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Mineral resources and mineral resource potential of the Panamint Dunes Wilderness Study Area, Inyo County, California

by

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The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas "to determine the mineral values, if any, that may be present." Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of the Panamint Dunes Wilderness Study Area (CDCA-127), California Desert Conservation Area, Inyo County, California.

SUMMARY

On the basis of studies conducted by the U.S. Geological Survey and the U.S. Bureau of Mines in 1981-1983, the Panamint Dunes Wilderness Study Area has an identified volcanic cinder resource and few areas with mineral resource potential. Hydrothermal deposits of lead-zinc-silver occur in veins and small replacement bodies along and near the Lemoigne thrust fault on the eastern side of the wilderness study area. Two workings, the Big Four mine with 35,000 tons of inferred subeconomic lead-zinc-silver resources and a moderate potential for additional resources, and the Apple 1 claim with low potential for lead-zinc-silver resources, are surrounded by the study area but are specifically excluded from it. A low resource potential for lead-zinc-silver is assigned to other exposures along the Lemoigne thrust, although metallic minerals were not detected at these places. The Green Quartz prospect, located near the northern tip of the study area, has low resource potential for copper in quartz pegmatites in quartz monzonite of the Hunter Mountain batholith.

Nonmetallic mineral resources consist of volcanic cinders and quartz sand. An estimated 900,000 tons of inferred cinder reserves are present at Cal Trans borrow pit MS 242, on the southern margin of the study area. The Panamint Valley dune field, encompassing 480 acres in the north-central part of the study area, has only low resource potential for silica because of impurities. Other sources of silica sand outside the study area are of both higher purity and closer to possible markets.

INTRODUCTION

Panamint Dunes Wilderness Study Area is located in Inyo County in southeastern California, approximately 27 mi east-southeast of Lone Pine, and 32 mi southwest of the California-Nevada state line (fig. 1). The area encompasses 93,220 acres of northernmost Panamint Valley and surrounding mountains. It is bounded by Death Valley National Monument on the east, Wildrose Canyon Wilderness Study Area on the southeast, California State Highway 190 on the south, the approximate rim of Darwin Plateau and Lee Flat on the west, and Hunter Mountain Wilderness Study Area on the north. Two mine workings and an access road on the east side of Panamint Valley are specifically excluded from wilderness consideration.

Access to the wilderness study area is from California Highway 190 on the south and southeast, by the access road to mine workings at the Big Four mine on the east, and by unpaved secondary roads on the northwest side of the area.

Panamint Valley is a 65-mi-long valley that contained one of several pluvial lakes that existed in the basins of southeastern California in the late Quaternary. The northernmost part of the valley floor is playa and is surrounded on three sides by bajada. The wilderness study area gets its name from The Dunes, a 480 acre dune field

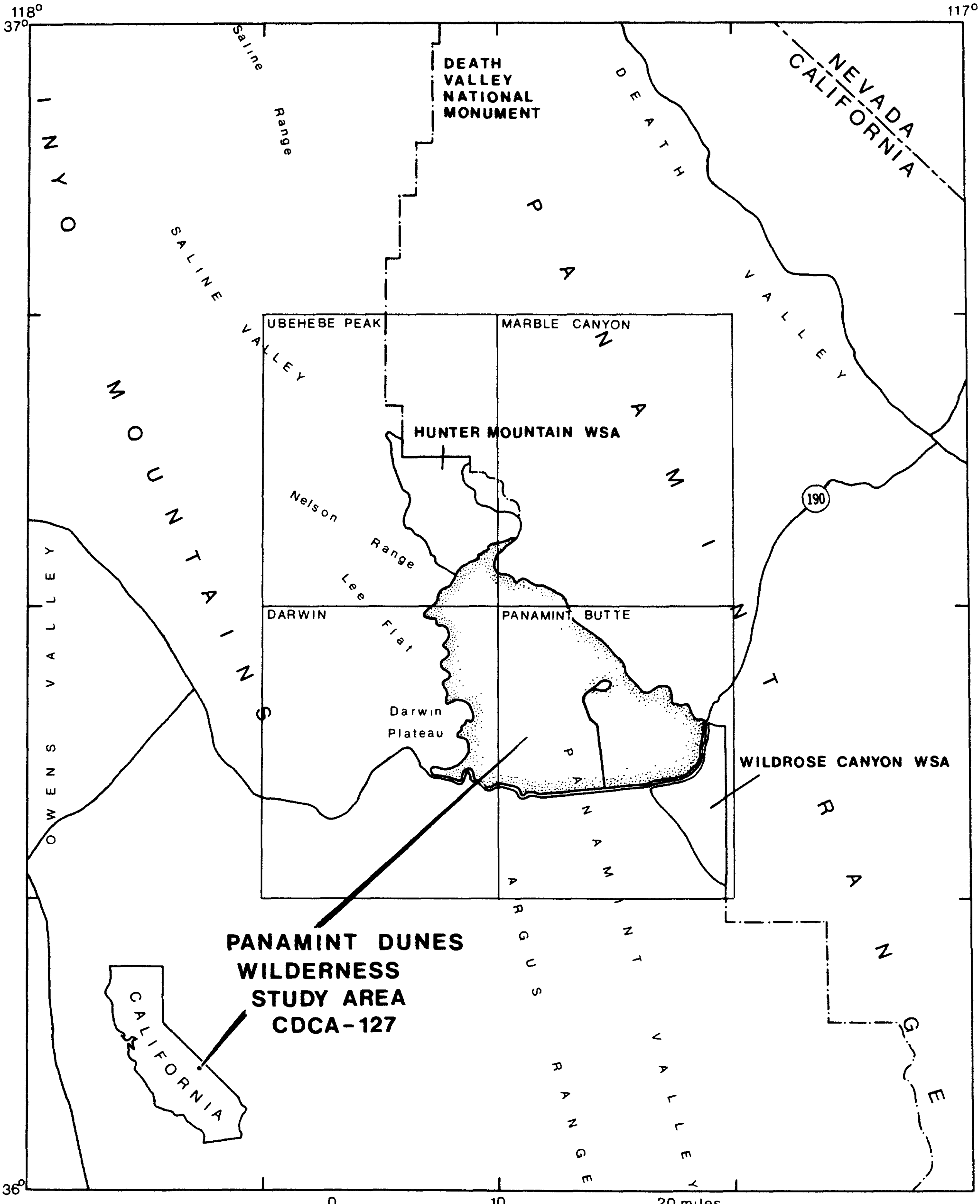

Figure 1.—Index map showing location of Panamint Dunes Wilderness Study Area (WSA), Inyo County, California.

on the northern bajada. The dune field contains good examples of star dunes. The valley walls are steep and composed of parallel-step faulted volcanic cap rocks on the west, granitic rocks of the Hunter Mountain batholith around the northern end, chaotically faulted Paleozoic limestone and dolomite on the east side, and by massive, faulted, Tertiary and Quaternary fanglomerate on the southeast.

Previous and present studies

The wilderness study area encompasses parts of the Panamint Butte, Darwin, Ubehebe Peak, and Marble Canyon 15-minute quadrangles. Studies on the geology and mineral deposits of the Panamint Butte, Darwin, and Ubehebe Peak quadrangles have been published by Hall (1971) and Hall and Stephens (1963), Hall and Mackevett (1958, 1962), and McAllister (1955, 1956). A summary report on the geology and a composite geologic map of the Panamint Dunes Wilderness Study Area and contiguous Hunter Mountain and Wildrose Canyon Wilderness Study Areas have been compiled by Conrad and McKee (1984). Other geologic studies on the area include those of Norman and Stewart (1951), Smith and Pratt (1957), and Mabey (1961).

Field work for this report was conducted by the U.S. Bureau of Mines in 1981 and by the U.S. Geological Survey in 1982-1983. Studies included examination and evaluation of mines, prospects, and mineralized areas by the Bureau of Mines, and geochemical sampling of stream sediments and reconnaissance geologic mapping by the Geological Survey. The Bureau of Mines also conducted a literature search and examined Inyo County and U.S. Bureau of Land Management claim records.

All known mines, prospects, and mineralized areas were examined and sampled by the Bureau of Mines. Fifty-nine samples were collected, of which 53 were lode, four were dune sand, and two were alluvium. All samples were checked for radioactivity and fluorescence. Lode samples were analyzed quantitatively for selected elements; some were analyzed for 42 elements by a semiquantitative spectrographic method. Visibly mineralized samples were analyzed for particular elements by a quantitative method. Black sand concentrates were checked for gold. Complete analytical data and accompanying report are on file at the U.S. Bureau of Mines, Western Field Operations Center, Spokane, Washington. A summary report on the area is in preparation (Leszcykowski, 1984).

Geochemical sampling by the Geological Survey consisted of 76 stream-sediment samples and 76 heavy-mineral concentrate samples. Analytical data for these are given in Detra and others (1984).

GEOLOGY

The Panamint Dunes Wilderness Study Area lies near the southwestern margin of the Basin and Range physiographic province and near the southeastern part of the Sierra Nevada batholith.

The rocks in the study area are divided into four major groups: (1) Paleozoic marine sedimentary rocks; (2) Jurassic intrusive rocks; (3) upper Tertiary and Quaternary fanglomerates and interbedded basalt flows; and (4) Quaternary surficial and lacustrine deposits.

Paleozoic rocks range in age from Late Cambrian to Permian and are part of a conformable sequence with a composite thickness of approximately 15,000 ft. Pre-Devonian rocks are predominantly dolomite, with minor limestone, chert, and interbedded quartzite units. Devonian and younger rocks are predominantly limestone and silty and shaley limestone, with minor dolomite and cherty limestone. These rocks have been metamorphosed to varying degrees to marble or calc-silicate hornfels, particularly in the western part of the study area. A detailed description of the Paleozoic formations is given by Hall (1971) and Conrad and McKee (1984).

The Jurassic intrusive rocks are part of the Hunter Mountain Quartz Monzonite, a composite batholith considered to be comagmatic with the Sierra Nevada batholith (Bateman and others, 1963; McKee and Nash, 1967; Ross, 1969). These granitic rocks have intruded and metamorphosed the Paleozoic sedimentary rocks of the area. Contacts between the plutonic and surrounding country rocks are generally sharp and steep, but contact-metamorphic effects may extend as far as 2 mi from the contact. The Hunter Mountain batholith is primarily quartz monzonite in composition, but along border zones reaction with country rock has produced monzonite, syenodiorite, diorite, and hornblende gabbro (Hall, 1971). Locally, small intrusive bodies of aplite, leucogranite, pegmatite, and andesite porphyry of probable Cretaceous age cut the Hunter Mountain Quartz Monzonite and older stratified rocks.

Unconformably overlying the Paleozoic and Mesozoic rocks is a sequence of upper Tertiary and Quaternary fanglomerates and basalt flows. The fanglomerates, exposed mainly in the southeastern part of the study area, are part of a sequence that reaches a maximum thickness of nearly 10,000 ft south of the study area. Monolithologic breccias of shattered Paleozoic dolomite and quartzite are interbedded in the fanglomerates and are interpreted as debris flows that originated in the highlands to the east.

Olivine basalt of Pliocene age is interbedded in the upper part of the fanglomerate. Later flows, also of Pliocene age, cap the Cenozoic and older rocks. Extensive basaltic flows on the west side of the study area are associated with pyroclastic rocks.

Quaternary surficial deposits include alluvial fan material marginal to the Panamint Range, and playa deposits and sand dunes in Panamint Valley. In the northern part of the valley, the basin fill is generally less than 500 ft thick. A bore hole drilled near the center of the basin by the U.S. Geological Survey revealed no alkaline lacustrine deposits (Smith and Pratt, 1957).

Deformation of the rocks in the northern Panamint Valley area and vicinity can be assigned to one of three major periods of deformation. These are: (1) pre-Jurassic faulting and folding, recognized in regional geologic studies (Sylvester and Babcock, 1975; Dunne and others, 1978); (2) deformation associated with emplacement of Jurassic plutonic rocks; and (3) basin and range style faulting that is responsible for most of the present geomorphic expression of the region.

Paleozoic rocks that previosuly had been faulted and gently folded were deformed further by the intrusion of the Hunter Mountain batholith. The Lemoigne thrust sheet, a prominent tectonic feature of the area, was uplifted and thrust to the southeast by emplacement of the batholith (Hall, 1971).

During the Cenozoic, low angle faulting under shallow cover caused extensive shattering of the Paleozoic strata, resulting in the chaotically broken terrain that lies in the southeastern part of the study area. Uplift on normal faults created highlands east of the study area that were the source areas of the Pliocene fanglomerates. Range-front faults along the base of the Panamint Range are responsible for the down-drop of Panamint Valley.

GEOCHEMISTRY

The geochemical survey of the study area is based on analyses of stream sediments and nonmagnetic heavy-mineral concentrates collected from 76 sampling sites from within and along the margins of the study area. Sample preparation and analytical procedures and complete analytical data are given in Detra and others (1984). All samples were analyzed for 31 elements (Ag, As, Au, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, La, Mg, Mn, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, Th, Ti, V, W, Y, Zn, Zr) by semiquantitative emission spectrography. Geochemically anomalous heavy-mineral concentrate samples were examined under a binocular microscope and with shortwave ultraviolet light to determine their mineralogical composition.

Stream-sediment samples provide information on major rock types and surficial materials present within the drainage system. Heavy-mineral concentrate samples are more useful in isolating and yielding information on sulfide minerals, their oxidation products, and other minerals that contain most of the elements related to ore deposits.

Analyses of these types of samples reveal drainages that contain anomalous concentrations of ore-related elements. Most often the anomalies reflect known mining activity or mineralized areas, but in some instances, they reveal areas not previously known to be mineralized. Geochemically anomalous areas are ones in which the amount of ore-related elements in the sample deviate sufficiently from the upper limit of normal background values to suggest that concentrations of these metals may occur in the rocks. Anomalous values, i.e., those enriched relative to normal crustal abundances, were determined by inspection of analytical and graphical data. Geochemically anomalous elements in stream-sediment (SS) or heavy-mineral concentrate (Con) samples from the study area are shown on Plate 1, as are the important constituent minerals.

MINING AND PRODUCTION

Panamint Dunes Wilderness Study Area lies in an areally extensive geologic terrain that over the past 100 years has seen considerable mining activity, particularly for hydrothermal deposits containing lead, zinc, copper, silver, and gold (Tucker and Sampson, 1938). Four mining districts are located in the vicinity, but none encompasses any of Panamint Valley. The districts are the Darwin district, established in 1874 and located 4 mi to the southwest; the Modoc district, established in 1875 and located 2 mi to the south; the Skidoo district, established in 1906 and located 12 mi to the east; and the Cottonwood district, established in 1907 and located 5 mi to the northeast. According to Inyo County mining records, the first mining activity in the study area was in 1903. Subsequently more than 250 mining claims have been recorded inside or within 1 mi of the study area. A summary of the workings and production of the major mines and prospects is given in Table 1.

Only the Big Four mine (excluded from, but surrounded by, the study area) has any recorded production; 566 tons of ore were produced between 1944 and 1952. The ore yielded 177,496 lbs of lead, 129,715 lbs of zinc, 1,408 lbs of copper, 1,399 oz of silver, and 6 oz of gold. In 1981, 10 tons of ore averaging about eight percent each of lead and zinc were stockpiled by a leasee. The only other production from the area was 30 tons of ore from the Apple 1 claim (Norman and Stewart, 1951), located near the Big Four mine and also excluded from the study area.

The only nonmetallic commodity mined in the study area is volcanic cinders, at Cal Trans (California Department of Transportation) borrow pit MS 242, on the southern margin of the area. Approximately 3,000 to 4,000 tons of cinders have been mined to date. The cinders are used for traction sand or as a base for road construction.

MINERAL DEPOSITS AND ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The assessment of mineral resource potential in the Panamint Dunes Wilderness Study Area is expressed by a favorability classification. The terms high, moderate and low resource potential are defined as follows: high indicates that the nature of the geologic environment and the geologic processes that have acted on the area suggest a high degree of likelihood that a stated mineral resource is present. The data define a geologic environment favorable for the presence of mineral resources, and support the interpretation that resources are present; moderate indicates that the nature of the geologic environment and the geologic processes that have acted in the area suggest a reasonable chance for the presence of mineral resources; low indicates the data define a geologic environment permissive for the presence of mineral resources, but that there is no evidence of resource accumulation.

Metallic commodities

The Panamint Dunes Wilderness Study Area lies within a province characterized by the presence of lead, zinc, and silver hydrothermal-type deposits. The lead-zinc-silver deposits are mainly metalliferous vein and replacement bodies in carbonate rocks close to the margins of granitic plutons. Skarns that contain tungsten, molybdenum, and copper are present in adjoining areas where granitic plutons have metamorphosed carbonate rocks. Indications of lead-zinc-silver hydrothermal vein deposits are found in the Panamint Dunes Wilderness Study Area, but areas with tungsten-molybdenum-copper skarn mineralization are not.

Although the Panamint Dunes Wilderness Study Area is located in an area dotted with local mining districts, only one mine in northernmost Panamint Valley has had production. The Big Four mine (see pl. 1, no. 2) and nearby Apple 1 claim (pl. 1, no. 3) lie at the base of the Panamint Range on the east side of Panamint Valley; they are surrounded by the study area, but are specifically excluded from wilderness consideration.

Workings at the Big Four mine and Apple 1 claim are in hydrothermally altered Paleozoic limestone, dolomite, and siltstone along and adjacent to the Lemoigne thrust fault, which is the dominant ore controlling structure in the area. The lead-zinc-silver ore is mostly oxidized and found in veins and small tabular replacement bodies in or adjacent to the thrust (Hall and Stephens, 1963). The replacement bodies containing sulfides are up to 4 ft thick and 25 ft long. Seven chip samples from the middle level of the Big Four mine contained 0.43 to 9.5 percent lead, 0.47 to 35.0 percent zinc, 0.005 to 0.01 oz gold and 0.05 to 0.96 oz silver per ton. An estimated 35,000 tons of inferred subeconomic lead-zinc-silver resources averaging 4.6 percent lead, 17 percent zinc, and 0.36 oz silver per ton are present at the Big Four mine. The mine has moderate potential for additional resources.

The Apple 1 claim (pl. 1, no. 3) is located on the Lemoigne thrust less than one half mile from the Big Four mine. Lead and zinc sulfides occur in replacement bodies in limestone and dolomite, with minor occurrences of sulfides in quartz veins. Seven chip samples from this claim contained 0.07 to 10.1 percent zinc (average 1.5%) and 0.02 to 15.5 percent lead (average 2.5%). Three of the samples contained 5.9, 8.4, and 43.0 oz silver per ton and two had 0.09 and 0.15 oz gold per ton. The Apple 1 claim has low potential for lead-zinc-silver resources.

Additional exposures of the Lemoigne thrust are present on the west face of Panamint Butte. All oxidized (red-colored) exposures of dolomite, limestone, and marble along the 1.5-2 mi-long fault trace were examined and sampled, but hydrothermally altered base- or precious-metal-bearing deposits were not discovered. A low resource potential is assigned to these exposures.

Spectrographic analyses of stream sediments and heavy-mineral concentrates from the wilderness study area have revealed several areas with geochemically anomalous concentrations of metallic elements. The most significant of these are located in drainages below, and to the south of, the Big Four mine. The nonmagnetic heavy-mineral concentrates here are particularly enriched in ore and ore-related elements. The anomalous trace element suite included lead, zinc, silver, arsenic, antimony, and molybdenum. Lead was the only element detected in anomalous concentrations in the stream sediments near the Big Four mine. Mineralogical examination of the nonmagnetic heavy-mineral concentrates revealed an assemblage of minerals of both primary (sphalerite, galena, rutile, anatase, and barite) and secondary origin (hydrozincite, wulfenite, cerrusite, massicot (lead oxide), and limonite after pyrite). The trace element signature and observed mineral assemblage suggest a low temperature hydrothermal origin for the base-metal mineralization that occurred in and around the Big Four mine. The geologic environment is conducive to hydrothermal processes; the proximity of intrusive bodies to reactive host rocks (carbonates) and penecontemporaneous faulting that created natural conduits for migration of hydrothermal fluids.

At the Green Quartz claim (pl. 1, no. 5), in the northern tip of the study area, pegmatite zones in quartz monzonite of the Hunter Mountain batholith contain malachite, azurite, and minor amounts of bornite. Secondary copper minerals and radioactive allanite also have been reported from quartz pegmatites in this vicinity by McAllister (1955). Two select samples from the Green Quartz claim, one from a pit wall and the other from a dump, contained 1.74 and 1.23 percent copper. The potential for copper resources here is low.

Copper minerals were found also at an unidentified prospect (pl. 1, no. 8) and at several mineralized outcrops in the northwestern part of the study area (pl. 1, no. 9). The copper mineralization is probably hydrothermal and related to intrusion of the plutonic rocks. No resource potential was recognized for copper at these occurrences.

Geochemically anomalous elements found in stream-sediment samples (molybdenum, bismuth, silver, and barium) and nonmagnetic heavy-mineral concentrate samples (lead, zinc, and silver) in the western half of the study area are scattered and, for the most part, are isolated occurrences. The molybdenum, from north of Rainbow Canyon, and the bismuth and silver in the stream sediments in Mill Canyon possibly traveled as constituents of clay minerals and (or) iron-manganese oxides and may be derived from known contact-metamorphic and (or) metasomatic mineralization that occurred in the area of Darwin Plateau, Lee Flat, and the Nelson Range. The barium from stream sediments in and near Lee Wash, along the northwestern margin of the study area, most likely was derived from the weathering of potash feldspars in granitic host rocks within these drainages. Barite, a common gangue mineral in hydrothermal deposits, was not present in any of the nonmagnetic heavy-mineral concentrate samples from this area.

Mineralogical examination of the anomalous heavy-mineral concentrate samples from the western drainages revealed mostly granitic accessory minerals, such as sphene, apatite, and zircon. Sparse scheelite, pyrite, and lead oxides were noted in samples from a drainage two miles north of Rainbow Canyon. The anomalous trace elements in the heavy-mineral concentrates, and the identified ore-related minerals probably represent mineralized areas some distance away. Known areas of hydrothermal mineralization on the eastern slope of the Inyo Mountains, the Santa Rosa Hills, and the Darwin Plateau could account for the ore minerals and related elements found in the sediments.

Radioactive elements

Radioactivity has been detected in two areas in the wilderness study area. McAllister (1955) reported radioactive allanite associated with secondary copper minerals at the Hourglass claim (pl. 1, no. 5), located about one mile southwest of Jackass Spring in the northern tip of the study area. A radioactive anomaly in quartz monzonite exposed at the head of Rainbow Canyon (pl. 1, no. 13), in the southwest corner of the study area and near the north end of the Argus Range, was indicated by scintillometer readings. The anomalous area, however, was only 5 ft wide and 15 ft long. Neither area is considered to have potential resources of radioactive materials. Considerable prospecting for uranium in the northern end of the Argus Range in the 1950s yielded no significant discoveries.

Nonmetallic commodities

The only nonmetallic commodities with resource potential in the study area are volcanic cinders and quartz sand.

Volcanic cinders have been mined from Cal Trans borrow pit MS 242 on the southwestern margin of the study area along State Highway 190 (pl. 1, no. 11). The deposit being mined is an accumulation of air-fall scoria derived from a local cinder cone or cone-vent complex. The cinder deposit is about 20 ft thick in the borrow pit and covers about 21 acres. The deposit is estimated to contain 900,000 tons of inferred cinder reserves. Additional outcrops of pyroclastic materials are exposed along State Highway 190 west of the borrow pit. These could possibly yield additional amounts of cinders if found to be of suitable character.

The sand dunes at the northern end of Panamint Valley cover several square miles, but large dunes (The Dunes, pl. 1, no. 4) comprise only about 480 acres. The average composition of the dune sand is about 20 percent clear silica (suitable for glass), 50 percent heavily iron-stained silica, 20 percent obsidian, 2 percent magnetite, 2 percent feldspar, and 6 percent hornblende and various minor silicates. Concentrations of eolian black sand are present locally. The dunes have low potential as a silica resource.

Saline deposits in southeastern California occur in several of the broad, flat basins that contained shallow pluvial lakes during the late Pleistocene and early Holocene. The character of Panamint Valley, however, is different in that it is long, narrow, and deep; when filled to the point of overflow, Panamint Lake was at least 950 ft deep (Gale, 1914). A bore hole drilled in 1953 in search of saline minerals did not discover any significant deposits of alkaline lacustrine deposits (Smith and Pratt, 1957).

No indications of coal, oil, gas, or geothermal energy resources were found in the wilderness study area during this study.

REFERENCES CITED

Bateman, P. C., Clark, L. C., Huber, N. K., Moore, J. C., and Rinehart, C. D., 1963, The Sierra Nevada batholith—a synthesis of recent work across the central part: U.S. Geological Survey Professional Paper 414-D, p. i-iv + D1-D46.

Conrad, J. E., and McKee, E. H., 1984, Geologic map of the Hunter Mountain, Panamint Dunes, and Wildrose Canyon Wilderness Study Areas, Inyo County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF- , scale 1:62,500 [in press].

Detra, D. E., Kilburn, J. E., and Chazin, B., 1984, Analytical results and sample locality map of stream-sediment and panned-concentrate samples from the Inyo Mountains (CDCA 122), Hunter Mountains (CDCA 123), Panamint [Dunes] (CDCA 127), and Wildrose [Canyon] (CDCA 134) Wilderness Study Areas, Inyo County, California: U.S. Geological Survey Open-File Report 84-011, 58 p.

Dunne, G. C., Gulliver, R. M., and Sylvester, A. G., 1978, Mesozoic evolution of rocks of the White, Inyo, Argus, and Slate Ranges, eastern California, in Howell, D. G., and McDougall, K. A., eds., Mesozoic paleogeography of the western United States, Pacific Coast Paleogeography Symposium 2: Los Angeles, Society of Economic Paleontologists and Mineralogists, Pacific Section, p. 189-207.

Gale, H. S., 1914, Salines in the Owens, Searles, and Panamint basins, southeastern California: U.S. Geological Survey Bulletin 580-L, p. i-vii + 251-323.

Hall, W. E., 1971, Geology of the Panamint Butte quadrangle, Inyo County, California: U.S. Geological Survey Bulletin 1299, 87 p.

Hall, W. E., and Mackevett, E. M., 1958, Economic geology of the Darwin quadrangle, Inyo County, California: California Division of Mines Special Report 51, 73 p.

________, and __________, 1962, Geology and ore deposits of the Darwin quadrangle, Inyo County, California: U.S. Geological Survey Professional Paper 368, 87 p.

Hall, W. E., and Stephens, H. G., 1963, Economic geology of the Panamint Butte quadrangle and Modoc district, Inyo County, California: California Division of Mines and Geology Special Report 73, 39 p.

Leszcykowski, A. M., 1984, Mineral resources of the Panamint Dunes Wilderness Study Area (BLM no. CDCA-127), Inyo County, California: U.S. Bureau of Mines Mineral Land Assessment MLA -84 [in preparation].

Mabey, D. R., 1961, Regional magnetic and gravity anomalies in the Darwin area, California, in Geological Survey research 1961: U.S. Geological Survey Professional Paper 424-C, art. 249, p. C276-C279.

McAllister, J. F., 1955, Geology of mineral deposits in the Ubehebe Peak quadrangle, Inyo County, California: California Division of Mines Special Report 42, 63 p.

____________, 1956, Geology of Ubehebe Peak quadrangle, California: U.S. Geological Survey Geologic Quadrangle Map GQ-95, scale 1:62,500.

McKee, E. H., and Nash, D. B., 1967, Potassium-argon ages of granitic rocks in the Inyo batholith, east-central California: Geological Society of America Bulletin, v. 78, no. 5, p. 669-680.

Norman, L. A., and Stewart, R. M., 1951, Mines and mineral resources of Inyo County, California: California Journal of Mines and Geology, v. 47, no. 1, 223 p.

Ross, D. C., 1969, Descriptive petrography of three large granitic bodies in the Inyo Mountains, California: U.S. Geological Survey Professional Paper 601, p. i-vi + 1-47.

Smith, G. I., and Pratt, W. P., 1957, Core logs from Owens, China, Searles, and Panamint basins, California, in Geologic investigations in the Mojave Desert and adjacent region, California: U.S. Geological Survey Bulletin 1045-A, p. i-iii + 1-62.

Sylvester, A. G., and Babcock, J. W., 1975, Regional significance of multiphase folding in the White-Inyo Range, eastern California [abs.]: Geological Society of America Abstracts with Programs, v. 7, no. 7, p. 1289.

Tucker, W. B., and Sampson, R. J., 1938, Mineral resources of Inyo County, California: California Journal of Mines and Geology, v. 34, no. 4, p. 368-500.

Table 1.--Mines, Prospects, and Mineral Occurrences in and adjacent to the Panamint Dunes Wilderness Study Area
[Underlined name indicates identified mineral resources or potential; asterisk (*) indicates outside study area]

Map no.	Name	Summary	Workings and production	Sample data and resource estimate
1	Happy Anniversary Nos. 2 and 36 claims	The claims are on light to dark grey Ely Springs Dolomite covered by dune sand.	None	One sample of dune sand yielded no significant mineral values.
2	Big Four mine*	The mine area is on the Lemoigne thrust fault. Mineral occurrences are in limestone, dolomite, marble and siltstone of the Pogonip Group and Keeler Canyon Formation. Replacement-type deposits of lead and zinc sulfides in pods up to 4 ft thick and 25 ft long occur in limestone and dolomite and in quartz veins. Hydrothermal lead- and zinc-bearing solutions from Hunter Mountain batholith migrated along shear zones and bedding planes.	Numerous pits and 3 adits; 1 adit 600 ft long and 2 adits less than 100 ft long. No lead or zinc minerals were observed in the lower, 600 ft adit, and the only production came from the upper adits. A total of 566 tons of mined ore yielded 177,496 lb of lead, 129,715 lb of zinc, 1.408 troy oz of silver and 6 troy oz of gold. In 1981, ten tons of ore averaging about 8 percent each of lead and zinc were stockpiled by John Harbison, leasee.	Fifteen samples were taken (12 chip and 3 grab samples). Two chip samples were taken in the lower adit where no lead or zinc minerals were observed. Three other chip samples were on the contact between the Pogonip Group and Keeler Canyon Formation and contained no significant mineral values. The seven remaining chip samples contained 0.43 to 9.5 percent lead, 0.47 to 35.0 percent zinc, 0.005 to 0.01 troy oz gold and 0.05 to 0.096 troy oz of silver per ton. An estimated 35,000 tons of inferred subeconomic lead-zinc-silver resources average 4.6 percent lead, 17 percent zinc and 0.36 troy oz silver per ton. The potential for additional resources is moderate.
3	Apple 1 claim*	Mineral occurrences are in limestone, dolomite, marble and siltstone of the Pogonip Group and Keeler Canyon Formation. Lead and zinc sulfide minerals occur as replacement bodies in the limestone and dolomite, with minor occurrences of sulfides in quartz veins. The base-metal bearing hydrothermal solutions originating in the Hunter Mountain batholith migrated along the Lemoigne thrust fault.	Several pits and two adits 20 ft long. According to Norman and Stewart (1951), 30 tons of ore were shipped in 1947.	Seven chip samples contained 0.07 to 10.1 percent zinc (average 1.5 percent) and 0.02 to 15.5 percent lead (average 2.5 percent). Three of the samples contained 5.9, 8.4 and 43.0 oz silver per ton and two had 0.09 and 0.15 oz gold per ton. Low potential for silver-lead-zinc resources.
4	(Panamint Valley dune field)	Dune sand composed of quartz, magnetite, feldspar and other constituents (obsidian and hornblende). Local concentrations of wind blown black sand are present. The large dunes cover 480 acres in Panamint Valley.	None	Three samples (6 to 7 lb each) contained 0.5, 2.2 and 24.5 percent magnetite. The average composition of the dune sand is about 20 percent clear silica (suitable for glass), 50 percent heavily iron stained silica (with high iron content), 20 percent obsidian, 2 percent magnetite, 2 percent feldspar, and 6 percent hornblende and various minor silicates. The dunes have low potential for silica resources.
5	Green Quartz (Humbug, Hourglass) claim	Pegmatite zones in quartz monzonite of the Hunter Mountain batholith contain malachite, azurite, and minor amounts of bornite.	Five small pits.	Eight samples (6 chip, 2 grab) were taken from pits and dumps. Two select samples (one from a pit wall and another from the dump) contained 1.74 and 1.23 percent copper, respectively. Potential for copper resources is low.
6	(Mineralized outcrop)	A volcanic ash layer 5 ft thick near contact of Hunter Mountain Quartz Monzonite and overlying basaltic flows.	None	One 5-ft-long chip sample contained no significant mineral values.
7	A Placer No. 1 claim	Gravel bench in canyon bottom. Gravels range from well-sorted, with black sand layers and minor iron-oxide staining, to chaotic unsorted material. The gravel is comprised primarily of quartz monzonite of the Hunter Mountain batholith.	None	Concentrates of two gravel samples yielded no significant mineral values.
8	(Unidentified claim)	A narrow, discontinuous shear zone in quartz monzonite of Hunter Mountain batholith. The shear has a localized occurrence of quartz containing chalcopyrite, malachite, and iron oxides.	One small pit.	A select sample of quartz with chalcopyrite, malachite, and iron oxide from pit dump contained 0.99 percent copper.
9	(Mineralized outcrops)	Samples were taken from a contact zone between basaltic and andesitic volcanic flows that overlie Paleozoic quartzite and argillite. The sedimentary rocks are locally silicified and contain minor amounts of copper carbonate.	None	Seven chip samples were taken. Two contained 0.36 and 0.40 percent copper.
10	(Mineralized outcrops)	Four samples were taken from outcrops of iron-oxide-stained quartz monzonite and tuff. Paleozoic quartzite and argillite crop out locally in the canyon bottoms.	None	Four chip samples were taken. One contained 0.45 oz silver per ton.
11	Cal Trans borrow pit MS 242	Volcanic cinder cone or vent complex with an accumulation of air-fall scoriaceous material. Cinders are of moderately uniform size. The deposit covers approximately 21 acres with an exposed thickness of 20 ft in the pit.	Several bulldozer cuts and a large pit and loading area. Pit size indicates that 3,000 to 4,000 tons of cinders have been mined by the California Department of Transportation (Cal Trans) for use as road material and traction grit.	Inferred cinder reserves are estimated at 900,000 tons. No samples were taken but the size of the cinder deposit and uniformity of particle size are suitable for continued use as road metal and traction grit. The potential for additional resources is high.
12	(Mineralized outcrop)	Locally silicified Paleozoic quartzite and argillite. Bedding strikes N. 80° E., and dips vertically. Beds have been contorted and fractured. Stratabound discrete pods and grains of pyrite and arsenopyrite occur primarily in the quartzite but some sulfide minerals occur in the argillite.	None	Seven chip samples contained no significant mineral values.
13	(Mineralized outcrop)	Quartz monzonite (probably of the Hunter Mountain batholith) overlain by a layer of friable sandstone is capped by a thick sequence of basaltic and rhyolitic flows. A radioactive anomaly in the quartz monzonite was indicated by a scintillometer. However, the anomalous area was only about 15 ft long and 5 ft wide.	None	One chip sample across the quartz monzonite outcrop, where the scintillometer indicated a radiation count two times background, yielded no significant mineral values.
14	(Exploratory drill hole)	Alluvial fill in northern Panamint Valley is generaly less than 500 ft thick. At the drill site, the sedimenta are predominantly interbedded sand and silt to a depth of 80 ft, and below that, by interbedded clay, gravel, marl, sand and silt to a depth of 365 ft.	A 375-ft core hole drilled for the U.S. Geological Survey in 1953 (see log in Smith and Pratt, 1957, p. 54-57).	No alkaline lacuatrine deposits were discoverd.