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BOOTSTRAP WINDOW, ELKO AND EUREKA COUNTIES, NEVADA

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Abstract.—The Bootstrap window in the Roberts Mountains thrust of north-central Nevada contains a 1,500-ft (460-m)-thick autochthonous section of carbonate assemblage rocks. These carbonate rocks include the upper part of the Roberts Mountains Formation and an unnamed limestone of Devonian age. They contain abundant material that must have been deposited in or near a reef. Allochthonous chert and shale of the siliceous assemblage, presumably Ordovician and Silurian in age, are present around the window and in a north-trending graben within the window.

The Paleozoic rocks contain altered dikes, most of which may originally have been granodioritic. The localized recrystallization in the Paleozoic rocks probably occurred during dike emplacement. Sometime after the intrusion, both the dikes and their host rocks were epithermally altered. Some gold has been mined, and relatively high gold values (≧1 ppm) occur in rocks of the siliceous assemblage in and near the northern part of the steep north-trending fault zone on the west side of the graben. Areas of secondary alteration and of high values of silver and mercury are more widespread than the area of high gold values. The highest concentrations of silver and mercury, however, are also found near the same gold-bearing fault zone.

A major geologic structure in north-central Nevada, the Roberts Mountain thrust, separates autochthonous carbonate rocks of the lower plate, generally called the eastern assemblage, and allochthonous siliceous rocks of the upper plate, generally called the western assemblage. The upper plate was emplaced during the Late Devonian and Early Mississippian Antler orogeny. Since that time, localized doming and upfaulting of the early and middle Paleozoic sedimentary rocks involved in the thrusting, accompanied by erosion, have formed windows in the Roberts Mountains thrust. In the southern Tuscarora Range three such windows, the Carlin, Lynn, and Bootstrap, are alined northwest-southeast (fig. 1).

The Bootstrap window, the northwesternmost window, covers about 1 mi² (2.6 km²) and lies astride the Elko-Eureka County line. A well-graded dirt road between Interstate 80 near Dunphy Ranch and the Rossi mine, 3 mi (4.8 km) north of the Bootstrap window, passes along the west side of the window.

The Bootstrap window (fig. 2) is surrounded on three sides by chert and shale of the siliceous assemblage and lies on the east edge of the late Miocene and early Pliocene volcanic flows of the Sheep Creek Range (see Roberts and others, 1967; McKee and Silberman, 1970). Although the Bootstrap window is the northwesternmost window known, the autochthonous carbonate assemblage shows no signs of grading into the allochthonous siliceous assemblage. In fact, the carbonate rocks are mainly reeflike limestone and do not fit the commonly accepted (Roberts and others, 1967; Stewart and Poole, 1974) concept of westward gradation to rocks deposited in deeper water.

DESCRIPTIONS OF THE ROCK UNITS

Carbonate Assemblage

General features

About 1,500 ft (460 m) of carbonate rock exposed on the west side of Round Mountain (fig. 2) includes the upper 590 ft (180 m) of the Roberts Mountains Formation and about 900 ft (275 m) of unnamed Devonian limestone. The contact between the two rock units was not drawn on the geologic map because it cannot be readily traced south and north of the well-exposed section. On the west side of Round Mountain the contact is at the 5,500-ft contour and trends north-south for about 2,000 ft (610 m).

Roberts Mountains Formation

The lowermost 590 ft (180 m) of the section on the west side of Round Mountain is mixed silty dolomitic laminated limestone and coarse-grained limestone in the ratio 4:1. Beds of black chert 1–2 in. (2.5–5 cm) thick occur within the laminated limestone. The beds of laminated and thick-bedded coarse-grained limestone range in thickness from a few inches (several centimetres) to 60 ft (18.3 m). The thickest zones of coarse-grained limestone are about 30 ft (9 m) thick.

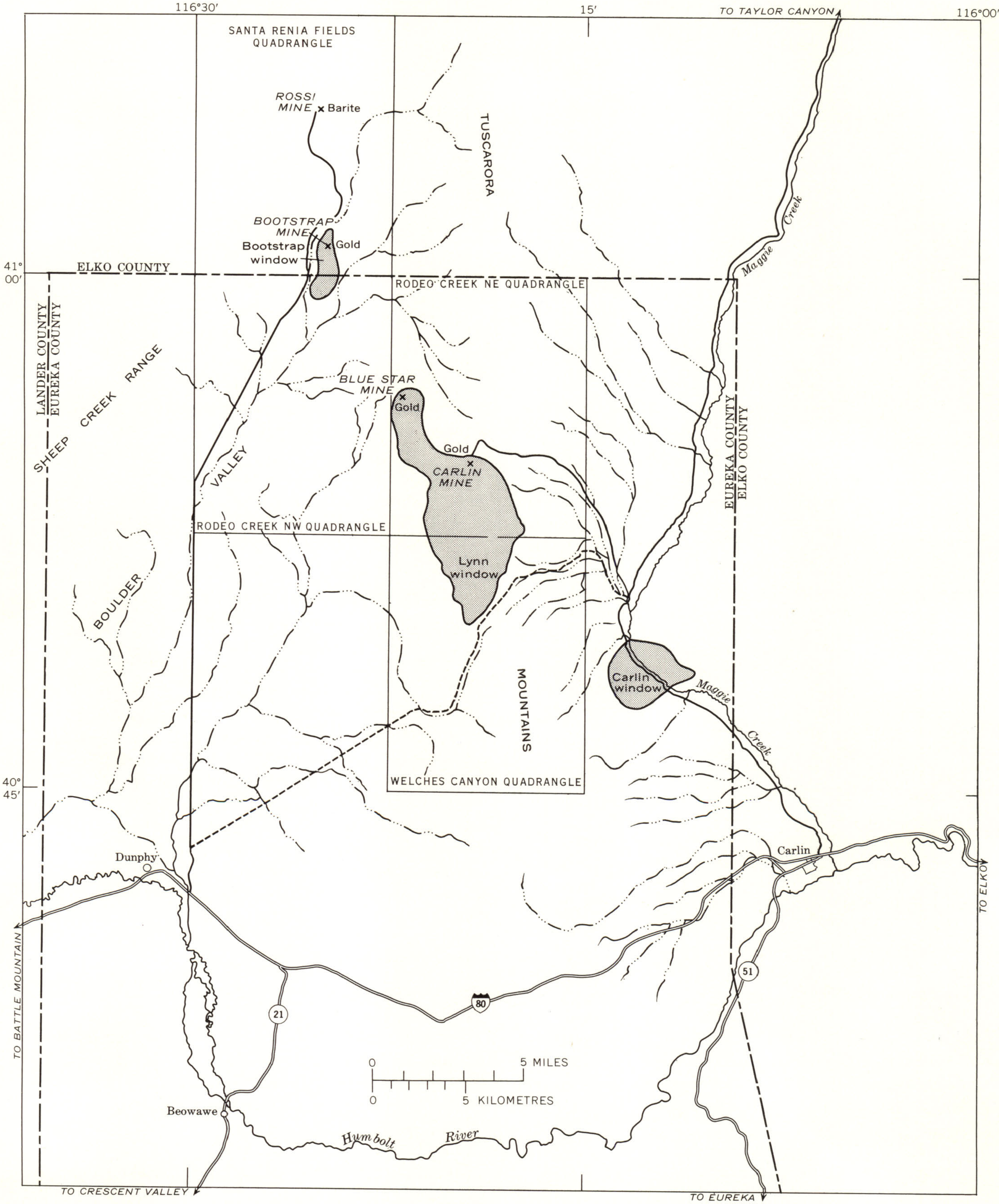

FIGURE 1.—Index map showing location of the Bootstrap window in north-central Nevada.

cite 10–60 percent; dolomite 20–50 percent; quartz (largely detrital) 15–35 percent; and clay (chiefly illite with minor kaolinite) 5–15 percent. Potash feldspar (1–8 percent) is a minor constituent. Plagioclase, iron oxide, collophane, zircon, tourmaline, and chlorite occur in trace amounts.

Brachiopod collections, probably from the lower part of the limestone section, were identified by Boucot and Johnson as closely resembling collections within the Roberts Mountains Formation in the Roberts Mountains (Roberts and others, 1967, p. 119–120). Collections of graptolites and conodonts from the lower 600 ft (184 m) of the section range in age from Middle Silurian to Early Devonian (T. E. Mullens, unpub. data.). *Monograptus uniformis* Pribyl, which defines the lowest graptolite zone within the Devonian System, occurs 570 ft (174 m) above the base of the carbonate section. The contact of the Roberts Mountains Formation and the unnamed Devonian limestone is 20 ft (6.1 m) higher than this graptolite locality and at the base of the predominantly coarse-grained limestone part of the section.

Unnamed Devonian limestone

The upper 900 ft (275 m) of the carbonate section is mainly coarse-grained limestone; it includes less than 5 percent laminated limestone identical to the characteristic lithology of the underlying Roberts Mountains Formation. The thickest zone of the laminated limestone occurs in the lowermost 100 ft (30.5 m) of the Devonian limestone and is 10 ft (3 m) thick. The thick-bedded coarse-grained limestone is as much as 40 ft (12.2 m) thick between thin (<1 ft, or 0.3 m) zones of laminated limestone. Some of the coarse-grained limestone contains pelmatozoan stems and fragments of algae, bryozoa, and corals.

Most of the coarse-grained limestone is pelletal to oolitic. Pellets of very fine grained dirty calcite, ranging in diameter from 0.1 to 1.5 mm (average 0.3 mm), form more than 50 percent of the limestone and are locally deformed into irregular shapes by compaction.

The coarse-grained limestone is predominantly calcite, 60–90 percent, and also contains quartz, 10–35 percent. Most of the quartz is authigenic and replaces calcite in pellets, occurs in fractures in clear calcite grains and in the pellets, and forms euhedral grains up to 0.1 mm across. A little of the quartz is angular to rounded detrital grains that locally are partly replaced by calcite. Dolomite and clay, chiefly illite, are minor constituents. Accessory minerals in some samples include potassium feldspar, iron oxides, collophane, zircon, and tourmaline.

The collection of conodonts from the highest beds in the section, on the east side of Round Mountain near the crest, contained *Spathognathodus remscheidensis* Ziegler, whose presence indicates an Early Devonian age (J. W. Huddle, written commun., 1971).

Alteration and recrystallization

The silty laminated limestone is locally considerably altered by hydrothermal action. The alteration includes leaching of carbonate, hematitic and argillic alteration, quartz veining, and silicification (fig. 3). The end product of altering the laminated limestone is a partly silicified, light-brown, yellow, and red siltstone that locally contains conspicuous zones of jasperoid and jasperoid breccia. The coarse-grained limestone was not altered as much as the silty laminated limestone. Recrystallized limestone occurs on the north end of the Bootstrap window. There the limestone, which is probably part of the unnamed Devonian limestone, was changed into an interlocking mosaic of very coarse calcite grains locally more than 0.4 in. (1 cm) long.

Siliceous Assemblage

The siliceous assemblage includes laminated to thin-bedded generally black chert and shale and gray and white mottled quartzite. The shale, especially below the thrust at the north end of the window, has been altered to a multicolored unconsolidated gouge and breccia. The chert at the north end of the window is partly recrystallized to a black, gray, white, and light-brown fine- to medium-grained quartzite with numerous white quartz veins. Generally, the quartz in the veins is very fine grained although in some of these veins the grains of quartz are as much as 1 cm long. Cavities as much as 5 cm across occur between quartz veins.

The chert and shale around the window are continuous with early and middle Paleozoic rocks of the siliceous assemblage in the northern Rodeo Creek NE quadrangle (Evans, 1974a). No fossils were found in the siliceous assemblage in the Bootstrap area, but Ordovician and Silurian graptolites were found in the shale in the Rodeo Creek NE quadrangle. The siliceous rocks around the Bootstrap window, therefore, are probably early and middle Paleozoic in age and may be partly correlative with the Vinini Formation.

Overlap Assemblage

Although rocks of the overlap assemblage (post-Antler Paleozoic sedimentary rocks) are not exposed in the Bootstrap window, these rocks probably once

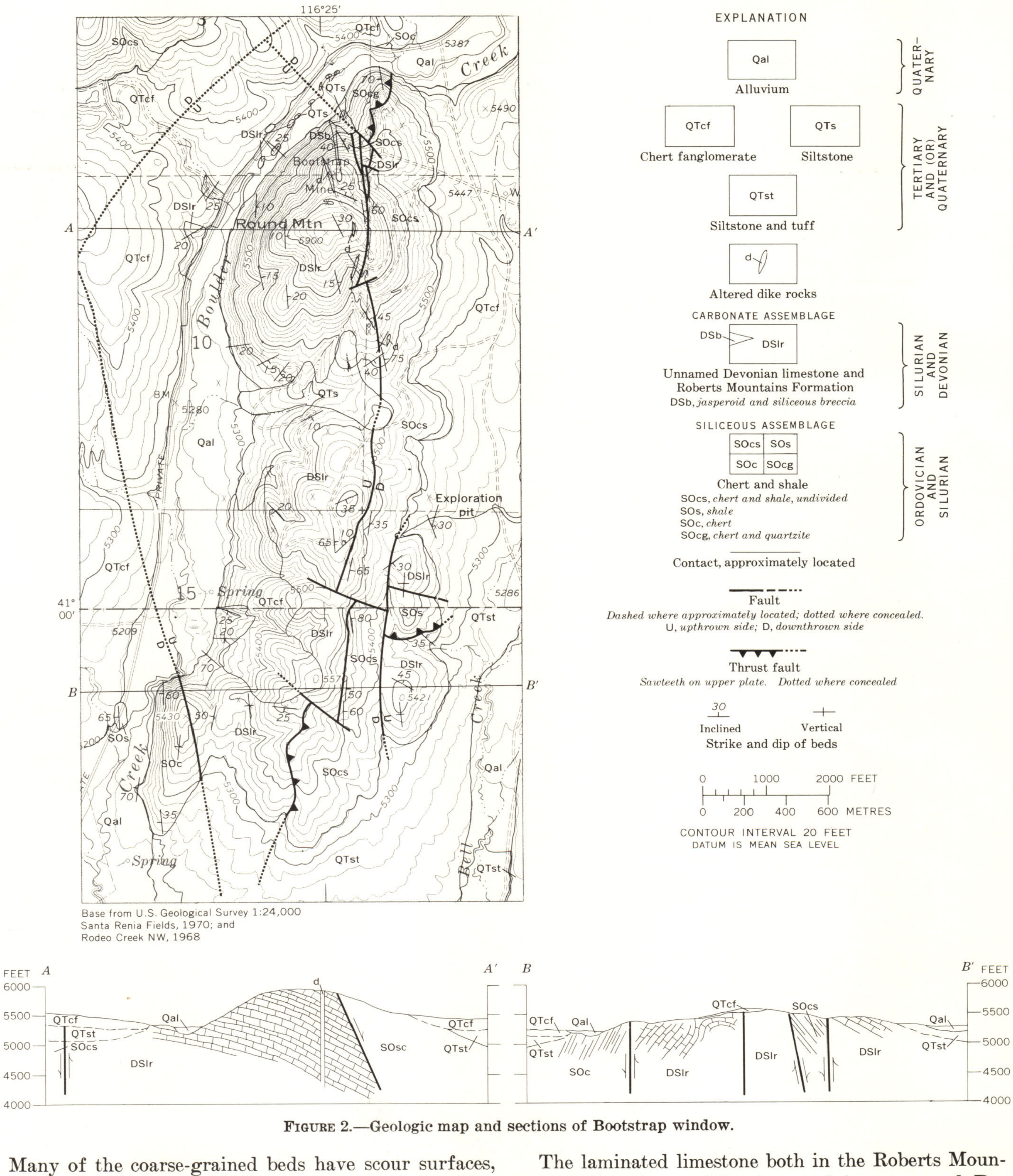

Figure 2.—Geologic map and sections of Bootstrap window.

Many of the coarse-grained beds have scour surfaces, bioclastic debris (corals, stromatoporoids, brachiopods, and algae), angular fragments of coarse-grained pelletal limestone, and graded bedding. Such beds were probably deposited as debris flows from a reef.

The laminated limestone both in the Roberts Mountains Formation and in the overlying unnamed Devonian limestone has similar compositions. The laminated limestone samples studied show a wide variation in the proportions of major mineral constituents: calwith the dissected valley fill in Little Boulder Basin. These rocks form few outcrops and weather to a buff clay and silty soil. The only outcrop near the Bootstrap window is in an exploration pit on the east side of the window and is shown by an attitude on the map (fig. 2). The rocks there are thin- to thick-bedded white and buff siltstone, friable tuffaceous siltstone, light-gray tuff, and thin pale-yellow beds of silica-cemented siltstone.

Chert fanglomerate

Unconsolidated chert fanglomerate, possibly a few tens of metres in maximum thickness, underlies the hills to the west of Boulder Creek, the headwaters of Bell Creek, and covers part of the carbonate assemblage in the Bootstrap window. The chert fragments are angular, as much as several centimetres long, and are in a light-brown-gray matrix of silt and fine sand. Locally, boulders as much as 8 ft (2.6 m) long occur in the fanglomerate. The pervasive occurrence of chert clasts over much of the carbonate rocks suggests that at least the southern and lower part of the window was originally covered by the fanglomerate. The relation between the fanglomerate and the siltstone and tuff described above is not clear. Possibly the fanglomerate overlies the siltstone and tuff as well as the Paleozoic rocks and is the younger deposit.

Siltstone

Variegated siltstone containing minor beds of conglomerate is exposed in three localities.

In a gulley at the north end of the window, poorly lithified, light-brown, creamy-white, violet, and pink siltstone, containing sand-sized fragments of siltstone, is overlain by unconsolidated conglomerate composed of angular fragments of silty laminated limestone and chert. The conglomerate grades upwards into brown soil with angular chert and quartzite boulders as much as 2 ft (0.65 m) across.

Thin-bedded to laminated, poorly lithified to well-cemented, white, pink, green, intensely fractured siliceous siltstone forms small outcrops in the bed of Boulder Creek, below the stream gravels, near the north end of the window.

The largest deposit is on the west side of the window about 3,000 ft (980 m) south of the Bootstrap mine. This deposit contains three principal rock types: (1) angular chert pebble and cobble conglomerate having a red silt and clay matrix; (2) white and pink siltstone having sand-sized particles of altered Paleozoic siltstone and a few chert pebbles 1 in. (2.5 cm) long; and (3) an uppermost fanglomerate 2–3 ft (0.65–1 m) thick, consisting of angular cobbles of limestone, chert, quartzite, and siltstone (Paleozoic lithologies) as much as 1 in. (2.5 cm) across in a brown silt and clay matrix.

The age relations of the siltstone, although clearly post-Paleozoic and older than the Quaternary alluvium and possibly the chert fanglomerate, are not clear.

Quaternary Alluvium

Alluvium of Quaternary age in the area consists of the terrace deposits along Boulder and Bell Creeks and the stream gravels within the channels. The terraces are composed of subrounded and rounded unconsolidated boulder and cobble conglomerate composed of chert, quartzite, and chert breccia clasts in a brown sandy and silty matrix. The clasts range in size from 1 in. (2.5 cm) to 2 ft (0.65 m) across but are generally less than 6 in. (15 cm) long. In places along the top of the conglomerate, fine soil has accumulated in marshy depressions in the flood plain of Boulder Creek. The stream gravels are virtually the same composition as the terrace deposits but have a coarser grained matrix.

STRUCTURAL GEOLOGY

Most of the southern part of Bootstrap window consists of a north-trending graben of siliceous assemblage rocks lying between blocks of carbonate rocks (fig. 2, *B–B′*). Probably the graben continues northward beneath Tertiary and Quaternary rocks, but only the west side of the graben is exposed. The main faults bounding the graben trend north and are generally steep. These faults are offset by minor steep faults trending principally west-northwest. Segments of thrust faults are present at the north and south ends of the window. The two southern ones are contacts between the siliceous and carbonate assemblage. One of them appears to be the southern extension of the steep fault on the west side of the graben. The thrust fault at the northern end is within rocks of the siliceous assemblage and places chert and quartzite on chert. Whether any of these thrust faults are segments of a larger regional thrust, like the Roberts Mountains thrust, is not known.

ECONOMIC GEOLOGY

Development at the Bootstrap mine area in this century was along a complex 600-ft (184-m)-wide steeply dipping fault zone at the north end of the window (fig. 3). The gold ore came principally from an altered porphyry dike. Total production of gold through November 1959 was $330,532. Antimony ore was also

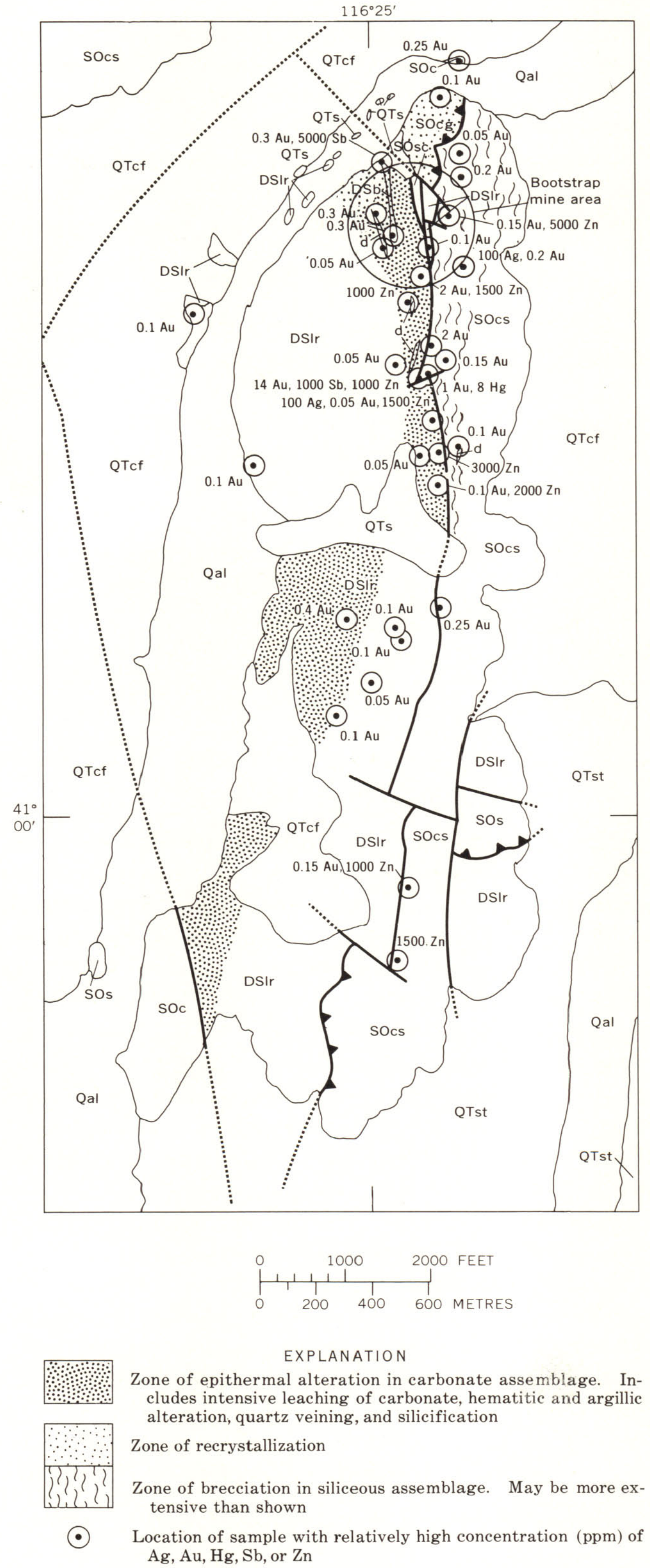

FIGURE 3.—Map showing zones of epithermal alteration, recrystallization, and brecciation, and distribution of elements in Bootstrap window. Large circle, Bootstrap mine area. See figure 2 for explanation of geology.

occurred nearby. At the northern end of the window, an isolated rounded boulder of chert pebble conglomerate about 6 ft (1.8 m) in diameter occurs in a creek bed. The chert pebble conglomerate is similar to the post-Antler conglomerates in Elko County (R. R. Coats, written commun., 1974). The chert pebbles are white and gray and subrounded to well rounded and range in diameter from one-fourth inch (6.2 mm) to 6 in. (15 cm) with the smaller sizes predominating. The pebbles are in a matrix of coarse sand that is also composed of chert fragments and is cemented by chert.

Altered Dikes

Steeply dipping dikes that trend generally north-south and range from 1 ft (30 cm) to 80 ft (24.4 m) wide (widest dike exposed only in a trench) intrude the Paleozoic rocks. These dikes may represent more than one compositional type, and they have undergone different kinds and degrees of alteration.

The most common dikes consist of brown, light-gray, and black rocks that contain euhedral phenocrysts that form as much as half of the rock and are as much as 3 mm long. These phenocrysts are intensely sericitized and, locally, saussuritized. The groundmass consists largely of anhedral plagioclase grains 0.1–0.3 mm in diameter. Quartz is present in amounts less than 10 percent. Mafic silicate minerals are not commonly preserved, although scattered biotite and sphene can be identified in a few of the dikes. These dikes contain abundant dark-brown and black spots that are aggregates of jarosite and hematite.

These dikes resemble granodiorite dikes in the northern part of the Lynn window, not far from the Gold Strike plug, 4 mi (6.4 km) southeast of the Bootstrap window (fig. 11). The dikes near the plug are similar in composition to the plug and were correlated with it (Evans, 1974a). The Gold Strike plug is of Early Cretaceous age (Hausen and Kerr, 1968), and the dikes in the Bootstrap area may be the same age.

Less common dikes are mottled creamy white to light-gray and as much as 3 ft (1 m) wide. These dikes are soft and generally exposed only in the exploration pits and roadcuts. The dikes contain black-, brown-, yellow-, and red-stained altered zones. The freshest samples have white feldspar phenocrysts as much as 2 mm long set in a light-gray extremely fine grained to aphanitic groundmass.

Tertiary and (or) Quaternary Rocks

Siltstone and tuff

A siltstone and tuff unit lies on the Paleozoic rocks south and southeast of the window and is continuous mined and hauled to Dunphy in 1914 but was not shipped (Lawrence, 1963, p. 58).

Recent interest in the Bootstrap mine area arose from the similarities between the altered and mineralized limestone there and the limestone at the Carlin gold mine. The Carlin Gold Mine Co. controls the mining claims in the Bootstrap window and has investigated the gold potential of the area; the conclusion of these studies has not been released. However, a low-grade gold ore body is being mined by open pit methods at the north end of the window. The ore body at the Bootstrap mine and at the Blue Star mine, 8 mi (13 km) southeast of the Bootstrap window, together are estimated at 1.1 million tons averaging less than 0.297 ounces of gold per ton (West, 1974, p. 572).

A summary of the major findings based on the results of spectrographic and atomic absorption (Au, Hg) analyses for surface rock samples collected from the Bootstrap window (Evans, 1974b) is given below and shown in figure 3.

Samples of rock with at least 1 ppm gold (max 14 ppm) were collected from the siliceous assemblage south of the old mine workings along the steep north-trending fault zone on the west side of the graben. Samples with gold values $\geqq$0.05 ppm (maximum 0.4 ppm) were taken from several localities in the limestone. Concentrations of silver and mercury >0.5 ppm are common and widespread in the Bootstrap area, although the greatest values of these two elements (Ag maximum 100 ppm; Hg maximum 8 ppm) were in samples from near the north-south fault on the west side of the graben. Concentrations of antimony and zinc $\geqq$1,000 ppm (Sb maximum 5,000 ppm; Zn maximum 5,000 ppm) occur in samples in the vicinity of the same fault. Most of the high values of zinc are in samples from the siliceous assemblage.

REFERENCES CITED

Evans, J. G., 1974a, Geologic map of the Rodeo Creek NE quadrangle, Eureka County, Nevada: U.S. Geol. Survey Geol. Quad. Map GQ-1116.

——— 1974b, Bootstrap Window, Elko and Eureka Counties, Nevada—Geological summary and analyses of rock samples: U.S. Geol. Survey open-file rept. (74-369).

Hausen, D. M., and Kerr, P. F., 1968, Fine gold occurrence at Carlin, Nevada, *in* Ridge, J. D., ed., Ore deposits of the United States, 1933-1967, (Graton-Sales, v. 1): New York, Am. Inst. Mining Metall. and Petroleum Engineers, Inc., p. 908-940.

Lawrence, E. F., 1963, Antimony deposits of Nevada: Nevada Bur. Mines Bull. 61, 248 p.

McKee, E. H., and Silberman, M. L., 1970, Geochronology of Teritary igneous rocks in central Nevada: Geol. Soc. America Bull., v. 81, p. 2317-2328.

Roberts, R. J., Montgomery, K. M., and Lehner, R. E., 1967, Geology and mineral resources of Eureka County, Nevada: Nevada Bur. Mines Bull. 64, 152 p.

Stewart, J. H., and Poole, F. G., 1974, Lower Paleozoic and uppermost pre-Cambrian Cordilleran miogeocline, Great Basin, Western United States, *in* Dickinson, W. R., ed., Tectonics and sedimentation, a symposium: Soc. Econ. Paleontologist and Mineralogists Spec. Pub. 22. (In press.)

West, J. M., 1974, Gold: U.S. Bur. Mines Minerals Yearbook 1972, v. 1, p. 567-588.

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