central Arizona (1,165 sq mi), in the Yellowpine district of west-central Idaho (1,300 sq mi), and in the San Juan Mountains and the Cripple Creek district of south-central Colorado (about 8,200 sq mi). A detailed aeromagnetic map with flight lines a quarter of a mile apart was made of the volcanic basin of the Cripple Creek mining district in central Colorado, and a similar detailed low-level study was made of the Wickes mining district between Helena and Butte in western Montana.

Aeromagnetic surveys with 1-mile flight-line spacing were made under contract in northeastern Idaho and western Montana, an area of about 8,500 sq mi that includes the Coeur d'Alene mining district of Idaho and extends north to Libby, Mont., east nearly to Kalispell, Mont., and south to Superior, Mont.; in several places in Alaska with a total extent of about 7,300 sq mi and including areas on, north, and east of Seward Peninsula, in the southern Alaska Range, and at Nixon Forks north of McGrath in southwestern Alaska; and on and offshore from the coast of Oregon over an area of about 18,500 sq mi.

Electromagnetic surveys were made in the Burnt Nubble area northeast of The Forks, Maine and the Catheart Mountain area east of Jackman, Maine; and radioactivity surveys covering about 1500 sq mi were made in Alaska.

Aeromagnetic maps of 39 15-minute quad- rangles, the Virginia City quadrangle, and part of three other quadrangles in Nevada have bee placed on open file. Other aeromagnetic map completed are of the Grass Valley-Nevada City and northern Mother Lode areas, California, an the Central City area, Colorado. Some data ar now available on combined aeromagnetic, electro- magnetic, and gamma-ray surveys of the Hail and Brewer mine area in north-central South Carolina, the Eastport-Calais area in easternmost Maine, and the Grass Valley and Mother Lode areas in California.

GROUND SURVEYS

Ground-based electromagnetic (EM), induce polarization (IP), magnetic, seismic, gravit gamma-ray, and very low frequency (VL studies were made for many projects. Stu areas included the Chulitna district (EM, IP) south-central Alaska; the Nevada City ar (seismic, gravity, EM, IP, resistivity) in Ca fornia; the Ouray-Silverton district (gamma-ra

IP, EM, VLF), Cripple Creek district (gravity, magnetic, and gamma-ray) and Silver Cliff district (gravity, seismic) in Colorado; the Barker and Neihart districts (gravity) and Wickes district (magnetic) in Montana; Swales Mountain and Lone Mountain in Elko County (magnetic, resistivity), Snowstorm mine in the Sheep Creek Range north of Battle Mountain (IP), the Midas and Ivanhoe districts in Elko County (magnetic), and the Tenabo and Cortez districts in Lander County (gravity), all in Nevada; and the Gros Ventre River valley (resistivity) in Wyoming.

BOREHOLE INVESTIGATIONS

Development and testing of borehole instruments continued, and field tests were made in the Nevada City area, California; the Burnt Nubble area near The Forks and Catheart Mountain east of Jackman, both in Maine; and Cornwall Knob near Virginia City, Iron Canyon south of Battle Mountain, and Tenabo and Buckhorn districts southeast of Battle Mountain, all in Nevada. Methods used included gamma-ray, magnetic susceptibility, resistivity, self-potential, IP, and temperature.

NEW FACILITIES AND EQUIPMENT

To extend and improve laboratory and field support for the program, new mineralogical laboratories were completed at field centers in Denver, Colo., and Menlo Park, Calif., and considerable new equipment was acquired. A mass spectrometer for sulfur isotope studies, an electron microprobe, and an X-ray diffractometer were installed at the Denver center.

Analytical laboratories of the Field Services Section were consolidated at the McIntyre Street site, in Denver, Colo., and capacity much increased through the lease of two additional buildings. Two new fire-assay furnaces are planned for this facility.

PUBLICATIONS

Publications resulting from or pertaining to the Heavy Metals program during 1968 included 29 Geological Survey Circulars, seven Geological Survey Professional Papers or Bulletins, nine articles in Geological Survey research 1968, three Geological Survey maps, and nine articles in technical journals. Instructions for ordering Geological Survey publications appear at end of report. The following reports were published (in approximate chronological order):

Professional Paper 594-F, Hydraulic equivalence of grains of quartz and heavier minerals, and implications for the study of placers, by H. F. Tourtelot, 13 p. Price, 20 cents.

Circular 553, Silver in veins of hypogene manganese oxides, by D. F. Hewett, 9 p.

Bulletin 1251-I, Devonian and Mississippian rocks and the date of the Roberts Mountains thrust in the Carlin-Pinyon Range area, Nevada, by J. F. Smith, Jr., and K. B. Ketner, 18 p. Price, 15 cents.

Map MF-301, Map of southeastern Maine showing heavy metals in stream sediments, by E. V. Post, W. L. Lehmbeck, W. H. Dennen, and G. A. Nowlan. Price, 50 cents.

Bulletin 1242-F, Geochemical cycle of selected trace elements in the tin-tungsten-beryllium district, western Seward Peninsula, Alaska—a reconnaissance study, by C. L. Sainsbury, J. C. Hamilton, and Claude Huffman, Jr., 42 p. Price, 75 cents.

Circular 557, Lead, copper, molybdenum, and zinc anomalies south of the Summitville district, Rio Grande County, Colorado, by W. N. Sharp and J. L. Gualtieri, 7 p.

Circular 560, U.S. Geological Survey Heavy Metals Program Progress Report, 1966 and 1967, 24 p.

Determination of palladium, platinum, and rhodium by fire-assay-emission spectrography, by Joseph Haffty and L. B. Riley: Talanta, v. 15, no. 1, p. 111-117.

Spatial relation of metal-mining districts to Tertiary volcanic centers in Nevada, by J. P. Albers and F. J. Kleinhampl: Am. Inst. Mining Metall. Petroleum Engineers mtg., New York, N. Y., February 1968; informal distrib.

Professional Paper 594-C, Silver-rich disseminated sulfides from a tungsten-bearing quartz lode, Big Creek district, central Idaho, by B. F. Leonard, C. W. Mead, and Nancy Conklin, 24 p., 4 pl. Price, 35 cents.

Map. I-530, Regional geologic map of the Selawik and southeastern Baird Mountains quadrangle, Alaska, by W. W. Patton, Jr., and T. P. Miller. Price, $1.00.

Circular 559, Lead, zinc, and silver deposits at Bowser Creek, McGrath A-2 quadrangle, Alaska, by B. L. Reed and R. L. Elliott, 17 p.

Professional Paper 600-B, Geological Survey research 1968. Price, $2.00:

Determination of palladium and platinum in rocks, by F. S. Grimaldi and M. M. Schnepfe, p. B99-B103.

Concentration and minor element association of gold in ore-related jasperoid samples, by T. G. Lovering, H. W. Lakin, and A. E. Hubert, p. B112-B114.

Rapid analysis for gold in geologic materials, by C. E. Thompson, H. M. Nakagawa, and G. H. VanSickle, p. B130-B132.

Circular 561, An atomic-absorption method for the determination of gold in large samples of geologic material, by G. H. VanSickle and H. W. Lakin, 4 p.

Circular 562, Utilization of humus-rich forest soil (mull) in geochemical exploration for gold, by G. C. Curtin, H. W. Lakin, G. J. Neuerburg, and A. E. Hubert, 11 p.

Circular 563, Favorable areas for prospecting adjacent to the Roberts Mountains thrust in southern Lander County, Nevada, by J. H. Stewart and E. H. McKee, 13 p.

Circular 564, Occurrences of gold and other metals in the upper Chulitna district, Alaska, by C. C. Hawley and A. L. Clark, 21 p.

Bulletin 1278-A, Metal absorption by *Equisetum* (horsetail), by H. L. Cannon, H. T. Shacklette, and Harry Bastron, 21 p. Price 15 cents.

Circular 565, Cassiterite in gold placers at Humboldt Creek, Serpentine-Kougarok area, Seward Peninsula, Alaska, by C. L. Sainsbury, Reuben Kachadoorian, T. E. Smith, and W. C. Todd, 7 p.

Circular 566, Tertiary gold-bearing channel gravel in northern Nevada County, California, by D. W. Peterson, W. E. Yeend, H. W. Oliver, and R. E. Mattick, 22 p.

Circular 569, Geochemical anomalies and metalliferous deposits between Windy Fork and Post River, southern Alaska Range, by B. L. Reed and R. L. Elliott, 22 p.

Circular 570, Suggested areas for prospecting in the central Koyokuk River region, Alaska, by T. P. Miller and O. J. Ferrians, Jr., 12 p.

Circular 587, Gold distribution in surface sediments on the continental shelf off southern Oregon: a preliminary report, by H. E. Clifton, 5 p.

Evidence for possible placer accumulations on the southern Oregon continental shelf, by L. D. Kulm, D. F. Heinrichs, R. M. Buehrig, and D. M. Chambers: The Ore Bin, v. 30, p. 81-104.

Circular 588, Geochemical anomalies in the Swales Mountain area, Elko County, Nevada, by K. B. Ketner, J. G. Evans, and T. D. Hessin, 13 p.

Circular 589, Distribution of gold, silver, and other metals near Gold Acres and Tenabo, Lander County, Nevada, by C. T. Wrucke, T. J. Armbrustmacher, and T. D. Hessin, 19 p.

Fluorometric determination of gold in rocks with Rhodamine B, by John Marinenko and Irving May: Anal. Chemistry, v. 40, p. 1137-1139.

Determination of gold in rocks by neutron activation analysis using fire-assay preconcentration, by F. O. Simon and H. T. Millard, Jr.: Anal. Chemistry, v. 40, p. 1150-1152.

Map I-554, Regional geologic map of the Shungnak and southern part of the Ambler River quadrangles, Alaska, by W. W. Patton, Jr., T. P. Miller, and I. L. Tailleur. Price, $1.00.

Circular 590, Potential for lode deposits in the Livengood gold placer district, east-central Alaska, by R. L. Foster, 18 p.

Use of mercurous chloride to recover trace amounts of gold from waters, by E. A. Jenne, T. T. Chao, and L. M. Heppting: Econ. Geology, v. 63, p. 420-21.

Geologic environment of gold deposits in Nevada [abs.], by R. J. Roberts, K. B. Ketner, and A. S. Radtke, 1967: Inst. Mining and Metallurgy [London] Trans., v. 76, sec. B, Bull. 732, p. B228-B229.

Coagulation of humic colloids by metal ions, by H. Ling Ong and R. E. Bisque: Soil Sci., v. 106, no. 3, p. 220-224.

Circular 591, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials, by D. J. Grimes and A. P. Marranzino, 6 p.

Circular 592, Interpreting pan-concentrate analyses of stream sediments in geochemical exploration for gold, by R. P. Fischer and F. S. Fisher, 9 p.

Professional Paper 600-C, Geological Survey research 1968. Price, $2.25:

Geology of the Klamath River delta, California, by G. W. Moore and E. A. Silver, p. C144-C148.

Determination of gold, platinum, and palladium by a combined fire-assay, ion-exchange, and spectrochemical technique, by P. R. Barnett, D. L. Skinner, and Claude Huffman, Jr., p. C161-C163.

Circular 593, Distribution of gold and some base-metals in the Slana area, eastern Alaska Range, by D. H. Richter and N. A. Matson, Jr., 20 p.

Circular 595, Geochemical and geophysical anomalies in the western part of the Sheep Creek Range, Lander County, Nevada, by G. B. Gott and C. J. Zablocki, 17 p.

Circular 596, Preliminary results of geological, geochemical, and geophysical studies in part of the Virginia City quadrangle, Nevada, by D. H. Whitebread and D. B. Hoover, 20 p.

Circular 597, Distribution of beryllium, tin, and tungsten in the Lake George area, Colorado, by C. C. Hawley and W. R. Griffitts, 18 p.

Circular 599, The determination of gold in geologic materials by neutron-activation analysis using fire assay for the radiochemical separations, by J. J. Rowe and F. O. Simon, 4 p.

Professional Paper 612, Geology of niobium and tantalum, by R. L. Parker and Michael Fleischer. Price, 50 cents.

Simultaneous determination of tantalum and hafnium in silicates by neutron activation analysis, by L. P. Greenland: Anal. Chim. Acta., v. 42, p. 365-370.

Geology of lode tin deposits, by C. L. Sainsbury and J. C. Hamilton, *in* A technical conference on tin, London, 1967: London, Internat. Tin Council, v. 1, p. 314-349.

Tin and beryllium deposits of the central York Mountains, western Seward Peninsula, Alaska, by C. L. Sainsbury, *in* Ore deposits of the United States 1933-1967: New York, AIMMPE Inc., v. 2, p. 1555-1572.

Professional Paper 610, Principal gold-producing districts of the United States, by A. H. Koschmann and M. H. Bergendahl, 283 p. Price, $4.75.

Circular 600, Geochemical evidence for possible concealed mineral deposits near the Monticello Box, northern Sierra Cuchillo, Socorro County, New Mexico, by W. R. Griffitts and H. V. Alminas, 13 p.

Circular 603, Gold in meteorites and in the earth's crust, by R. S. Jones, 4 p.

Circular 606, Anomalous concentrations of gold, silver, and other metals in the Mill Canyon area, Cortez quadrangle, Eureka and Lander Counties, Nevada, by J. E. Elliott and J. D. Wells, 20 p.

Circular 604, Distribution of gold, copper and some other metals in the McCarthy B-4 and B-5 quadrangles, Alaska, by E. M. MacKevett, Jr., and J. G. Smith, 25 p.

Circular 605, Gold distribution on the sea floor off the Klamath Mountains, California, by G. W. Moore and E. A. Silver, 9 p.

Circular 607, Platinum and associated elements at the New Rambler mine and vicinity, Albany and Carbon Counties, Wyoming, by P. K. Theobald, Jr., and C. E. Thompson, 14 p.

Professional Paper 600-D, Geological Survey research 1968. Price, $3.25:

- Adsorption of traces of silver on sample containers, by T. T. Chao, E. A. Jenne, and L. M. Heppting, p. D13-D15.
- Prevention of adsorption of trace amounts of gold by containers, by T. T. Chao, E. A. Jenne, and L. M. Heppting, p. D16-D19.
- Residual enrichment and supergene migration of gold, southeastern United States, by A. R. Kinkel, Jr., and F. G. Lesure, p. D174-D178.
- Determination of rhodium in rocks, by M. M. Schnepfe and F. S. Grimaldi, p. D210-D213.

REPORTS AND MAPS ON OPEN FILE

The following reports and maps were placed on open file during 1968.

REPORT

Gold gradients and anomalies in the Pedro-Cleary Summit area, Fairbanks district, Alaska, by R. B. Forbes, H. D. Pilkington, and D. B. Hawkins.

GEOLOGIC MAPS

Geochemical reconnaissance maps of granitic rocks, Coleen and Table Mountain quadrangles, Alaska, by W. R. Brosgé and H. N. Reiser.

Reconnaissance geologic map of the Tanacross quadrangle, Alaska, by H. L. Foster.

AEROMAGNETIC MAPS

Nevada: aeromagnetic maps covering all or parts of the following areas:

- Elko County: Bull Run, Hat Peak, Jarbidge, Midas, Mountain City, Mount Velma, North Fork, Norths Ranch, Owyhee, Rowland, Tuscarora, Wild Horse, and Wilson Reservoir quadrangles.
- Eureka and White Pine Counties: Eureka region.
- Humboldt County: Golconda quadrangle.
- Lander County: Battle Mountain quadrangle and Austin region.

Lander and Eureka Counties: Dunphy quadrangle.
Pershing County: Unionville region.
South Carolina: airborne electromagnetic and total intensity magnetic profiles in the vicinity of the Haile, Brewer, and Blackmon mines, Lancaster, Chesterfield, and Kershaw Counties.

STUDIES ON LAND

Abbreviations commonly used are:

ppm = parts per million (1 ppm = 0.0001 percent, or about 0.03 oz per ton; for gold at $35.00 per oz, 1 ppm equals about $1.00 per ton)

ppb = parts per billion (1 ppb = 0.0000001 percent)

Analytical data for gold, platinum metals, and silver are usually given in parts per million or parts per billion. Results are frequently reported as "less than" a certain amount, this amount being the limit of detection of the analytical method employed. Such a result means that the element was not detected and, if present at all, occurs only in an amount below the detection limit.

ALASKA

The second full field season under the program was completed in Alaska in the summer of 1968. The Alaska program comprised 16 projects and a research contract with the University of Alaska. Work was done in selected areas of southeast, central, and southwest Alaska and on and east of Seward Peninsula. About 25 Geological Survey scientists took part, as well as three professors from the University of Alaska. Nearly 32,000 samples were analyzed during the year, many of these in a mobile laboratory stationed at Anchorage. Publications on Alaskan studies included one bulletin, eight circulars, two maps, one press release, and two outside publications.

Southern Alaska Range

Lead-silver-zinc occurrences between Windy Fork and Post River in the southern Alaska Range south of Farewell were reported in U.S. Geological Survey Circulars 559 and 569. Replacement deposits in limestone are associated with felsic breccia pipes. As a result of considerable exploration activity, additional deposits were discovered in 1968.

Massive fine-grained copper-silver-zinc sulfide deposits were observed in 1967 in the Talkeetna C-6 quadrangle 2 miles north of Shellabarger Pass in the Alaska Range. The deposits were mapped and sampled in more detail in 1968. The deposits are of two general types, bedding replacements of calcareous units in a sequence of chert and argillitic limestone that is cut by diabasic dikes, and fracture fillings in chert. The dominant minerals are pyrite, chalcopyrite, sphalerite, arsenopyrite, and sulfosalts. The largest body exposed is slightly more than 100 feet long and at least 17 feet thick. Massive sulfides crop out 1000 feet south and also 800 feet west of the main showings. Analyses of samples show 0.5 to 5 percent copper and zinc, and 0.2 to 9 ounces of silver per ton. These deposits are of a new type and occur in a different geologic setting than those south of Farewell.

Several alteration zones and occurrences of float containing lead, silver, zinc, and molybdenum were noted during reconnaissance mapping and sampling of plutonic rocks between Two Lakes and Farewell.

A series of biotite granites containing anomalous amounts of tin appears to define a new tin belt in the central Alaska Range. Additional mapping and analyses are necessary to further define this belt.

A pilot study using soil sampling in the Nixon Fork gold lode district may have defined a new ore body or given an excellent example of an intense gold anomaly displaced by soil creep from a previously worked deposit. This pilot study should provide guidelines for geochemical exploration in this part of Alaska. An aeromagnetic survey of the Nixon Fork district indicates the presence of covered intrusive bodies which cut limestone and a thrust fault. Inasmuch as all the known ore bodies in this district are contact metamorphic deposits in limestone along the contacts of quartz monzonite stocks, these magnetic anomalies may be of economic significance. (B. L. Reed, R. L. Elliott, and G. D. Eberlein, Menlo Park, Calif.)

Central and Eastern Alaska Range

Geochemical investigations in the Slana area of the eastern Alaska Range, made in cooperation with the Alaska Division of Mines and Geology were reported in U.S. Geological Survey Circular 593. This study suggests that lead-zinc-molybdenum-silver mineralization is associated with a large zoned quartz monzonite-granodiorite pluton, the Ahtell Creek pluton, whereas gold-copper mineralization is associated with small diorite-quartz diorite intrusives. Preliminary drilling of an altered area in the Ahtell Creek pluton has revealed significant amounts of molybdenite. Further exploration is planned by industry.

Reconnaissance geologic mapping and geochemical studies have been completed in the Nabesna B-4 and A-3 quadrangles with some overlap into the Nabesna A-2, A-5, B-3, B-5 and C-5 quadrangles. All investigations were south of the Denali lineament in an area underlain by upper Paleozoic and Mesozoic sedimentary and volcanic rocks.

A thick unit of amygdaloidal basalt flows of Permian or Triassic age warrants attention as a potential source of copper. This unit, which is as much as 5000 feet thick, has now been traced from the head of the Chistochina River, in the Mount Hayes quadrangle, southeast over 140 miles to the Canadian border. Native copper and occasionally copper sulfides occur in minor amounts throughout the flows in amygdules, scoriaceous flow tops and bottoms, and fractures and local shear zones. Mineralogically and petrographically the flows appear similar to the Precambrian basalts of the Upper Peninsula of Michigan and to the Nikolai Greenstone of Triassic age exposed along the south flank of the Wrangell Mountains in Alaska. Amygdule minerals consist chiefly of chlorite, calcite, quartz, and epidote with lesser amounts of pumpellyite, prehnite, heulandite, analcime, and natrolite.

Preliminary potassium-argon dates indicate emplacement ages of Early Cretaceous for some diorite, quartz diorite, and quartz monzonite stocks. Field evidence suggests an even younger age for some of the larger complex granodiorite intrusives. The granodiorite intrusives appear to be more economically significant than the smaller less alkalic stocks and plutons. The "Bond Creek" batholith in the Nabesna area is host for at least one low-grade porphyry copper deposit and a number of contact-metamorphic base-metal deposits.

The character and distribution of placer gold in the Chistochina district indicate that the source of the gold is a highly weathered conglomerate, probably of pre-Tertiary age. Significant residual concentrations of gold are present locally in the conglomerate on upland surfaces.

Placer gold has been found in Tertiary conglomerate in the Nelchina district in the western part of the Talkeetna Mountains. These rocks had been considered as a possible source of placer gold in the district but heretofore no gold has been found in them. This finding will aid in locating areas most likely to contain other gold placer deposits. (D. H. Richter, Anchorage, Alaska, and O. J. Ferrians, Menlo Park, Calif.)

Bettles-Wiseman Area

Geochemical studies along the upper Kanuti River, a tributary of the Koyokuk River south of Bettles in north-central Alaska, led to the discovery of a small disseminated deposit of lead, silver, and zinc. Geochemical sampling along a tributary of the Kanuti revealed anomalous concentrations of tin which appear to be related to nearby biotite granites, some of which run as high as 70 ppm tin in bulk samples.

A heretofore unknown belt of ultramafic and mafic rocks has been mapped from Caribou Mountain, southeast of Bettles, at least 65 miles southwestward along the margin of the Yukon-Koyukuk basin. The ultramafic rocks contain 2,000-5,000 ppm nickel. The possibility of residual concentration, particularly beneath overlapping nonmarine Cretaceous sediments, warrants further investigation.

Small bench placers on the South Fork of the Koyukuk River south of Wiseman appear to have their source in quartz veins in a belt of schist exposed along the south side of the river. Reconnaissance mapping and preliminary results of geochemical sampling suggest that these deposits mark the southern limit of the Wiseman-Chandalar gold district. (W. W. Patton, Jr., Menlo Park, Calif.)

Study of electrical properties of schist bedrock along the Middle Fork of the Koyukuk River shows that the conductivity of the schist is similar to that of the overlying gravels. Study of resistivity data indicates a depth to bedrock of only about 60 feet on Porcupine Creek, well within reach of modern gold dredges. Bedrock depth along the Koyukuk at Wiseman is about 250 feet. (L. A. Anderson, Denver, Colo.)

Eastern Brooks Range

Reconnaissance stream sediment sampling in the Chandalar quadrangle and the eastern part of the Wiseman quadrangle on the south slope of the Brooks Range in eastern Alaska has revealed only two conspicuous regional anomalies; these coincide with the two known gold mining districts near Wiseman and Chandalar. A third anomalous area is suggested by the clustering of samples with anomalous amounts of silver in a zone along the contact between granite and carbonate rock north of the mining districts. The concentration of silver is not high, but silver is known to occur in galena at one prospect and as nuggets in a stream placer in the area.

The Old Crow granite pluton, of Carboniferous age, in the Coleen quadrangle, easternmost Alaska, may be in part a tin granite. Tin has not been detected in stream sediments derived from Mesozoic granites farther west, but does occur with beryllium in sediments of two streams near the center of the Carboniferous granite at the Canadian boundary. Tin also occurs in rhyolite associated with this granite. Analyses of the granite are to be made. (W. P. Brosgé, Menlo Park, Calif.)

Eagle Quadrangle and Adjacent Areas

During geologic reconnaissance of the Eagle quadrangle, easternmost central Alaska, an asbestos occurrence was observed in 1968 and reported in U.S. Geological Survey Circular 611, (published in 1969). The exposed part of the deposit consists of large joint blocks of serpentine which are cut by closely spaced subparallel veins, mostly about a quarter of an inch thick, of cross-fiber chrysotile asbestos. The asbestos appears to be of commercial quality, but the total quantity is unknown.

Geochemical sampling and reconnaissance geologic mapping along a portion of the Tintina fault zone in the Seventymile River area indicates a zone of mineralization at least 30 miles long and up to 15 miles wide. Gold mineralization appears to be associated with a belt of serpentinized ultramafic rocks in the zone of faulting, and placer gold in part of the area, particularly Flume Creek and vicinity, appears to be derived from rocks in the fault zone. At Flume Creek, lode gold and arsenopyrite occur in quartz-carbonate rock and quartz veins in ultramafic and mafic rock.

Geochemical sampling and reconnaissance geologic mapping in the Fortymile River area indicate a previously unsuspected possible anomaly on Alder Creek and on Champion Creek. Near Champion Creek a lead-zinc vein of unknown size was located. Anomalies found in American Creek, North Fork, Gold Run area, Montana Creek area, and Ketchumstuk area indicate some further investigation may be warranted, although placer mining and (or) prospecting has already been done there. Geochemical sampling did not indicate mineralization in addition to known prospects in the My Creek-Our Creek area. (H. L. Foster and S. H. B. Clark, Menlo Park, Calif.)

Ester-Cleary Mineral Belt, Fairbanks Region

The Ester-Cleary mineral belt, an area of some 800 sq mi lying immediately northwest, north and northeast of Fairbanks, is being studied under a research contract with the University of Alaska.

The area is one of mica schist and micaceous quartzite intruded by quartz monzonite plutons and dikes and cut by auriferous quartz veins. The gold and sulfide lode deposits are chiefly localized along domed portions of the Cleary anticline and in the southeast quadrant of Ester Dome. They seem to be genetically related to quartz monzonite intrusives in favorable structural settings.

Gold anomalies have been found in fracture and shear zones, as much as 40 feet in width, in quartz monzonite, quartz diorite, and crystalline schists. These anomalies are commonly surrounded by haloes with traces of antimony and (or) arsenic. Geochemical sampling on the southeast slopes of Ester Dome has found several wide hydrothermal alteration zones in schists. These zones contain anomalous amounts of gold, and at least one high-grade gold-quartz vein has been found. In the Cleary Summit area, 16 samples across an alteration zone 20 feet wide contained as much as 17 ppm gold, and half of these samples had 0.5 ppm or more. Sampling of discordant quartz veins beyond the usual limits of the Fairbanks lode belt shows that the zone of gold enrichment is much broader than previously recognized.

Geochemical and structural data show that fracture- and shear-zones along the axial zone of the Cleary anticline cut all the major rock units and that heavy metals mineralization is accompanied by silicification and hydrothermal alteration along these zones. Some of the more persistent zones in the quartz diorite and crystalline schists may be of potential economic interest.

Approximately 40 miles of magnetometer, gravity, resistivity, and induced polarization traverses were made by members of the Regional Geophysics Branch. About 370 shallow holes were drilled with a truck-mounted mobile drill for bedrock mapping and geochemical analysis, and about 500 samples were taken from these holes. Several hundred geochemical samples were taken from surface exposures, rubble-soil, prospect trenches, and streams. Several gold anomalies (as much as 200 ppm) were found in samples from auger holes on the Ester Dome road.

Geochemical sampling in and near the Gilmore Dome granite-monzonite pluton showed some slightly anomalous metal values, but none of the anomalies appear to indicate significant zones of mineralization.

An interesting problem being studied by several Heavy Metals projects is the distribution of gold in wallrocks of lode deposits—that is, are any high grade or bonanza precious metal deposits bordered by or enclosed in envelopes of low-grade disseminated ore? Field and laboratory investigation of this problem in the Ester-Cleary region shows that gold gradients do exist in wallrocks adjacent to veins. Gold assays as high as 1.1 ppm were found as much as 5 feet from a vein, and assays of >1 ppm, as far as 9 feet from a vein. At least four veins were found at which gold contents of 0.5 ppm or more were found in wallrocks several feet from the vein.

A detailed structure section across the Ester-Cleary mineralized belt with reasonably good geological control and supporting geophysical data gives new information on the probable thrust fault in the Cleary anticline, on the relationship of two rock units of different metamorphic facies and structural habit, and on the structural and facies control of the lode deposits. Gravity and magnetometer traverses seem to confirm the other geologic field evidence for a fault and an eclogitic rock unit in the Cleary anticline. The eclogitic rocks are apparently within the more complex lower plate, which is mostly barren of mineral deposits. (R. M. Chapman, R. B. Forbes, H. D. Pilkington, and D. B. Hawkins, Fairbanks, Alaska)

Hyder District

Geologic and geochemical studies are being made in the Bradfield Canal A-1 and Ketchikan D-1 quadrangles of the Hyder district northeast of Ketchikan in southeasternmost Alaska.

The Bradfield Canal A-1 quadrangle has been mapped in as much detail as vegetation and snow cover will allow, and the Ketchikan D-1 quadrange, underlain almost wholly by granitic rock and glacial deposits, in slightly less detail. The geology along much of the Portland Canal, which cuts through the Coast Range batholith, was mapped in rapid reconnaissance fashion in conjunction with a gravity survey of southeastern Alaska by the Branch of Regional Geophysics. Granitic rock samples for potassium-argon and fission-track dating were collected. In a general way, the average composition of the Coast Range batholith changes from diorite and granodiorite on the southwest to quartz monzonite on the northeast. More detailed studies of mineralogical and chemical variations in the intrusive rocks along the Portland Canal and in the Hyder area are underway.

Detailed geochemical sampling was concentrated in the Bradfield Canal A-1 quadrangle around altered margins of roof pendants of Hazelton volcanics and in the sheared granodiorite of Texas Creek where these are intruded by rocks of the Coast Range batholith. Reconnaissance geochemical sampling and mapping was done in the Bradfield Canal A-2 quadrangle along the eastern margin of the Coast Range batholith in the headwaters of the Leduc and Chickamin Rivers to search for anomalies similar to those associated with the nearby Granduc Mine in British Columbia, Canada. Reconnaissance stream sediment sampling in the Ketchikan D-1 quadrangle was also carried out in conjunction with geologic mapping. Several small local anomalies of gold, silver, and molybdenum were delineated. A geochemical map on the results of the geochemical work is in preparation. (J. G. Smith, Menlo Park, Calif.)

Livengood District

A geochemical anomaly near Ruth Creek in the Livengood gold district, about 60 miles northwest of Fairbanks, was reported in U.S. Geological

Survey Circular 590. The anomaly is defined by abnormally high concentrations of several elements (gold, arsenic, mercury, tin, molybdenum, and silver) in stream sediments, by highly acid stream water, and by gold deposits in bedrock. The lode deposits, although small, may be indicative of larger deposits at depth in or below major fault zones. (R. L. Foster, Menlo Park, Calif.)

St. Lawrence Island

The geology of St. Lawrence Island, in the Bering Sea about 150 miles southwest of Seward Peninsula, is being studied to aid in interpreting geologic structures in the Bering Sea and in understanding possible controls for the accumulation of gold and other heavy minerals in the sea.

Preliminary investigations in the eastern part of the island indicate the presence of a heretofore little known Paleozoic and Mesozoic sequence possibly as much as 8,500 feet thick. The oldest strata are approximately 4,000 feet of dolomite and dolomitic limestone, succeeded disconformably by 1,000 to 1,500 feet of cherty limestone. These carbonate rocks range in age from Devonian to Late Mississippian and include a considerable thickness of reefy dolomites. If these rocks extend northward and southward beneath the shallow Tertiary basins that underlie the Bering Sea shelf they could offer major petroleum possibilities.

The Paleozoic rocks are overlain disconformably by a 400-foot shaly sequence that is probably of Early Triassic or Permian age in the lower part and is definitely of Late Triassic age in the upper part. The youngest sedimentary rocks are a thick section of graywacke and mudstone; no fossils have yet been found in them but a Jurassic or Cretaceous age is strongly suggested by their stratigraphic position and by their similarity to rocks of the same age in adjoining parts of mainland Alaska.

Detailed mapping and geochemical sampling in the Boxer Bay area at the west end of the island have revealed zinc and molybdenum anomalies on the upper Boxer River and lead, zinc, and silver mineralization in a belt extending northeast from Southwest Cape to the Putgut Plateau. (W. W. Patton, Jr., and Bela Csejtey, Menlo Park, Calif.)

Eastern Seward Peninsula

A geochemical and geological reconnaissance has been made of part of the western Hogatza Trend in the Candle quadrangle (published at 1:250,000) in the eastern Seward Peninsula. In addition, a stream sediment sampling program was carried out over a 2,000 sq mi area and the intrusive rocks were sampled in detail. This work resulted in the discovery of two large mineralized areas near Granite Mountain. The larger of the two is along Quartz Creek west of Granite Mountain where numerous occurrences of lead-silver-zinc sulfide minerals were found over a length of 18 miles. The other mineralized area is east of Granite Mountain in the headwater basin of the upper Peace River, where molybdenum-silver-bismuth-lead-uranium minerals were found associated with an alkaline intrusive stock. These results were reported in U.S. Geological Survey Circular 614 (published in 1969).

A zoned alkaline intrusive complex was observed at Granite Mountain. The complex is a circular body 30 sq mi in area with a silica-oversaturated and silica-saturated core and an alkaline undersaturated rim.

Regional mapping and geochemical sampling were begun in the eastern half of the Bendeleben quadrangle (published at 1:250,000), and several small geochemical anomalies were found.

Several geochemical anomalies of copper, lead, zinc, silver, gold, uranium, and thorium were found in the central Koyokuk River region near Hughes and Hog Landing. These findings were reported in U.S. Geological Survey Circular 570. (T. P. Miller, R. L. Elliott, and O. J. Ferrians, Menlo Park, Calif.)

Western Seward Peninsula

Recognition of abundant cassiterite in gold placer deposits on Humboldt Creek in the Serpentine-Kougarok area was reported in U.S. Geological Survey Circular 565. A bedrock source for the cassiterite has now been discovered.

Continued mapping of the Seward Peninsula at a scale of 1:250,000 has demonstrated that rocks of the entire Seward Peninsula are involved in thrust sheets of a major thrust belt. A large terrane of blueschist facies rocks of probable Precambrian age has been defined. The Paleozoic stratigraphy, from pre-Ordovician through at least the Mississippian, reflects shelf-type sedimentation, and is represented almost entirely by carbonate rocks. In the western Seward Peninsula, thrust sheets of unmetamorphosed carbonate rocks lie above high rank metamorphic rocks; at the east end of the peninsula, the Paleozoic carbonate rocks are metamorphosed to marble, but rest upon metamorphic rocks of much higher rank.

A regional zonation of mineral deposits is suggested, from greisen-type tin deposits on the western Seward Peninsula to base-metal deposits with silver and moderate amounts of tin in the central and eastern Seward Peninsula. (C. L. Sainsbury, Denver, Colo., and Reuben Kachadoorian, Menlo Park, Calif.)

Southeastern Alaska

The area around the famous Alaska-Juneau and Treadwell gold mines is being studied to determine the economic potential of this widely mineralized part of Alaska.

The northeasternmost part of the large Tertiary granodiorite-adamellite complex that forms the core of the Coast Range northeast of Juneau has abundant iron-stained zones within it and near it. Spectrographic analysis of samples from several of these zones shows that most are not economically significant, but one such zone, an intensely iron-stained aplite body which is a dike-like extension of the main composite granodiorite complex, was found to contain as much as 1,000 ppm molybdenum, 9.6 ppm silver, and 300 ppm copper. The occurrence has not been mapped or sampled in detail. Iron-stained zones are less abundant in and near the west-central part of the complex. The complete periphery of this Tertiary intrusive complex has not yet been studied.

Study of old reports dealing with the northern Juneau Gold Belt suggests that there is a consistent spatial relation between the larger deposits and the contact between a persistent metavolcanic unit and a black slate unit. This contact is poorly exposed and may warrant closer attention than it has received.

Stream sediment samples from drainages cutting the host rock unit of the Alaska-Juneau deposit as much as 15 miles to the northwest and southeast of that deposit give little indication that any similar but undiscovered deposit may be present. However, some resampling is needed in two drainages southeast of the Alaska-Juneau mine.

Large volumes of altered greenschist and phyllite containing disseminated sulfides and small veins occur on southeastern Douglas Island, to the southeast of the Treadwell group of mines. The metal content is great enough to cause significant anomalies in stream sediments, but analyses of the schists show that the metal content is generally too low to be economically significant. However, spectrographic analyses of single and composite samples show as much as 17 ppm gold, 0.5 ppm silver, 1,000 ppm copper, 20 ppm molybdenum, 5,000 ppm lead, and 700 ppm zinc. Stream courses and old mine workings provide the only exposures of the altered rocks. (D. A. Brew, A. L. Ford, and A. L. Clark, Menlo Park, Calif.)

Mineral deposits of the belt are characterized primarily by arsenic and gold and subordinately by silver, lead, zinc, antimony, bismuth, and tin. The main deposit of the northern part of the belt is the Golden Zone, which was discussed in U.S. Geological Survey Circular 564. Other principal deposits are new identified occurrences at Costello Creek and Lookout Mountain and vein and associated disseminated deposits in basalt and limestone host rocks at Partin and Canyon Creeks. The main deposits of the southern part are placer gold deposits of the Cache Creek-Peters Creek basin in the Yentna district. These placers were derived from the erosion of small but rich lode deposits such as those at Bird Creek and probably from erosion of lower grade deposits in major shear zones. Arsenic and gold are ubiquitous elements of the belt; they characterize both lode and placer deposits and have a regionally high abundance in stream sediments. Less abundant but diagnostic elements include copper, antimony, tin, and bismuth. (C. C. Hawley and A. L. Clark, Menlo Park, Calif.)

Talkeetna Mountains and Central Alaska Range

A mineralized belt called the Chulitna-Yentna belt is defined by lode occurrences, geochemical anomalies, and placer deposits derived from lodes within the belt and extends for more than 100 miles along the southern flank of the central Alaska Range. The belt extends at least from Collinsville on the south to Bull River in the north and goes through the Yentna, Curry, and upper Chulitna districts. It is subparallel to the regional strike of rock units and faults and in its northern part to elongate serpentinite masses which locally contain chromite.

The Yentna-Chulitna belt is underlain by rocks of pre-Permian to Cretaceous age which are cut by small igneous bodies of ultramafic to granite composition and a major batholith in the Curry district. The oldest rocks are in a fault block in the valley of the Chulitna River; they are overlain unconformably by red beds, basalt, and limestone of Permian and Triassic age which in turn are overlain by dark detrital rocks of Jurassic(?) and Cretaceous age. The Permian and younger rocks were strongly folded and faulted in post-Early Cretaceous, pre-Oligocene time.

Wrangell Mountains

Results of geologic mapping and geochemical investigations in the McCarthy B-4 and B-5 quadrangles in the southern Wrangell Mountains and Chitina Valley were reported in U.S. Geological Survey Circular 604. Anomalous concentrations of copper, silver, antimony, molybdenum, gold, and arsenic and local occurrences of tungsten, lead, and zinc were found. (E. M. MacKevett, Jr., and J. G. Smith, Menlo Park, Calif.)

Yakutat Region

Geologic mapping at a scale of 1:250,000 has been completed in the Yakutat quadrangle and small areas of the adjacent Mount St. Elias quadrangle of southern Alaska, and mapping at a scale of 1:63,360 is nearly completed in the Yakutat D-3 and D-4 quadrangles. All major lithologic units and altered zones in the Yakutat quadrangle were delineated and sampled, and 140 stream sediment samples were collected. No potentially economic mineral deposits were found, although spectrographic analyses indicate anomalous concentrations of copper, zinc, vanadium, titanium, manganese, chromium, nickel, cobalt, and molybdenum in several altered zones, stream sediment samples, and rock specimens.

In the course of geochemical sampling in the Yakutat quadrangle and adjacent areas, float of mafic and ultramafic rocks in glacial moraines was traced to a pluton on the southwest flank of Mount Fairweather. Aerial observation indicated that the float was derived from a stratiform pluton exposed above an altitude of about 8,000 feet over an area of several square miles. The discovery is noteworthy because it extends the known occurrence of mafic and ultramafic rocks in the Fairweather Range 20 miles farther northwest and because nickel-copper deposits are known to be associated with bodies of ultramafic rock elsewhere in the Range. (George Plafker and E. M. MacKevett, Jr., Menlo Park, Calif.)

ARIZONA

Lode and Placer Gold Deposits, Mohave County

Gold deposits in Precambrian rocks of the Gold Basin-Lost Basin district in Mohave County are closely associated with small masses of quartz leucosyenite and aplite that intrude porphyritic biotite granite. Fluorite, pyrite, calcite, and gold are disseminated in two bodies of leucosyenite.

Reconnaissance sampling of Quaternary gravels, colluvium, and prospect dumps has greatly expanded the area of known gold-bearing gravels and has revealed appreciable concentrations of scheelite in some pediment gravels; the source of the scheelite is not yet known. (P. M. Blacet, Menlo Park, Calif.)

CALIFORNIA

Geochemical Studies at Bodie

The Bodie district in Mono County appears t be in the resurgent center of a large volcani collapse feature. The south rim of the featur is intruded by one or more rhyodacite plugs an is overlain by rhyodacite tuff breccia. In th resurgent core, andesite tuff breccia is intrude by a north-trending faulted body of porphyriti andesite. Although the andesite is not exter sively exposed, its occurrence on mine dump indicates that it underlies most of the district a less than a thousand feet. Quartz veins cut th intrusive andesite and the overlying lavas an tuffs.

At Bodie approximately 400 samples, most surface, were collected, including about 100 th were taken in a detailed traverse of the Bod Tunnel, which provides a good profile across t major structural trends of the district. Most these samples have now been analyzed. In add tion, 60 orientation samples collected earlier ha also been analyzed. The analytical results a being studied statistically and are summariz as follows:

1. The average content of gold and silver fou in 29 specimens of vein quartz and ore c

lected on dumps was 19 ppm gold and 216 ppm silver. In samples of wallrock these values drop off sharply, especially those for gold.

2. A correlation analysis on the total set of samples shows that the following elements have significant positive correlation with gold: Bismuth, tin, silver, arsenic, antimony, and zinc. The following elements are positively correlated with silver: Molybdenum, zinc, gold, lead, antimony, and copper. In addition, measurable quantities of tungsten and beryllium occur in samples that have higher than average contents of gold and silver.
3. Correlation analyses on the 29 samples of vein quartz show the same element correlations, although the numerical values of the correlation coefficients are higher.

Potassium-argon ages on adularia-quartz veins from different parts of the district indicate that mineralization occurred approximately 8 million years ago. Three potassium-argon age determinations of plagioclase separated from two different samples of the intrusive andesite yield an average age of 8.8 m.y. (million years). A rhyodacite body intruded along the probable extension of a fault that may limit the collapsed part of the district on the southwest yielded a potassium-argon age of 8.9 m.y. on biotite and 9.0 m.y. on hornblende. This body may be the same age as, or slightly younger than, the postulated collapse. Results so far appear to indicate near contemporaneity of collapse and intrusion of the andesite, with mineralization following shortly thereafter.

Fluid-inclusion studies on the adularia used for dating the mineralization indicate a temperature of homogenization of $245 \pm 5^\circ$ C. Oxygen-isotope studies by J. R. O'Neil on quartz-adularia mineral pairs yielded similar results. (F. J. Kleinhampl and M. L. Silberman, Menlo Park, Calif.)

Mother Lode, Amador County

Detailed mapping of part of the Mother Lode in western Amador County has defined the probable sequence of geologic events as follows:

1. Sedimentation, with possible unconformities.
2. Regional tilting and folding, with development of foliation; possible metamorphism?
3. Intrusion of basic and ultrabasic rocks at depth generally below present exposures.
4. Faulting in polygonal sets, with probable north-south extension and east-west shortening.
5. Intrusion of hypabyssal rocks.
6. Metamorphism to greenschist facies.
7. Intrusion of granitic rocks.
8. Local penetrative deformation forming mylonite; second folding?
9. Faulting to bring about present gross distributional pattern of Paleozoic metamorphic rocks and Mesozoic rocks; probable vertical extension and east-west shortening.
10. Fracturing with deposition of quartz veins, locally associated with sulfides and gold.
11. Erosion.

The structure and, possibly, the stratigraphy of the area are extremely complex. The Foothills fault zone of Clark now appears to be a belt of complex steeply-dipping polygonal fractures in Paleozoic and Mesozoic metasediments and metavolcanics, complicated further by igneous intrusion. Minor folds can be seen at some outcrops, but the distribution of lithologic units and determinations of tops of beds preclude the possibility of large-scale folding in this particular region.

A preliminary aeromagnetic map shows two conspicuous north-northwest-trending belts of magnetic highs. The western highs correspond to a belt of serpentinite exposures at the western edge of the Foothills fault zone. The eastern highs are centered over belts of green phyllite and schist, and in part coincide with the Mother Lode belt of gold-bearing quartz veins; however, this high correlates more closely with the Melones fault of Clark.

The quartz veins of the Mother Lode system are poorly exposed in western Amador County, and the mine workings are now inaccessible. Nevertheless, several samples of altered rock adjacent to quartz veins have been collected and analyzed for gold and certain other metals. In most samples, the gold content is less than 0.02 ppm, and in nearly all the other samples the gold content is less than 0.20 ppm. (W. A. Duffield and R. V. Sharp, Menlo Park, Calif.)

Tertiary Gravels, Nevada City Area, Sierra Nevada

Preliminary results of a study of gold-bearing Tertiary gravels in the Sierra Nevada near Nevada City were reported in U.S. Geological Survey Circular 566.

Detailed seismic and gravity surveys were made on San Juan Ridge to refine earlier interpretations of the position of the buried bedrock depression. Rotary drilling of four holes proved the existence of expected sands, clays, and gravels beneath the volcanic breccia on San Juan Ridge but failed to prove the existence of a defined channel in the bedrock as indicated by the seismic work. A cursory examination of the panned concentrates of the cuttings from the buried gravels revealed very little gold.

Three churn-drill holes penetrated 325-465 feet of gold-bearing gravel near the center of the wide channel at North Columbia. These holes were drilled to check drilling done in 1939 and the seismic and resistivity surveys done in 1967. Panned concentrates from these three holes are being analyzed for gold. Abundant secondary sulfides were found in all holes. The depths to bedrock in all three holes were very close to those predicted from the seismic surveys.

Two additional shallow holes were drilled near the margins of the hydraulic pit at North Columbia. One drilled near a high gravity anomaly entered bedrock at 27 feet, and it is reasonable to think that the near-surface occurrence of bedrock at this locality is responsible for the gravity anomaly. Another hole drilled at the position of an electromagnetic anomaly cut several tens of feet of bentonite before hitting bedrock at 77 feet. It seems clear that the relatively thick section of clay is responsible for the electromagnetic anomaly.

Density, seismic, electrical, gamma-ray, and susceptibility logs are being obtained in the open holes on San Juan Ridge, and seismic and gamma-ray logs, in the cased holes at North Columbia. The susceptibility log is most useful for differentiating between the Tertiary gravels and the volcanic breccia; self-potential logs define most of the clay-rich zones within the gravel section; density and velocity logs show marked contrasts at the gravel-basement contact. The contacts between the volcanics, gravel, and Calaveras basement are difficult to identify on resistivity logs.

Mapping of the ancestral Yuba River drainage continued to the south on Washington Ridge. The area being mapped includes such notable gold mining areas as Sailor Flat, Blue Flat, and Scotts Flat.

On the basis of work of the U.S. Geological Survey on the Tertiary gravels, the U.S. Bureau of Mines is carrying out detailed geophysical exploration, mapping, and sampling within the Badger Hill hydraulic pit. This area is on the divide between the Middle and South Forks of the Yuba River in Nevada County. (W. E. Yeend, Menlo Park, Calif.)

COLORADO

Gold in Castle Rock Conglomerate

In the Castle Rock area of Douglas County, gold in modern stream alluvium is derived from reworking of fossil placers in the Castle Rock Conglomerate, of early Oligocene age. Electron microprobe studies indicate that individual gold grains originating from the Castle Rock Conglomerate average more than 99 percent gold; the remainder is chiefly silver. Most of the gold grains are less than 1 mm across, and some are as small as 0.10 mm. Paleocurrent studies indicate that the primary source of the gold apparently is not the Georgetown-Central City area to the northwest as previously thought, but rather is an area to the west or southwest of the town of Castle Rock, either in the Front Range or possibly as far west as the headwaters of the Platte River. At present it is not known whether the primary source of the gold has been completely removed by erosion or is concealed by sediments or faulting of post-early Oligocene age. (G. A. Desborough, W. H. Raymond, and C. E. Soule, Denver, Colo.)

Ore Deposits of Chicago Basin

In the Chicago Basin district of the Needle Mountains in southwestern Colorado, two hypabyssal porphyries of possible Tertiary age intrude Precambrian granite. The older hyperalkalic quartz porphyry is pervasively altered and locally mineralized, whereas the younger rhyolite porphyry is less altered and appears to be barren. Intensely sericitized and silicified porphyry contains anomalous amounts of arsenic, gold, copper, molybdenum, antimony, and tin, particularly on the west side of the older porphyry. Anomalous amounts of silver, lead, and zinc are more widely distributed but are also somewhat concentrated on the western side.

The granite enclosing the porphyry complex is cut by numerous fractures and quartz veins. Most pyritic quartz veins containing shoots of base and precious metal ores are along a belt more than 4 miles long and about 2 miles wide that trends north-northwest. Veins are along regional sets of joints, along fractures radiating from intrusive centers, and along fractures that follow no regional trend. Geochemical anomalies of lead and zinc show a zonal distribution around the intrusive center, whereas molybdenum is distributed along the entire north-northwest-trending belt.

Much of Chicago Basin and Vallecito Basin to the southeast lie within an area of intersecting east-trending fractures or faults and north-trending joints. This area of structural weakness includes the mineralized intrusive center of Chicago Basin, vein-associated fluorite mineralization, and the strongest vein-associated silver, bismuth, copper, antimony, and tin anomalies in the district. Vein-filled joints appear to be concentrated in Vallecito Basin, and most vein-associated metal anomalies are centered in that basin rather than in Chicago Basin. An intrusive body related to the Chicago Basin center may underlie the metal anomalies in Vallecito Basin. (L. J. Schmitt, Denver, Colo.)

Geophysical Studies at Cripple Creek

Model studies of gravity data along a structure section across the Cripple Creek volcanic basin, Teller County, support the concept of a subsidence basin whose base consists of a series of granite ridges. These ridges are defined by a system of northwest-trending fractures which also were the loci for ore-bearing solutions. A reasonable fit to observed gravity is obtained using a density contrast of 0.25 g/cm^3 between volcanic and granitic rock.

The low-level aeromagnetic map of the Cripple Creek caldera is based on 22 lines about 5 miles long spaced a quarter of a mile apart and flown at 10,700 feet altitude and shows the caldera to be marked by a well-defined magnetic low. The axis of the principal low correlates with an area of minimum gravity and the geochemical anomaly over the Cresson-Mollie Kathleen mineralized zone. An east-trending magnetic low is over the south part of the district, in which most of the gold was produced. Gold content was still high at the time mining ceased. Magnetic lows are believed to correlate with areas of greatest pyritization or maximum alteration of magnetite.

Strong potassium anomalies recorded during ground gamma-ray spectrometry surveys correlated with areas of hydrothermal alteration previously identified by geochemical studies. An airborne survey of the area is planned next year. (M. D. Kleinkopf and J. A. Pitkin, Denver, Colo.)

Niobium and Other Elements, Gem Park Complex

Work in the laboratory and field on the Gem Park Complex of mafic-ultramafic igneous rocks and associated carbonatites in Custer and Fremont Counties 11 miles northwest of Westcliffe has shown that some carbonatite dikes and fenite contain concentrations of niobium, rare-earth elements, thorium, phosphorus, some other elements, and vermiculite.

The Gem Park Complex is a small funnel-shaped composite body related to the McClure Mountain alkalic complex a few miles to the northeast. The Gem Park Complex consists mostly of pyroxenite and gabbro with minor dikes and bodies of lamprophyre, syenite porphyry, and nepheline syenite pegmatite, and abundant dikes and irregular bodies of carbonatite, all of Cambrian age. A mass of fenite lies near the center of the complex. The whole complex lies discordantly in Precambrian gneissic terrane and is overlain by Tertiary volcanic rocks. Large areas in the complex are covered by Quaternary alluvium and colluvium. The arrangement of carbonatite dikes, the position of the fenite, and other features suggest that a large carbonatite body lies beneath the surface near the center of the complex.

The hydrous nickel arsenate annabergite has been identified in one of the carbonatite dikes. This finding indicates the presence of a primary nickel mineral, probably niccolite. The mine reported long ago by Cross and Genth to have produced niccolite ore may have been here.

U.S. Geological Survey Prof. Paper 612, Geochemistry of niobium and tantalum, by R. L. Parker and Michael Fleischer, was published in 1968. (R. L. Parker, Denver, Colo.)

Silver and Copper in McElmo Canyon

The Bluff Sandstone (Upper Jurassic) in a west-northwest-striking shear zone which passes through Battle Rock in McElmo Canyon, Montezuma County, contains anomalously high amounts of silver (4 to 50 ppm) and copper (270 to 14,000 ppm) for at least a mile west-northwest of the Battle Rock prospect. The prospect and the Karla Kay uranium mine, 2 miles west-northwest, appear to lie on the same shear zone. A wide fault zone that strikes northeast intersects the Battle Rock shear zone about 1 mile west-northwest of Battle Rock. Anomalous copper and detectable gold were found in one locality in the Entrada Sandstone (Upper Jurassic) in the fault zone 3 miles northeast of Battle Rock, and samples of mud from a carbon dioxide well 0.3 mile north of this locality showed high copper (70 ppm) and silver (1.6 ppm) and detectable gold (0.02 ppm). Bluff Sandstone in the fault zone at its intersection with the McElmo Canyon road contains high silver (2 ppm). Results of the geochemical study to date suggest that the fault and shear zones contain the highest metal anomalies and probably contain or lie adjacent to any economically important metal deposits which may be present in the area. (R. A. Cadigan, Denver, Colo.)

Copper and Silver in Precambrian Rocks Near Gunnison

Anomalous amounts of copper have been found in Precambrian metamorphic rocks exposed in a roadcut along U.S. Highway 50 in sec. 30, T. 49 N., R. 2 W., about 11 miles west of Gunnison in Gunnison County. Analyses of samples from 14 50-foot intervals along the roadcut show that samples in five of these intervals have median contents of copper ranging from 20 to 230 ppm; from five to 11 samples in each interval were analyzed. The richest sample contained 26 percent copper. Median silver content ranged from 0.4 to 1.0 ppm. (R. A. Cadigan, Denver, Colo.)

Geology of Hahns Peak and Vicinity

The study of the general geology and mineral deposits in the Hahns Peak and Farwell Mountain quadrangles, Routt County, has been completed. Reports in preparation will include geologic maps and sections of the two 7½-minute quadrangles; descriptions of the stratigraphy; igneous and metamorphic geology; structure of the area; chemical, mineralogical, and petrographic data; and the results of radiometric age determinations.

A detailed geologic map of Hahns Peak and vicinity will depict the geology of a mineralized area of approximately 2.5 sq mi at a scale of 1 inch equals 400 feet. The map will also show silver, lead, and zinc geochemical anomalies, and induced polarization and electrical resistivity anomalies. (Kenneth Segerstrom, Denver, Colo.)

Lookout Mountain Area, Eastern San Juan Mountains

A base-metal geochemical anomaly in the Lookout Mountain area on upper Alamosa Creek south of Summitville was reported in U.S. Geological Survey Circular 557. A lead anomaly more than 1.5 sq mi in extent and lesser anomalies of copper, molybdenum, and zinc occur in altered silicic volcanic rocks, quartz monzonite, and quartz latite porphyry. The area is geologically similar to the productive Summitville district and is an attractive exploration target. (W. N. Sharp and J. L. Gualtieri, Denver, Colo.)

Northwestern San Juan Mountains

A detailed geologic and geochemical study of the strongly mineralized area around Ouray in the northwestern San Juan Mountains was begun in 1968.

Fieldwork to date has included detailed mapping of the Red Mountains area and pilot sampling studies for geochemical control. Reconnaissance examination of the extensive vein systems in the area suggests that studies of trace-element content of selected ore and gangue minerals will perhaps be the most fruitful method of examining possible zonation and paragenetic relationships of the vein system, and some initial sampling of vein material was done. Studies are also being made on experimental design and development of the computer programs necessary to handle the statistical and geochemical data. (F. S. Fisher, Denver, Colo.)

Silver Cliff-Rosita District

Restudy of the Silver Cliff volcanic center in the Silver Cliff-Rosita district, which in the past was prospected extensively and mined for silver and some base metals, has defined two early volcanic throats and a foundered block of layered volcanic rocks centered between the two volcanoes.

The rather small area of volcanic rocks (6-7 sq mi) remaining at Silver Cliff represents only the remnant of a much greater volcanic inundation. The two volcanoes, which appear to have been predominantly latitic in character at the outset, apparently broke through onto a Precambrian terrane in late Oligocene time and must have poured out several cubic miles of ash and breccia, very little of which is presently exposed A block several square miles in area, including a thick section of these early ejecta, dropped gradually into the underlying magma chamber. Rhyolitic flows and ash vented along the faults bounding this downdropped block and continued to overflow the area and fill in the subsiding block. Cores from a series of exploratory drill holes put down by Congdon and Carey Mining Co. in 1966-67 disclose that the lower parts of some of the holes cut thinly layered "lake beds" of volcanic ash and pellet conglomerate. The deepest holes, 700 to 800 feet long, bottom in "lake beds"; therefore, the foundered volcanics are dropped at least that amount relative to exposed peripheral Precambrian rocks.

Gravity surveys suggest that volcanic centers may be outlined by this method. Measurements have been made at more than 200 stations. A gravity minimum of 5 milligals or more corresponds with a subsidence area underlain by rhyolite, and local lows near Round Mountain and Ben West Hill may outline volcanic centers.

A seismic refraction profile 3 miles long south of Westcliffe crossed a suspected fault bounding the northeast side of Wet Mountain Valley. Minor faults may have been recognized near the south end of the profile. Three other lines across a volcanic subsidence area for 4 miles north from Westcliffe revealed a strong velocity contrast between Precambrian basement (about 23,000 feet per second) and overlying volcanic breccia (about 12,000 fps). Thick volcanic breccia was indicated just north of Ben West Hill and about three-quarters of a mile north of Westcliffe, an area indicated by geological and gravity data to be the deepest part of the volcanic basin.

Faults radial and peripheral to the volcanic throats are mineralized almost exclusively with sulfides of iron, zinc, lead, and copper, with minor silver and gold. The foundered block itself is unevenly broken, and fractures are filled with veinlets of predominantly iron, manganese, and calcium carbonates carrying unevenly distributed sulfides of iron, lead, zinc, and silver. In the near surface part of this block (down to 100-200 feet) these carbonate veinlets are weathered and oxidized so that the rocks are stained with iron and manganese. Veinlets of black oxides of iron and manganese contain unevenly distributed silver and are locally enriched in silver halides.

Preliminary analyses indicate that all the rocks of the foundered block are enriched in chlorine, bromine, and iodine. The distribution of halides over the Silver Cliff volcanic rocks may aid in identifying exploration targets. (W. N. Sharp and M. D. Kleinkopf, Denver, Colo.)

GEORGIA

Dahlonega Gold Belt

A geochemical reconnaissance of the Dahlonega gold belt has been completed. Rocks of the belt consist of interlayered mica, graphitic and garnet-rich schist, quartzite, and amphibolite that generally trend northeastward. Near Dahlonega and in parts of Cherokee, Paulding, and Carroll Counties the schists are intruded by dikes and small plutons of granite. From central Cherokee County northeast to Rabun County, a fault or shear zone probably separates the Dahlonega belt on the northwest from an extensive area of migmatite and granite on the southeast. In this part of the belt the mica schists seem to grade westward into mica gneiss typical of the Blue Ridge. In the southwestern part of the belt the eastern boundary may be the Brevard fault zone, and the western boundary the Cartersville or possibly the Whitestone fault. Locally the mica schist seems to grade westward into less metamorphosed phyllites and graywackes of the Ocoee Series.

Reconnaissance sampling in the Dahlonega belt indicates that small amounts of gold can be obtained from most of the old mines, and trace amounts, generally less than 0.2 ppm, are widespread in the country rock throughout the area. Over 1,680 samples of various rock types, minerals, and soil were collected in 40 old mines and along roadcuts across the trend of the gold belt in an area 145 miles long and 2 to 25 miles wide. Three hundred and six or 69 percent of the 558 mine samples and 236 or 21 percent of the 1,106 roadcut samples contained 0.02 ppm or more gold.

About 90 percent of the samples are saprolite or weathered rock. A comparison of sample data for fresh and weathered samples suggests some residual enrichment of gold in weathered rocks of the mine areas. Such enrichment is indicated at the Calhoun mine in Lumpkin County, where samples of mica schist saprolite from the opencut contained 0.02-0.1 ppm gold, whereas 17 samples of fresh mica schist from underground workings below the opencut contained no detectable gold.

Although gold is distributed widely throughout the district, the gold content of the average gold-bearing sample is small. Half of the mine samples and three-quarters of the roadcut samples that are gold-bearing contain less than 0.2 ppm gold, and only 20 mine samples contain 5 ppm gold or more. (F. G. Lesure, Washington, D. C.)

MAINE

Mineral Deposits Near West Pembroke

Detailed mapping in the area of the Barrett and Big Hill prospects near West Pembroke in Washington County, and study of approximately 80,000 feet of drill core that were made available by Consolidated Dolsan Mines, Ltd., have disclosed a well-defined pattern of mineral zoning. The sulfide deposits are along irregular fractures and small faults in weakly metamorphosed felsic and spilitic flows, tuffs, and shallow marine shales of Silurian age. The central part of the zoned area is about 1,000 by 500 feet in extent at the surface, but broadens in depth. It is characterized by intensely altered rock, some copper, and sporadic gold. It is succeeded upward and outward by a zone rich in zinc and then by a peripheral zone of lead, zinc, and silver. Ore minerals are chalcopyrite, sphalerite, galena, tetrahedrite, arsenopyrite, pyrite, possible silver sulfarsenides, native gold, and possible gold telluride minerals. Gangue minerals are carbonates, quartz, and barite.

The regional geochemical work generally confirmed the work of Post and others (1967). However, inasmuch as the gold contents of panned concentrates of stream and beach sediments that were sampled in 1967 correlated approximately with the distribution of sandstone of the Perry Formation, a largely fluvial deposit of Late Devonian age, the sandstone itself was sampled for its gold content in 1968 but samples gave entirely negative results. Panned concentrates of beach sediments adjacent to the Perry Formation were obtained at the same time. Of 97 concentrates, 25 showed detectable amounts of gold, ranging from 0.02 to 2.2 ppm. Concentration factors in samples with detectable gold range from 3,000 to one to 400 to one. Using approximate concentration factors, the maximum gold content of beach sediments obtained during 1967 and 1968 sampling is about 0.04 ppm. (R. H. Moench, Denver, Colo.)

Interpretation of Geophysical Logs, Burnt Nubble Area

Preliminary interpretation of geophysical logs of drill holes at the Burnt Nubble prospect northeast of The Forks indicates the following:

1. Unmineralized gabbro and norite have moderate to high resistivity (10^3-10^4 ohm-meters), relatively low gamma-ray intensity, and low magnetic susceptibility.

2. Hornfels has very high resistivity ($>10^5$ ohm-m), relatively high gamma-ray intensity, and low magnetic susceptibility.

3. More than 15 percent of pyrrhotite by volume apparently is necessary to make these rocks electrically conductive.

4. The pyrrhotite in rocks of this area appears not to be ferromagnetic, as measured susceptibility is less than 10^{-3} cgs units.

Airborne electromagnetic surveys of a small area near the Burnt Nubble prospect revealed good anomalies probably caused by pyrrhotitic slate and the pyrrhotite body that was drilled in 1967.

Chemical analyses of drill cores for copper, cobalt, and nickel have been completed; in general, the combined content of these metals is 0.1 to 0.3 percent, but a few analyses give somewhat higher results. (F. C. Canney, Denver, Colo.)

MASSACHUSETTS

Gold in Ores From Newburyport District

Closely spaced sampling in the Newburyport silver-lead district in northeasternmost Massachusetts has revealed two distinct northeast-trending gold anomalies, possibly along the Newburyport fault system. Samples of gangue minerals from the dumps of the Chipman mine assayed about 2 to 8 ppm gold, those from the Newhall Farm prospect 0.2 to 2 ppm, and those from the Dodge prospect 0.1 to 0.2 ppm. Gangue material from copper prospects, as well as samples of barren rock and alluvial soils, contained 0.04 to 0.1 ppm gold. (J. P. D'Agostino, Beltsville, Md.)

MONTANA

Gravity Survey at Neihart

A gravity survey has been made in the Little Belt Mountains at Neihart, Cascade County, in an effort to delineate the subsurface extent of the Snow Creek Porphyry (post-Cretaceous(?)), which is associated with deposits of silver, gold, and base metals in the Neihart district. Gravity observations were made at 342 sites across exposed and postulated buried parts of the porphyry and also around the periphery of the porphyry body. (M. D. Kleinkopf, Denver, Colo.)

Virginia City District

Geologic mapping in the Virginia City district, Madison County, indicates that the gold-silver quartz veins are discontinuous and of restricted extent. Beds of dolomite, 5-50 feet thick, locally define structure and limit the postulation of faults in the Precambrian gneissic rocks.

Analyses of the gold content of soils indicate that soil sampling may aid in detecting and tracing gold veins in the district; most high gold analyses could be correlated with known ore deposits. Of 911 samples, 38 had 0.1 ppm gold or more, 45 had 0.04-0.09 ppm, 58 had 0.02-0.03 ppm, and 770 had <0.02 ppm.

Ages of some of the Tertiary volcanic rocks in the general area of Virginia City have been measured by the potassium-argon method. Biotite from andesite porphyry gave 49.3 m.y., biotite from a rhyolite plug gave 44.7 m.y., whole rock from two basalt flows gave 32.7 m.y. and 30.3 m.y., and whole rock of basalt from Black Butte (a probable volcanic neck 20 miles south of Virginia City) gave 23.1 m.y. The ages suggest a more complex igneous history than is apparent from the geologic relationships. (K. L. Wier and R. F. Marvin, Denver, Colo.)

NEVADA

Aurora District

The ore-bearing rock in the Aurora district, Mineral County, is andesite of unknown age, overlapped and intruded by younger andesitic to rhyolitic volcanic rocks. Some of these younger rocks appear to be postmineralization in age. Approximately 800 samples of altered (argillized, propylitized, and silicified) rock and quartz veins were collected in 1968 for spectrographic analysis and chemical analysis for gold, silver, arsenic, antimony, zinc, tellurium, molybdenum, and mercury. Approximately 200 samples of altered rocks from outside the main Aurora district will be analyzed to evaluate the potential for additional ore deposits outside the main district. About one-half of the Aurora samples have been analyzed. Preliminary geochemical anomaly maps for gold, silver, and molybdenum indicate the following:

1. Silver and gold values are highest in the northern part of the district and are concentrated around a small rhyodacite intrusive. A secondary and areally smaller concentration occurs on Silver Hill in the southern part of the district.

2. No low-grade wallrock mineralization has been found in the district. Quartz veins yield spotty assay results, although gray-streaked quartz, which is mentioned as a guide to ore in numerous old reports, generally contains several parts per million gold, and as much as ten times greater amounts of silver.

3. Background values of 0.02 to 0.06 ppm gold and 0.5 ppm silver in the propylitized, argillized, and silicified rocks of the district are anomalously high when compared to the average for the particular rock type in question. The values approach the detectability limits for these elements and may not be reliable.

4. Anomalously high values of molybdenum (up to 2 percent) have been found in quartz veins and limonite-coated fractures in a small area in the northern part of the district. Molybdenum apparently is not found elsewhere in the district in anomalous amounts, nor in the surrounding region. It may be related to a Mesozoic(?) granite lying beneath the basal andesite of Aurora, which is approximately 1,000 feet thick.

5. A possible breccia pipe complex crops out on the summit and southern flank of "East" Brawley Peak, approximately 1 mile south of the main part of the district. The outcrops consist for the most part of dense, silicified, extremely brecciated rock. The rock is commonly bleached white and has scattered hematite- and limonite-stained patches as well as a few concentrations of sulfides. Chemical analyses of samples are as yet incomplete, but samples not particularly rich in sulfides show a low but anomalous silver content, averaging 0.4 ppm. The presence of sulfides and the brecciated rock, which might produce a good host for ore at depth beneath the oxidized zone, make this an interesting area for further exploration.

Several volcanic units of basic to felsic composition intrude and overlap the mineralized andesite at Aurora. Potassium-argon analysis by Gilbert and others (1968) on an andesite flow overlying the mineralized andesite yielded an age of 12.4 m.y., indicating that mineralization occurred before that date. Potassium-argon ages on biotite and hornblende, 2.6 and 2.5 m.y. respectively, were obtained on a latite plug that forms a part of the eastern margin of the district. These dates indicate that volcanism was continuous in the Aurora district over a period of at least 10 million years and that ore mineralization was early in the sequence of events. (F. J. Kleinhampl and M. L. Silberman, Menlo Park, Calif.)

Carlin Mine

Geologic mapping in and around the Carlin gold mine in Eureka County shows that the gold mineralization is strongly influenced by structural controls. Premineralization faults and shear zones, and the intersections of these features, provided channels for ore solutions. The amount and extent of shattering in the surrounding rock controlled the lateral movement of the solutions outward from the main structures.

In addition to gold, numerous other elements were introduced into or concentrated within areas of mineralization. These include arsenic, antimony, barium, boron, cobalt, copper, lanthanum, lead, manganese, mercury, molybdenum, nickel, niobium, scandium, tungsten, and zinc. The total abundance range for any element is much greater in mineralized than in unmineralized rocks. Normal fresh Roberts Mountains Formation, the host rock for the gold deposit, contains only very minor amounts of most elements.

Three distinct types of carbonaceous materials are present in the Roberts Mountains Formation. These include an activated carbon, mixtures of high molecular weight hydrocarbons, and an organic acid similar to humic acid. All three are important in controlling deposition of gold from hydrothermal solutions. Gold complexes in the ore solution interacted with these materials and, in the case of humic acids, the gold was removed from solution and chemically bound to the acid molecule. During late oxidation these compounds were decomposed and metallic gold was released. (A. S. Radtke, Menlo Park, Calif.)

Copper Canyon

A detailed study is being made of the Copper Canyon copper-gold deposit southwest of Battle Mountain in Lander County. The project includes a detailed study of stratigraphy and structure around the deposit; detailed mineralogy of sulfides, oxides, and silicates; wallrock studies to determine hydrothermal alteration assemblages; and geochemical studies to determine distribution and concentration of elements in fresh and altered rocks.

A broad pyritic halo surrounds the Copper Canyon deposit, and initial efforts have been directed toward determining the primary rock dispersion pattern of gold and other major and minor elements around the deposit. Deep core drilling by the U.S. Geological Survey at Iron Canyon has provided geochemical information on the pyritic alteration in the third dimension. The fact that a hole 2,672 feet deep and collared within the halo penetrated altered rocks only to to a depth of about 1,100 feet suggests that the halo dips in toward the center of metallization. The drill hole was entirely in chert and argillite of the Scott Canyon Formation (Lower or Middle Cambrian(?)). In the altered drill core, copper, barium, manganese, zinc, chromium, nickel, and to a lesser extent lead and molybdenum, are several times greater than background. Barium and manganese are the elements that best reflect the extent of altered rock. (T. G. Theodore, Menlo Park, Calif.)

Cortez-Mill Canyon-Buckhorn Area

Detailed geologic studies are being made around the Cortez and Mill Canyon districts in Lander County and the nearby Buckhorn area in Eureka County. Results of geochemical investigations at Mill Canyon were reported in U.S. Geological Survey Circular 606.

The Cortez disseminated gold deposit is in laminated silty dolomitic, pyritic, carbonaceous limestone in the upper part of the Roberts Mountains Formation in a fracture zone near a biotite-quartz-sanidine porphyry dike of Oligocene age. The host rock has been hydrothermally altered by oxidation and leaching from a dark-gray rock to one grading from light gray to reddish gray. Mineralization was accompanied by leaching of carbonate and carbon and addition of silica. The iron content remained constant. Gold was accompanied by trace amounts of mercury, arsenic, antimony, tungsten, and copper.

At Buckhorn Mine, gold and silver occur with pyrite and marcasite along faults associated with horst and graben structure in Pliocene basaltic andesite. Progressive alteration has changed the andesite to montmorillonite and then to kaolinite through a leaching process. Gold and silver accompanied by trace amounts of arsenic and mercury, are found in the altered material.

Regional geochemical maps of the Cortez-Buckhorn area show that carbonate rocks in the lower plate of the Roberts Mountains thrust fault contain stronger anomalies than cherts of the upper plate. Metals that commonly occur in anomalous amounts with gold and silver are mercury, arsenic, antimony, copper, lead, and zinc. Molybdenum and tellurium anomalies are also present. The stronger anomalies in both upper and lower-plate rocks are near granitic igneous rock masses and are localized along fracture systems, commonly in association with altered wallrock. Mineralization does not appear to be selectively associated with the Roberts Mountains thrust. (J. D. Wells and J. E. Elliott, Denver, Colo.)

Gold Acres and Tenabo Districts

The results of a geochemical study along the east flank of the Shoshone Range in the vicinity of Tenabo and Gold Acres, Lander County, were presented in U.S. Geological Survey Circular 589. Chemical analyses of 1,875 rock samples show that the gold-mining centers at Tenabo and Gold Acres lie in well-defined northwest-trending belts enriched in many elements.

Part of the mineral belt through Gold Acres contains bleached bedrock and has fractures along which rocks are greatly enriched in bismuth, copper, mercury, zinc, and other metals. The Roberts Mountains thrust in this area might reasonably provide an exploration target, because the nearby large open-pit mine at Gold Acres lies in the breccia zone of the thrust and was one of the largest producers of gold in Nevada in the 1950's. To determine the depth to the thrust, drilling was conducted in the spring and summer of 1968 at a site of 0.85 mile northwest of the open-pit mine. The thrust was cut at a depth of 1,706 feet, but no appreciable breccia zone was found. Rocks above the thrust consist of chert and argillite; those below the thrust consist of limestone and tactite to the bottom of the hole at 1,926 feet. The hole was drilled a few hundred feet north of the enriched area of bleached bedrock, mainly to avoid penetrating granitic rock before intersecting the thrust, and only trace amounts of gold were found, mostly above 1,200 feet.

A core hole, completed in the summer of 1968 at the former site of the town of Gold Acres, was drilled to obtain stratigraphic information in the lower plate of the Roberts Mountains thrust. The drill penetrated carbon-rich limestone of probable Devonian age from the surface to the bottom of the hole at 663 feet. Deeper drilling was not attempted because of the intensely fractured condition of the rock. A few samples from the core contained gold at the lower limit of detection (0.02 ppm).

Studies of the open-pit mine at Gold Acres show that numerous steep and some flat-lying faults of probable Tertiary age cut the breccia zone of the Roberts Mountains thrust. High gold values occur (1) along the faults, (2) in tabular and lensoid blocks of sedimentary rocks dragged into the breccia zone, and (3) in fractured felsic dikes that cut thrust blocks. Mineralized blocks from the lower plate consist of the Roberts Mountains Formation of Silurian age, and blocks from the upper plate belong to the Slaven Chert of Devonian age.

Gold deposits at Tenabo are spatially associated with dikes of felsite porphyry and are thought to have formed more or less contemporaneously with them. Biotite from a dike near Tenabo has been dated at 34.4±1.0 m.y., and sanidine from the same dike, at 34.7±1.6 m.y. (C. T. Wrucke and T. J. Armbrustmacher, Menlo Park, Calif.)

Goldfield District

Detailed geologic mapping of the western two-thirds of the altered area at Goldfield, Esmeralda County, has been completed. The area mapped to date is approximately 5 miles square, with its southwest corner near the town of Goldfield. As a result of the mapping, the stratigraphy of most of the prealteration volcanic units is being revised. The oldest volcanic unit is a rhyolitic welded tuff (formerly called Vindicator Rhyolite). It is overlain by a sequence of latitic and quartz latitic tuffs and flow latite (all previously called latite), followed by another sequence of tuffs and a flow, this time of rhyolitic composition (all previously called Sandstorm Rhyolite). Andesite flows blanket these units and spread over pre-Tertiary rocks to the southeast and probably to the north as well. Dacite domes and flows locally intrude and cover the andesite. The largest dacite intrusive-extrusive complex is located on the east side of the area, at Diamond Peak; here one or more early dacite domes are locally covered by a thick dacitic laharic breccia, and both domes and breccia are covered by a thick, extensive dacite flow. The dacitic welded tuff on the south side of the area (formerly called dacite vitrophyre), previously thought to be the oldest postalteration unit, is altered itself and may also be a product of the Diamond Peak volcanic center.

The complex fault pattern shown so far by the detailed mapping cannot be explained easily as one set of concentric collapse features, or even as an asymmetric collapse followed by partial resurgence. Features formed during one or two periods of collapse were apparently modified by a major east-west fracture zone on the south side of the area and later by westward tilting and north- to northwest-trending basin-range faulting. Although some collapse may have followed both the latitic and rhyolitic eruption cycles, most of the collapse features now visible formed after eruption of the andesitic and dacitic pyroclastic materials that now occur in the eastern, southeastern, and southern parts of the area. Almost all the ore deposits are along fault systems that probably represent the margins of the oldest collapse area. The unique complexity of these particular fault systems may be the result of repeated movements produced by later structural events.

Analyses of geochemical samples collected in 1966 and 1967 have been completed. Background values are being determined for the various rock units described above and for their altered equivalents. Geochemical data for surface samples showed a lead anomaly in the vicinity of Preble Mountain, but subsurface samples indicate that this anomaly probably does not extend to depths greater than a few hundred feet. The origin of the anomaly is not yet known.

Whole-rock X-ray study of samples along 10 profiles across veins in the altered area confirms earlier work showing that the assemblage quartz-alunite-kaolinite is typical of zones of intense silicification. Other minerals in and near silicified zones include halloysite, nacrite(?), diaspore, and beta-cristobalite. At increasing distances from silicified zones, the assemblages quartz-illite-kaolinite (pootassium feldspar of hydrothermal origin occurs in some rocks) and quartz-montmorillonite-illite-relict plagioclase are characteristic. Mineral assemblages resulting from hydrothermal alteration are the same over the entire district, regardless of proximity to ore-bearing areas and of the nature of the original rock (latite, dacite, or andesite). (R. P. Ashley, Menlo Park, Calif.)

Independence and Adobe Ranges

Geologic and geochemical studies are being made in central Elko County as part of a broad study of the mineral potential of north-central Nevada.

The southern Independence Range, extending 40 miles northward from Carlin, includes peaks at Swales Mountain, Lone Mountain, and Wheeler Mountain. The range consists of carbonate rocks of Ordovician to Mississippian age in the lower plate of a major thrust fault and rocks of Ordovician to Devonian age in the upper plate. The fault separating these plates of contrasting rock type can be regarded as the Roberts Mountains thrust fault, although some evidence indicates it is much younger structure. Both the upper and lower plates and the thrust fault have been folded into a complex anticline by forcible intrusion of quartz monzonite. Radiometric dating indicates this event took place in Oligocene time, 38 million years ago. Intrusive rocks are exposed along the crest of the anticline at Swales Mountain and Lone Mountain, and aeromagnetic data indicate intrusive rocks lie beneath Wheeler Mountain. Intrusive contact zones have been mineralized at Swales Mountain and Lone Mountain, and the thrust zone at Lone Mountain was mineralized in the area of the Rip Van Winkle mine. Weak geochemical anomalies at Wheeler Mountain point to possible subsurface mineral deposits similar to the exposed deposits at Swales Mountain and Lone Mountain. Results of geochemical studies at Swales Mountain were reported in U.S. Geological Survey Circular 588.

The Adobe Range, extending about 40 miles northeastward from Carlin, consists mainly of upper Paleozoic rocks. At the northern end of the range, siliceous Ordovician and Silurian rocks overlie Mississippian shale on a thrust fault which extends across the northern half of T. 38 N., R. 56 E. Some of the altered brecciated rocks along this fault contain anomalously high amounts of lead and zinc, but no sample was found that contained more than 1 percent of either metal, and the quantities of gold and silver were negligible.

On the west side of Marys River on the boundary between T. 38 N., R. 59 E., and T. 39 N., R. 59 E., upper plate rocks of the Roberts Mountains thrust fault are intruded and altered by a large stock of quartz diorite. Undoubtedly this intrusive intersects lower plate carbonate rocks and the thrust fault at depth. Subsurface mineral deposits are possible along the intrusive contacts, especially those with lower plate rocks and along the thrust zone.

Siltstone, limestone, and chert beds of Permian age in the Adobe Range in T. 34 N., R. 54 E., and T. 38 N., R. 56 E., are significantly phosphatic. The phosphate resembles that of the Phosphoria Formation, consisting of rounded pellets, irregular grains, and fillings and replacements of spicules and pelecypods. The average P_2O_5 content of 75 samples selected at arbitrary intervals from 5,000 feet of section is more than 1 percent and the maximum is 13 percent. (K. B. Ketner, Denver, Colo.)

Manhattan Mineral Belt

The Manhattan mineral belt in Nye County is a northwesterly-trending zone that includes, from northwest to southeast, the Lodi mining district in the Broken Hills Range, the Mammoth district in the Paradise Range, the Union district in the Shoshone Mountains, and the Manhattan district in the Toquima Range. Published geologic maps of these districts clearly show that northwesterly faults older than Tertiary volcanic rocks have localized many of the important mineral deposits. Together the faults form a zone alined within the Manhattan mineral belt and bordering the northwestward-trending Walker Lane of right-lateral strike-slip movement. In this zone, much of the country lying between the mining districts is covered by Tertiary volcanic and sedimentary rocks which undoubtedly conceal other northwesterly faults or extensions of those shown on the published maps. The frequency of mineral deposits known in the exposed rocks of prevolcanic age suggests that numerous undiscovered deposits lie beneath the Tertiary rocks along buried strands of the northwesterly fault zone. (D. R. Shawe and F. G. Poole, Denver, Colo.)

Sheep Creek Range

Highly anomalous concentrations of zinc, arsenic, mercury, silver, copper, and lead in siliceous rocks in the upper plate of the Roberts Mountains thrust fault along the west side of the Sheep Creek Range north of Battle Mountain in Lander County were reported in U.S. Geological Survey Circular 595. The present evidence indicates that these anomalies are leakage halos from a mineralized source below, possibly along the thrust or in the carbonate rocks below the thrust. (G. B. Gott and C. J. Zablocki, Denver, Colo.)

Tuscarora Range

Geologic mapping to date in the Tuscarora Mountains, Elko County, shows that these mountains are a relatively simple horst of lower Paleozoic rocks of the western assemblage, overlain by Tertiary rhyolite tuff and andesite and intruded by a stock of quartz diorite. Downthrown blocks on both sides of the horst are mineralized, but the greatest production has come from the Tuscarora mines in the block on the east. Gold, silver, and mercury have been produced from both downthrown blocks, and a crude zonal structure can be recognized, with the mercury peripheral to the gold and silver deposits. The age of neither the volcanic activity nor the mineralization has yet been determined. (R. R. Coats, Menlo Park, Calif.)

Virginia City District

Results of geological, geochemical, and geophysical studies north of the Comstock mining district, Virginia City, Storey County, were published in U.S. Geological Survey Circular 596. Reconnaisance geochemical sampling of altered volcanic rocks revealed anomalous amounts of mercury in the Cornwall Knob and Washington Hill areas, about 5 and 11 miles respectively north of Virginia City. An induced-polarization anomaly was recognized in an alluvium-covered area north of the Cornwall Knob. Core drilling to acquire more data on the geophysical anomaly was begun in August, and additional drilling is scheduled in the Cornwall Knob and Washington Hill areas to obtain geologic information and to compare geochemical data from depth with that obtained at the surface. Preliminary results suggest that the large areas of bleached rock are underlain by rock that has undergone intense argillic alteration and that contains finely disseminated pyrite. (D. H. Whitebread, Menlo Park, Calif.)

Positive aeromagnetic anomalies ranging from 200 gammas to more than 400 gammas are associated with mafic parts of the Kate Peak Formation in the Flowery and Virginia Ranges of the district, and prominent magnetic maximums of 750 and 500 gammas, attributed to intrusive rocks, occur over Mount Davidson and Clark Mountain. Bleached rocks of the Alta and Kate Peak Formations and much of the Lousetown Formation are reflected by broad zones of low magnetic intensity. Unknown mineralized zones may occur in parts of the contact between Alta and Kate Peak Formations near anomaly sources and in Alta rocks on the north and west sides of the Mount Davidson intrusive mass. (W. E. Davis, Menlo Park, Calif.)

NEW HAMPSHIRE

Central and Northern New Hampshire

Investigations and sampling continued on the mineralized rocks in central New Hampshire extending from the Gardner Mountain prospects along the Connecticut River northeast to the Milan mine in north-central New Hampshire and beyond to near Errol in the northeast corner.

The Milan mine, inactive but a former producer of copper and precious metals, is along the contact between volcanic rocks (Ammonoosuc volcanic belt) of Middle Ordovician age and granitic rocks of the Oliverian belt, of Middle or Late Devonian(?) age. Sulfide concentrations are associated with hornblende-rich dikes and very coarse-grained granitic pegmatites.

Sulfides, mostly pyrite and chalcopyrite with minor sphalerite and galena, were found north and south of the Milan mine in the Ellsworth Schist. However, no massive sulfides such as those at the Milan mine were seen in many prospects and surface exposures found in the area. A few very fine specks of gold were seen in gravels in a small stream at Stark.

About 5 miles west of the Milan mine, Ordovician volcanic rocks are cut by the Conway Granite (Jurassic or Triassic). Contacts between granite and wall rocks are sharp, and small alteration halos and sparse sulfides are seen only occasionally in the migmatites.

Samples of Clough Quartzite (Silurian) from the eastern belt of outcrops on the east side of the Connecticut River in western New Hampshire contain 0.02 to 0.06 ppm gold. Samples from the western belt of outcrops were mostly barren.

Pyritic schistose rhyolite near Gardner Mountain north of Woodsville in northwestern New Hampshire contains as much as 6 to 14 ppm gold as well as traces of chalcopyrite. Samples from various copper prospects contain from 0.2 to 3 ppm gold.

The Gile Mountain Formation in northeast New Hampshire showed only trace amounts of heavy metals. Sediments in northwest-flowing tributaries of Indian Stream contain small amounts of gold, but no gold has been found in southeast-flowing tributaries. (J. F. Harrington and J. P. D'Agostino, Washington, D.C.)

Ossipee Lake Area

Stream sediment sampling of the Ossipee Lake quadrangle, east-central New Hampshire, has been completed and the data prepared for publication. Cold-citrate-soluble heavy metal analyses of 602 samples show four anomalies directly related to outcrops of quartz veins and silicified fault breccia. Other anomalies not related to surface expression of hydrothermal activity are also present. The western part of the quadrangle, which is underlain by two large plutons of Conway Granite of Jurassic or Triassic age, has background values 60 percent higher than the eastern part. The silver-lead-zinc veins in the quadrangle are believed to be related to the last stages of crystallization of the Conway Granite, and the high background over the granite may represent disseminations or many small concentrations of sulfide minerals. (D. P. Cox, Washington, D.C.)

NEW MEXICO

Geochemical Anomalies, Sierra Cuchillo

Geochemical anomalies of lead, molybdenum, zinc, copper, tellurium, and barium in altered volcanic rocks in the Monticello Box area of the northern Sierra Cuchillo, Socorro County, were reported in U.S. Geological Survey Circular 600. In other areas molybdenum and tellurium are present in anomalous amounts wherever there is some other evidence of metallization; they may be generally useful indicators of metallization in the region. (W. R. Griffitts, Denver, Colo.)

NORTH CAROLINA

Burke, Caldwell, and Catawba Counties

During regional geochemical studies in western North Carolina, more than 200 bulk samples and panned heavy mineral concentrates were collected from soil and saprolite. A few other samples were collected from prospect dumps, and more than 200 from stream sediments. Most of the soil and saprolite samples are from the vicinity of the Shuford gold mine in Catawba County, and many of the stream sediment samples are from areas that were mined for placer gold. Mineral occurrences reported in the region were of no interest.

Visible gold was found in 67 samples of heavy mineral concentrates from stream sediments. Most of these samples were collected in two areas: near and south of the Shuford gold mine, and in Burke and Caldwell Counties near the common corner for the Chestnut Mountain, Collettsville, Oak Hill, and Morganton North 7½-minute quadrangles. The Burke County-Caldwell County area also contains anomalous niobium, tin, tungsten, and molybdenum. Gold was also found in concentrates from other parts of the area, but seldom in samples from three or more closely spaced localities Gold was seen in 51 concentrates of heavy minerals from soil and saprolite; however, 48 of these were from near the Shuford gold mine.

Some areas contain anomalous gold, niobium, tin, tungsten, molybdenum, lanthanum, and yttrium, and mineral analyses of the concentrates indicate areas containing rutile, monazite-xenotime, sillimanite, kyanite, garnet, zircon, and columbite-tantalite. However, no possibly commercial deposit of any element or mineral was found. Rutile occurs locally in crystals greater than one-fourth of an inch across, but no significant concentration of rutile was found, and it is very doubtful that any minable concentrations of rutile are in the area. Local placer deposits are too small to be of interest. Gold, monazite-xenotime, columbite-tantalite, rutile, and zircon could possibly be byproducts of sand and gravel operations on the flood plains of streams, but a relatively easy and cheap methods to recover the heavy minerals would have to be developed.

Studies and sampling of mined areas in the South Mountains of North Carolina and northward to lat. 36° N. indicate that no minable deposits of gold or other minerals are in saprolite or bedrock in the area. Most of the mines either were placers or were located where water could be used to separate the heavy minerals from the unsolidated debris or saprolite. The few shaft mines were small. Miners report that the gold found in saprolite and bedrock was in thin quartz veins that rarely contained enough gold to mine unless several veins were close enough to mine as a single vein, a rare occurrence. No surface evidence of mineralized, rock was seen. (J. W. Whitlow, Washington, D.C.)

Central North Carolina

Studies of the Carolina slate belt in central North Carolina indicate that the Silver Hill-Gold Hill fault-shear zone is several miles wide and can be traced for many miles, probably northeast into Virginia and southwest into South Carolina. East of this fault-shear zone, volcanic-sedimentary rocks of low-grade greenschist facies show both broad and minor open folds. West of the fault-shear zone, volcanic-sedimentary rocks are cut by intrusive rocks and are more highly metamorphosed, disturbed, and weathered than those to the east.

The gold and sulfide deposits are structurally controlled and to some degree are related to specific rock types. Most of the larger gold mines and prospects in North Carolina are in Mecklenburg, Rowan, Cabarrus, and Davidson Counties. In these counties, the main mining districts—Conrad Hill, Silver Hill, Gold Hill, and Georgeville—are west of the Silver Hill fault. The host rocks are sericitized and chloritized schists derived from sheared interbedded felsic and mafic volcanic-sedimentary rocks. The deposits east of the Silver Hill-Gold Hill shear zone lie in smaller shears that cut a sequence of volcanic-sedimentary rocks. In this area, the deposits are richest where the shear zone cuts rhyolitic layers or tuffaceous mudstone; the Hoover-Jones-Laughlin-Cid(?) line of prospects is an example.

During regional geochemical studies of residual soils, soils derived from rhyolitic rocks or tuffaceous mudstones were found to have the highest content of copper, 60 to >100 ppm, as well as traces of gold. One sheared gabbro lens within the Silver Hill-Gold Hill shear zone contains 80 to 500 ppm copper along a strike length of about 1,800 feet. Other gabbro lenses or sill-like bodies contain <80 ppm copper. (A. A. Stromquist, Denver, Colo.)

Moore County

Samples from 245 localities in road outcrops, nine gold mines, and six pyrophyllite mines collected during reconnaissance geochemical studies in Moore County, south-central North Carolina, have been analyzed for gold. The area studied was 18 miles long and 6 miles wide. Eighty samples from the gold mines contained 0.15 to 0.71 ppm gold, and 46 samples from the pyrophyllite mines, a trace to 0.12 ppm gold. The highest analysis, of thin quartz veins in a roadcut, was 2.4 ppm gold, and only eight samples, all from gold mines or prospects, contained >1 ppm gold.

The entire area seems to show a low-grade gold anomaly. Locally, concentrations of gold in sheared felsic tuff and thin seams of vein quartz were rich enough to encourage small-scale mining in the late 19th century. Thick quartz veins are abundant in the area but generally contain little or no gold. Trace amounts of gold in the pyrophyllite zones produced small placer deposits which were prospected before the discovery of the pyrophyllite. Total production from Moore County is unknown but probably small. (F. G. Lesure, Washington, D.C.)

SOUTH CAROLINA

Geochemical studies in South Carolina have been made in three areas— McCormick County, Spartanburg-Union Counties, and the vicinity of Mount Rehovah, Fairfield County. Samples have been collected from stream sediments and saprolite to test both for the distribution of gold and other heavy metals over a fairly wide area and for extensions of mineralized ground near old mines.

In McCormick County, reconnaissance geochemical sampling showed that gold- and copper-bearing silicic to intermediate pyroclastic rocks are associated with a mass of leucocratic quartz porphyry locally called metadacite. Geologic mapping and geochemical sampling along roads, supplemented by ground magnetometer traverses, indicate that the gold-bearing rocks at the Jennings mine extend along strike at least 1.6 miles and are 25 to 75 feet thick. The rocks average 0.03 ppm gold, and no high assays have been reported to date. Spectrographic analyses of stream alluvium, however, indicate that gold, barium, copper, lead, and tin may be distributed zonally around part of the metadacite. The association of manganese deposits with the gold mines near Graves Mountain in nearby Lincoln and Wilkes Counties, Ga., and the similarity of the mineralogy of the gold mines suggest that all are related to widespread mineralization in silicic volcanic rocks.

In Spartanburg and Union Counties, sampling of stream alluvium indicates that gold is widespread, and preliminary geologic mapping suggests that most of old mine workings are along an extensive shear zone.

In Mount Rehovah area of Fairfield County, a belt of gold-bearing quartz-sericite schists is probably an extension of the Haile-Brewer-Lamar belt farther to the east. Geochemical sampling along road traverses will test this connection and possible further extensions to the west, where samples of well water of unusual mineral content have been reported. (Henry Bell, Washington, D.C.)

SOUTH DAKOTA

Gold Deposits in Precambrian Rocks, Northern Black Hills

Geologic mapping of Precambrian rocks in the Rochford district, 20 miles south of Lead, is nearly completed. The principal structure is a refolded anticlinorium in which the oldest rocks exposed are probably Ellison Formation of Hosted and Wright (1923), a quartzite unit that overlies the gold-bearing Homestake Formation of Hosted and Wright (1923) at Lead. Three rock units resembling the Homestake lie above the Ellison at Rochford, one close to the quartzite in a slate sequence that may correlate with the Northwestern Formation of Hosted and Wright (1923) at Lead and two associated with graphitic schist and ellipsoidal greenstone. The schist, greenstone, and chert-cummingtonite rocks of the Homestake-like units collectively could be correlative with the vaguely defined Flag Rock Formation of Dodge (1942) at Lead. As at Lead, the chert-cummingtonite rock is gold-bearing locally. Also as at Lead, the gold seems to prefer plunging anticlines, but there are a few exceptions. A few mineralized localities contain abundant pyrrhotite and are therefore anomalously magnetic.

Of 465 rock samples analyzed for gold, 221 have more than 0.02 ppm (the limit of detection); 8 have more than 0.10 ppm; and 22 exceed 1.0 ppm. The highest gold content found to date in an outcrop sample is 15 ppm. This sample came from a small plunging anticline in chert-cummingtonite rock. Six other samples from the same place have more than 3.5 ppm. The principal structure at Rochford was believed previously to be an upside-down syncline, but new detailed mapping shows it to be an anticline similar to those at Lead and involving the same rocks, and though refolded and rather complicated, it offers several exploration possibilities. For example, most mining to date has been in the uppermost chert-cummingtonite unit. It now seems probable that one or two similar units lie stratigraphically below and have not been tested. Also, a dozen mildly mineralized plunging anticlines of good size should be tested to a depth, as they are in every way similar to the Homestake structures.

Two diamond-drill holes to test stratigraphic concepts were put down in overturned folds in the Precambrian. The first, 3 miles southeast of Lead, started in pillow lava (probably Flag Rock Formation), passed at about 1,000 feet into graphitic pyrrhotite schist, and then passed into uncorrelatable banded garnet slate at about 1,250 feet. This hole was started at 85° and flattened to 5 so that the expected vertical depth was not obtained. Total length of the hole was 1,850 feet. The pyrrhotite schist is arsenic-poor and therefore gold poor, as is typical in this region. The highest value is 1.0 ppm. The second hole was started in the Ellison Quartzite in the principal anticline

Rochford and was aimed at finding the underlying Homestake Formation. The hole started in slate and quartzite and ended in quartzite without penetrating below the Ellison. It was started at 85° and then flattened to 25°, so that the expected vertical depth again was not attained. Total length was 1,500 feet. Pyritic rocks with pyrrhotite veinlets were cut, but all were low in arsenic and gold. The highest gold content was about 0.60 ppm. (R. W. Bayley, Menlo Park, Calif.)

Ore Deposits in Paleozoic Rocks, Northern Black Hills

Ore deposits in Paleozoic rocks of the northern Black Hills are being studied under a research contract with South Dakota School of Mines and Technology, Rapid City. These deposits have produced nearly 2 million ounces of gold and 4 million ounces of silver. The gold deposits are veins and replacement bodies of the telluride sylvanite, $(Ag,Au)Te_2$, in Mississippian limestone or dolomite and Cambrian quartzite. Stratigraphic control is well established in at least one district (Bald Mountain) and suspected in several others (Ragged Top, Squaw Creek, Carbonate).

The study has evolved through three phases: (1) compilation of all available data on ore deposits, (2) photogeologic study of the northern Black Hills to work out regional structure patterns, and (3) geologic mapping of selected areas, supplemented by geochemical investigations. Phases 1 and 2 have been completed; photogeologic mapping proved to be unsatisfactory because of heavy vegetation and structural complexities.

Mapping of about 100 square miles at a scale of 1:12,000 has been aimed at correlating mineralized horizons from district to district in order to predict likely new areas for exploration. In addition to surface work, two diamond-drill holes, 1,215 and 1,185 feet deep respectively, were put down north of Ragged Top Mountain to test stratigraphic and structural concepts developed during mapping. (J. P. Gries, L. H. Shapiro, and J. K. Fisher, Rapid City, S. Dak.)

UTAH

Silver Reef District

Preliminary study of the deposits of silver, copper, and uranium of the Silver Reef district at Leeds in Washington County indicates that they occur as disseminations, rolls, and blankets, as do the uranium-vanadium deposits of the Colorado Plateau. The principal silver mineral is cerargyrite in minute, nearly invisible grains or crusts, and the concentration of silver varies with copper rather than with uranium. Although the silver minerals are generally considered to be supergene, some possiblity exists that they were deposited as silver chlorides directly from sodium- and potassium-rich brines. Some slight redistribution of the silver may have occured along a few fault zones since the original deposition, but permeable zones, clay layers, and lenses of carbonaceous trash are the main loci of ore deposition. (A. V. Heyl, Denver, Colo.)

VERMONT

Copper prospects were found in road outcrops and a quarry in northwest Vermont almost on the border of Canada, between Berkshire and East Berkshire. Stringers of chalcopyrite occur in an area of mafic schists and greenstones. Sampling over minable widths showed only 50 ppm copper, but additional work may find higher grade ores. Analyses showed only traces of gold and silver.

Samples of pelitic schists of the Moretown Formation were collected in seven roadcuts in southeast Vermont near Dover. The samples showed from 50 to 3,000 ppm nickel and no platinum. Additional work will be needed to determine the extent of nickel mineralization. (J. F. Harrington and J. P. D'Agostino, Washington, D. C.)

VIRGINIA

Gossan Lead

The Great Gossan Lead is a major mineralized sulfide zone near Galax in Carroll County. The Lead consists of a series of elongated sulfide lenses extending over a strike length of 17 miles; they are enclosed in Precambrian schist and gneiss and generally conform to the schistosity of the wallrock. Recurrent faulting along the shear zone may have reopened fractures for ore solutions which have partly replaced breccias and conglomerates. Mineralization ranges from massive to scattered sulfides in quartz, schist, and aplite. Gangue material contains hydrothermal silicate minerals such as biotite and amphibole. Some fractures and pebble surfaces are replaced by ore minerals. Widths of ore lenses range from a few feet to about 80 to 100 feet in parts of the Betty Baker segment. Inferred reserves are at least several tens of millions of tons.

The Gossan Lead was mined only for supergene copper sulfate prior to World War I. Later, until shortly after World War II, it was exploited for manufacture of sulfuric acid and iron ore that remained after roasting. Principal sulfide minerals are pyrrhotite, pyrite, chalcopyrite, and sphalerite, with a little galena. Copper, zinc, and lead were not recovered, but these metals may be important byproducts if this large deposit is again worked for sulfur and iron. Preliminary samples along exposures in old workings that show primary sulfides gave the following analyses:

Copper	3,000-20,000 ppm.
Gold	None-trace.
Lead	500-1,000 ppm.
Molybdenum	5-20 ppm.
Nickel	0-200 ppm.
Silver	0-10 ppm.
Sulfur	25 percent.
Zinc	100-15,000 ppm.

(J. F. Harrington and J. P. D'Agostino, Washington, D. C.)

Reconnaissance Geochemical Studies, Southwest Virginia

Reconnaissance geochemical investigations in southwest Virginia have revealed four areas that merit additional study.

In Floyd County, samples taken from roadcuts near the Vest nickel mine contain 0.20 ppm gold, and samples of low-grade arsenic ore from the Old Arsenic mine contain 0.30 ppm gold. Ore and waste material have been largely removed from the Vest prospect and the prospect pits are filled with water. Some ore and large dumps are still present at the Old Arsenic mine, where about 1½ underground acres have been mined. In addition to arsenic, material on the dumps contains 1,000 to 3,000 ppm copper, 100 to 1,000 ppm tin, 6 to 20 ppm silver, and 100 to 500 ppm bismuth.

Numerous barren-appearing quartz veins occur in Floyd County. Of the few sampled, none contained gold. One sample of massive pyrrhotite with minor chalcopyrite from the Toncrae mine in western Floyd County assayed 0.06 ppm gold.

In Pulaski County along Reed Island Creek just west of Boom Furnace, brecciated Shady Dolomite (Cambrian) contains a few small disseminated pyrite cubes. Three assays of one sample gave 0.07, 0.10, and 0.40 ppm gold; the other sample was barren. The rocks are probably within the Gleaves Knob-Popular Camp overthrust zone, a part of the Great Gossan Lead overthrust belt about 5 miles north of the northern part of the Gossan Lead.

In Grayson County about 9 miles due west of Galax, phyllite of the Lynchburg Formation (Precambrian) is in contact with the Grayson Granodiorite Gneiss. The area is about 10 miles southwest of the Great Gossan Lead and on the same structural trend. A sample of siliceous rock with minor sulfides from the contact zone contained no gold, but a barren-appearing phyllite sample from near the contact zone assayed 0.60 ppm gold.

In Grayson County about 6 miles southwest of Galax, barren-appearing quartz stringers cut phyllitic bedrock of the Lynchburg Formation (Precambrian). The locality is about 200 yards northwest of prospect trenches of the Davis manganese mine, and the area is about 8 miles south of the southernmost part of the Great Gossan Lead. The only sample of vein quartz collected assayed 0.20 ppm gold. Other samples were from the immediate mine area; most contained manganese wad, but none had any gold. (J. P. D'Agostino, Washington, D. C.)

Virgilina District, Virginia and North Carolina

A reconnaissance geochemical study of the Virgilina district in Virginia and North Carolina was started in 1968. A preliminary geologic map by Lynn Glover of the U.S. Geological Survey and other published geologic maps were used as guides in collecting 230 samples of mineralized and barren rock in an area about 20 miles long and 14 miles wide. Only four of the first 40 samples contain detectable gold. These contained 0.02 to 0.08 ppm gold and came from the vein and adjacent wallrock of the Durgy copper mine in Person County, N. C. Other samples remain to be analyzed. (F. G. Lesure, Washington, D. C.)

WYOMING

Platinum Metals, Medicine Bow Mountains

An area of 100 sq mi or more in the east-central part of the Medicine Bow Mountains, Albany and Carbon Counties, has been identified as a region relatively rich in platinum metals and silver. Field studies and analytical data were reported in U.S. Geological Survey Circular 607 (published in 1969). The waste dump at the New Rambler mine, the principal mine in the area, is estimated to have 50,000 tons of material containing 0.3 percent copper, 7 ppm silver, 1 ppm platinum plus palladium, and 0.7 ppm gold. The platinum and silver content of samples from the entire region appears to be an order of magnitude higher than the estimated average crustal abundance. (P. K. Theobald, Jr., and C. E. Thompson, Denver, Colo.)

Quartzite Conglomerates, Northwest Wyoming

Reconnaissance sampling of quartzite conglomerates from seven formations of Late Cretaceous to Miocene age was completed in 1968. Analytical data on more than 10,000 samples are now being compiled. These data supplement the preliminary report published as U.S. Geological Survey Circular 541 in February 1967 and will probably show somewhat lower average gold contents in most of the formations. An exception may be the Pass Peak Formation of Eardley and others (1944) which crops out southeast of the southern part of the Pinyon Conglomerate. Higher values than those previously reported have been found in some Quaternary deposits derived from the conglomerates, particularly along Pacific and Lava Creeks.

Samples from some localities of the Wind River Formation, in addition to having gold, contain appreciable quantities of rare earths, thorium, uranium, zirconium, and other metals. The following analysis is from the South Fork of Warm Spring Creek, where a sluice concentrate contained 5 ppm gold:

	Percent
Ti	3.0
Ce	5.0
La	3.0
Th	1.5
U	.1
Zr	10.0

Sluice concentrates from gravels of Pacific Creek carry as much as 50 ppb platinum. Spectrographic analyses on gold from Pacific Creek, Box Creek, and Green River (near Big Piney) show as much as 30 ppm palladium.

Virtually all the gold is smaller than 0.3 mm in maximum dimension. Removal of cobbles, pebbles, and coarse sand by screening increases the gold content of the remaining material by a factor of 2 to 5, as is illustrated by the following typical example on gravel from Lava Creek (gold price, $35 per oz):

Value of gold in 1 cubic yard of in-place gravel	$0.17
Value of gold in 1 cubic yard of −60 mesh sand	.54

(J. C. Antweiler, Denver, Colo.)

Information bearing on the source and provenance of the quartzite-cobble conglomerates of the Harebell Formation (Upper Cretaceous) and Pinyon Conglomerate (Paleocene) is being analyzed. Paleocurrent directions deduced from crossbedding, imbrication, and roundstone diameter indicate sources to the west and northwest of Jackson Hole. Pebble counts and thin-section studies of clasts indicate a quartzite-volcanic-sedimentary source terrane. The Wyoming conglomerates bear numerous petrographic similarities to the Divide conglomerate lithosome of Ryder (1967) of the Beaverhead Formation, west of Jackson Hole. Paleocurrent directions indicate that the Divide conglomerate lithosome was derived from the southwest. It is likely that all these quartzite-cobble conglomerates were derived from the present vicinity of Belt Supergroup quartzites in Idaho.

Study of nonopaque heavy minerals from 26 samples of Harebell Formation and Pinyon Conglomerate from Jackson Hole, and of 12 samples from the time-equivalent Lance and Fort Union Formations on the west flank of the Bighorn Basin, suggests that rocks in the two basins were derived from different sources. In particular, monazite and epidote are more abundant in the Jackson Hole rocks. Petrographic study of quartzite cobbles in these rocks also suggests different sources; cobbles containing abundant feldspar and with xenoblastic mica are common in Jackson Hole rocks but do not occur in Bighorn Basin rocks. (D. A. Lindsey, Denver, Colo.)

MARINE STUDIES

GEOLOGY OF THE BERING AND CHUKCHI SEAS, ALASKA

A broad study of the geology, heavy minerals, glaciology, and bathymetry of the Bering and Chukchi Seas, in particular the region off the Seward Peninsula around Nome, is being made through a cooperative research contract with the University of Washington, Seattle, Wash., and also in cooperation with the U.S. Coast and Geodetic Survey, Environmental Science Services Administration, U.S. Department of Commerce.

Oceanographic studies have been made on board the University of Washington research vessel *Thomas G. Thompson* and the Coast and Geodetic Survey ships *Surveyor* and *Oceanographer*.

Studies Around Nome, Seward Peninsula

The richest offshore gold concentrations found to date in the northern Bering Sea are in relict coarse sediments near Nome. Relict sediments were found to extend along the shore, however, as far as Solomon, some 30 miles east of Nome, and traces of gold were found throughout the sampled area. Sparse reconnaissance sampling defined a promising area for further exploration offshore between Cape Rodney and Cape Wooley, 30 to 40 miles west and northwest of Nome; this area may be one in which shallow bedrock extends exceptionally far offshore, and the gold content may reflect a local source of bedrock mineralization.

Seismic records obtained along closely spaced lines in Norton Sound off Nome show that bedrock has only a relatively thin cover of sediments west of Nome and that bedrock crops out as much as 2 miles offshore. Bedrock deepens eastward and directly off Nome is covered by as much as 500 feet of sediment. Buried terraces seem to be present at depths of 120 and 180 feet below sea level.

Evidence from pollen and Foraminifera recovered from drill holes in Norton Sound 2 to 3 miles off Nome indicates that marine beds of late Miocene or early Pliocene age are covered by less than 50 feet of younger sediments. A buried beach 50 feet below sea bottom and 70 feet below sea level may mark the inner limit of the Miocene beds.

A recently competed bathymetric map of an area 30 to 40 miles west of Nome shows positions of submerged shorelines at depths of about 35 and 75 feet, as well as former courses of the Sinuk River and a linear scarp (fault?) southeast of Sledge Island. The area around this scarp may constitute a new exploration target, as faults associated with similar scarps in the Nome area are mineralized. The map is at a scale of 1:20,000, with a 2-foot contour interval.

Bottom Sampling in Northern Bering Sea

About 700 bottom samples have been collected from the northern Bering Sea and analyzed for their gold content; about half of these were collected in a closely spaced grid along the coast of southwestern Seward Peninsula, and the remainder were collected elsewhere. Nearly every sample contains traces of gold, reflecting the high background of gold that appears to be characteristic of the northern Bering Sea. Coarse, relict sediments were found in several areas, including two large patches that extend northward from St. Lawrence Island. The gold content of these coarse sediments is commonly higher than the background values in finer grained sediments, and the coarse sediments merit more detailed sampling to define areas likely to contain economic placer deposits. Coarse bottom sediments near and north of western St. Lawrence Island contain small quantities of native copper. These sediments appear to consist of glacial morainal material derived from the Siberian mainland, and the presence of native copper may point toward undiscovered copper deposits on the Chukotsk Peninsula of northeastern Siberia.

Fine-grained gold in amounts ranging from 0.03 to 0.10 ppm has been identified in fine muddy sands. Although the particle size of the gold is as yet unknown, the particles appear t[o] be hydraulically equivalent to quartz grains o[f] coarse silt or fine sand size (0.05 to 0.01 mm).

Glacial Studies, Bering Sea

Glacial drift has been identified in dredge haul[s] from the Bering Sea between St. Lawrenc[e] Island and Bering Strait, and the nature of th[e] material has been confirmed by electron micr[o]photographs of surface textures of sand grain[s]. In addition, new information on the extent an[d] stratigraphic position of the drift has resulte[d] from study of high-resolution seismic reflectio[n] profiles. The drift was derived from highland[s] on Chukotsk Peninsula and Seward Peninsul[a], both of which have deposits of gold and ti[n]. Thus, recognition of the extent of drift delimi[ts] areas within which concentrations of the[se] metals may occur along submerged beaches an[d] stream channels.

Seismic records indicate that the edges of tw[o] separate drift sheets can be recognized off th[e] coast of Nome. One sheet centers roughly o[n] Nome, and its western edge crosses the bea[ch] about 7 miles west of Nome. The east edge o[f] the second sheet crosses the beach near th[e] same place and then extends westward parallel with the beach and about 3 miles offshore.

General Geologic Studies, Bering Sea

Deep penetration seismic profiles in the Bering Sea have revealed a series of basins containing as much as 7,000 feet of Neogene sediments. The size of the basins, the nature of their sediments, and the presence of minor broad folds suggest the possibility of accumulations of petroleum.

The cooperative project of the Geological Survey and the Environmental Science Services Administration for geophyscial studies and sampling in the Bering Sea was carried out between July 24 and August 2. During this cruise, 214 grab samples and 38 box core samples were collected at 201 stations along a track 921 nautical miles long. (D. M. Hopkins, A. R. Tagg, and C. H. Nelson, Menlo Park, Calif.; D. A. McManus, Seattle, Washington.)

GULF OF ALASKA CONTINENTAL SHELF

The geology and possible heavy mineral potential of the nearshore Gulf of Alaska are being studied through a cooperative research contract with the University of Alaska. Fieldwork is being done on the oceanographic research vessel *Acona*. Cruises have been made off Yakutat Bay, southern Kenai Peninsula, and Kodiak Island. Yakutat Bay is in an area of black sand beaches that have produced some gold and platinum.

Samples collected around Yakutat at 135 localities using the Shipek grab sampler show that most of the unconsolidated sediments are muds. Only 36 samples contained material coarser than silt (0.062 mm). Small amounts of gold were found in nine samples.

Seismic profiling between Cross Sound, west of Juneau, and Yakutat Bay has not revealed any submerged beaches, but the outer limit of glacial moraine, which may be a site for heavy mineral accumulation, was recognized. Southeast of Yakutat Bay the outer margin of the continental shelf has a well-developed anticlinal structure and good petroleum potential.

In the Nuka Bay area of southern Kenai Peninsula, acoustical subbottom profiling and sampling were done in 1968, isopach maps were made for bottom sediments, and sedimentation rates were determined. The bay is a recently deglaciated fiord, and the area around the bay has rich gold deposits which are now being eroded. Local concentrations of gold may have formed during the present and earlier glacial cycles, and the study is aimed at discovering how gold is caried at present and where it is deposited. No gold has been found to date in 28 analyzed samples of sediment pockets in the fiord. (R. E. Von Huene, Menlo Park, Calif. and F. F. Wright, Fairbanks, Alaska)

HEAVY MINERALS, INNER CONTINENTAL SHELF OF WASHINGTON

Preliminary studies of the inner continental shelf off Washington have been as part of a cooperative research contract with the University of Washington at Seattle.

Two hundred grab samples have been collected using Van Veen and Shipek samplers. In the area around Cape Flattery, 35 samples contained from 0.3 to 5.5 percent of heavy minerals (sp gr >3.18), with one sample containing 40 percent. Opaque minerals constitute about 15 percent of the total heavy minerals. No data are available yet on metal content.

Heavy mineral content of samples elsewhere in the sampled area is generally <5 percent; some higher concentrations occur northwest of Grays Harbor. Analyses of 29 randomly selected samples indicate a very low background content of gold, less than 0.001 ppm; only one sample contained as much as 0.01 ppm. (P. D. Snavely, Menlo Park, Calif., and D. A. McManus, Seattle, Wash.)

GEOLOGY OF THE SIXES RIVER DRAINAGE, OREGON

The Sixes River enters the Pacific Ocean just north of Cape Blanco and directly east of the most extensive and highest concentration of gold and other heavy minerals found thus far on the Oregon continental shelf. The river appears to be a major source of heavy minerals and therefore a detailed study of its drainage basin is being made through a research contract with the University of Oregon at Eugene.

Bedrock in the drainage area has been mapped, and stream sediments at about 20 stations have been sampled in detail and analyzed chemically and petrographically. The work is aimed at determining the sources of heavy minerals in the drainage, the nature of their fluvial transport, and the amount and physical characteristics of gold and platinum contributed by the river.

The major source rock appears to be the Galice Formation (Jurassic) and associated small intrusive bodies. The Galice Formation consists mainly of slaty to phyllitic mudstone, siltstones, and sandstones. The intrusives, emplaced during the Late Jurassic Nevadan orogeny, are mainly diorites and quartz diorites. The Galice, where it is free of intrusives, and the larger masses of dioritic intrusive rock are less important gold sources. Conglomerate of Cretaceous age, which overlies the Galice Formation and associated intrusives, is apparently not a major contributor of second-cycle gold. Rocks of post-Nevadan Jurassic age, the Colebrooke Schist and associated ultramafic rocks and Cretaceous and Tertiary shales and sandstones are minor to negligible contributors of gold. (Sam Boggs, Jr. and E. M. Baldwin, Eugene, Ore.)

HEAVY MINERALS, OREGON CONTINENTAL SHELF

The mineralogy and heavy metal potential of sediments on the continental shelf of Oregon are being studied under a cooperative research contract with Oregon State University at Corvallis. Two cruises totalling 18 days were made on the research vessel *Cayuse*, between Tillamook Bay and the California border.

Thus far in the project, 38 box cores, 23 piston cores, 16 rock cores, 10 pipe or rock dredge hauls, and 30 Shipek samples (at 22 localities) were taken, and 75 deep sea camera stations were occupied, most at depths ranging from 16 to 200 m.

Studies of heavy mineral mineralogy of the four principal drainage basins contributing sediment to the continental shelf (Klamath—South Coast, Umpqua—Mid Coast, North Coast, and Columbia), of beach sands at 70 localities, and of relict sands on the continental shelf have shown that the predominant direction of sediment transport along the Oregon coast has been northward, both in the past and at present. The thickness of unconsolidated sediments on the southern part of the shelf averages about 20 m, and maximum thickness is about 40 m.

Study of heavy mineral concentrates has shown that from 3 to 59 percent of the heavy fraction consists of black opaque minerals, of which more than half locally is a magnetic mineral, magnetite or ilmenite. Magnetic anomalies were recognized off the mouths of the Rogue and Sixes Rivers in 1967, and therefore about 320 km of magnetometer track lines were run in 1968 to check these areas and to test several new areas. New anomalies were found off the Pistol River, south of Rogue River, at a water depth of 43 m, the same depth as the large anomalous area off Rogue River. The ocean floor at the Pistol River anomaly has a high concentration of heavy minerals.

A number of anticlines and synclines in Mesozoic and Cenozoic rocks underlying unconsolidated sediments trend roughly parallel to the present coastline between the Rogue River and Cape Blanco. The major folds still have slight topographic expression and may have controlled transport and accumulation of heavy minerals on the shelf during the Holocene; this possible structure control is being studied.

The distribution of gold in surface sediments on the Oregon continental shelf was reported in U.S. Geological Survey Circular 587. In summary, concentrations of 50 ppb or more were found at three places between the Coquille and Rogue Rivers; the largest area of gold concentration, 15-20 sq mi, was off Cape Blanco. Gold occurs in black sands believed to be relict beach placers formed during a previous low stand of the sea. Concentrations of black sand have also been found at the edge of the continental shelf; the finding of black sands at such depths and at such a distance from shore extends considerably the range of potential submarine placer deposits on the continental shelf. (H. E. Clifton, Menlo Park, Calif., and L. D. Kulm, Corvallis, Ore.)

GEOLOGY AND HEAVY MINERALS, CONTINENTAL SHELF, NORTHERN CALIFORNIA

The geology and heavy metal potential of the continental shelf of northern California is under investigation through a cooperative research contract with Scripps Institution of Oceanography, La Jolla, Calif. The oceanographic vessel *Oconostota* is participating in the work.

Gold distribution on the sea floor off the Klamath Mountains was reported in U.S. Geological Survey Circular 605. Analyses of 82 samples of surficial sediment in this area show that the background gold content is about 0.1 ppb. Four anomalous areas, as much as 30 square kilometers in extent, have sediment containing 10 ppb or more of gold; the highest gold content found to date is 390 ppb.

Analysis of these samples has revealed a hitherto unrecognized relationship between gold and heavy minerals. Contour maps showing percentages, in a group of samples, of minerals heavier than a given heavy liquid were prepared for several heavy liquids. These maps indicate that maxima for the various liquids are displaced systematically from the gold maxima, with the maxima for the heaviest liquid being closest to the gold maxima. The heavy-mineral trends may be useful in directing sampling toward areas of highest gold concentration.

An area of about 6 square degrees has been mapped on the continental margin off northern California during a 1-month cruise of the *Oconostota*. Some 4,100 km of subbottom profiling were run, and 33 dredge samples, including four large sand samples for platinum analysis, were collected.

Basement rock of a submarine plateau 25 km wide that lies west of the continental shelf off northermost California at depths of 800-1,000 m is of Eocene age. Dredge samples containing late Eocene Foraminifera were taken 75 km offshore. This finding approximately doubles the known width of possibly petroleum-bearing Tertiary rocks at the continental margin. (G. W. Moore and E. A. Silver, La Jolla, Calif.)

MINERALOGY OF CONTINENTAL-SHELF SEDIMENTS, SOUTHERN CALIFORNIA

The mineralogy of continental-shelf sediments off southern California is being investigated by scientists of the University of Southern California under a research contract. The oceanographic research vessel *Velero IV* is being used.

Analyses are being made of the light and heavy mineral fractions of sand and silt in 57 samples of sediments being carried by all the main rivers between the Mexican border and Point Conception, a distance of about 220 miles. Shallow-water sediments off Santa Rosa, Santa Cruz, and Santa Catalina Islands also were sampled. Work will continue to establish the sedimentological regime of the region—provenance of sediments, effects of weathering on mineral components in each river, dispersal patterns, and so forth. Preliminary results show that the percentage of heavy minerals (sp gr >2.9) in stream sediments increases from less than 1 percent between Jalama and Carpinteria at the northwest end of the sampled area, to 2 percent between Carpinteria and Palos Verdes, and to 6 or 7 percent southeast of Palos Verdes; the highest heavy mineral content is 25 percent. Neither river nor beach sediments appear likely to contain sizable concentrations of heavy minerals. Further work will be needed to evaluate the heavy mineral potential of shelf sediments. (D. S. Gorsline, Los Angeles, Calif.)

HEAVY MINERALS, MIDDLE ATLANTIC CONTINENTAL SHELF

Heavy minerals on the continental shelf of the middle Atlantic coast are being studied under a research contract with Duke University. The oceanographic research vessel *Eastward* is being used. This part of the continental shelf is characterized by low sedimentation rate, low proportions of sand-sized or coarser sediment, and abundance of calcium carbonate.

Samples collected by box dredge at more than 2,000 sites on the continental shelf between Cape Hatteras, N. C., and Cape Roman, S. C., and another 200 samples collected from dunes and beaches in North and South Carolina and in Virginia are being studied.

Heavy mineral concentrates from 60 samples of continental-shelf sediments and from eight beach sands have been analyzed for heavy metals. Most analyses for gold show <0.1 ppm, but one from the outer shelf off Cape Lookout, N. C., contains more than 2 ppm. (O. H. Pilkey, Durham, N. C.)

MISCELLANEOUS STUDIES

Silver Content of Foraminifera-Bearing Deep Ocean Sediments

The silver content of 80 Foraminifera-bearing samples from three cores collected at high latitudes in the South Pacific, of 12 grab samples from the continental slope and rise off the North Carolina coast, and of 30 samples of carbonate sediments from the continental rise and Sigsbee Abyssal Plain in the Gulf of Mexico has been determined. The silver content, several parts per million, is more than an order of magnitude higher than previously reported amounts in deep ocean sediments. The new analyses also suggest that the content of silver, copper, zinc, and lead in these deep ocean sediments varies directly with water temperature conditions. Further analyses are being made on samples from deep parts of the Atlantic Ocean. (H. L. Berryhill and C. W. Holmes, Corpus Christi, Tex.)

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