URANIUM IN CLASTIC ROCKS OF THE BASIN AND RANGE PROVINCE

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ABSTRACT

Uranium occurs in Tertiary lake sediments and water-laid tuffs at widely separated areas in the Basin and Range province of Nevada and California.

Miocene lake sediments near Tonopah, Nev., are composed chiefly of uniform finely stratified pyroclastic rocks and diatomaceous earth interbedded with discontinuous lenses of collophanite and uraniferous opal. Uranium minerals have not been identified, but anomalous radioactivity can be detected over an area about 1 mile wide and 8 miles long. Trenching and drilling have exposed marginal-grade material to a depth of 40 feet in 1 locality.

Near Olancha, Calif., gently dipping lakebeds of the Coso formation of Schultz (1937) of Pliocene age contain autunite on fracture surfaces in iron-stained zones. The locality is characterized by extensive faulting and volcanism. Only select samples from this area contained ore-grade material.

Stratified rocks in the Virgin Valley of northwestern Nevada consist of early Pliocene water-laid vitreous tuff and diatomaceous earth which contain discontinuous layers of opal. Small amounts of carnotite occur as fracture coatings or fine layers in the opal lenses, and a yellow fluorescent mineral, possibly schroeckingerite, is disseminated in the volcanic tuff.

A uraniferous deposit in water-laid tuff in Lander County, Nev., occurs in a topographic basin near the head of Dacie Creek that is surrounded by hills of rhyolite, andesite, and basalt. Appreciable radioactivity appears to be confined to minor fractures in the tuffs, although no uranium minerals have been observed.

Near Hawthorne, Nev., carnotite occupies a series of closely spaced vertical fractures in tuffaceous sandstone of the Esmeralda formation. The area is capped by basaltic flows, and a small rhyolite plug is in fault contact with the uranium-bearing sandstone.

Carnotite-type minerals have been found in a thin bed of soft water-laid tuff in the Panaca formation of Pliocene(?) age in Lincoln County, Nev. Minor amounts of carbonaceous material are present, and there is no apparent alteration or silicification of the mineralized stratum.

The uranium minerals in all the deposits generally are not in radioactive equilibrium, and the uranium content as determined by radiometric analyses is usually lower than by chemical analyses. This would suggest recent formation of the uranium minerals. Structural control is not readily apparent in any of the deposits, but small fractures and faults may have localized mineral concentrations.

INTRODUCTION

The Basin and Range physiographic province of the United States includes Nevada and parts of Arizona, Utah, and California. It consists of rugged, nearly parallel, northward-trending mountain ranges and broad arid troughs with interior drainage. Elevations range from 4,000 to 14,000 feet above sea level. The valleys are filled with thick accumulations of water-laid pyroclastic rocks, silts, fanglomerates, and evaporites. Ephemeral saline lakes and playas are found in many of the valleys as a result of interior drainage and arid climate. Gently sloping alluvial fans extend from the mouths of canyons toward the low central portions of most of the valleys.

Evidence of alpine glaciation is apparent in the higher mountains, and shorelines of Pleistocene lakes can be observed locally along the foothills. The highly alkaline soil of many of the valleys supports little vegetation other than salt grass and sage, but several types of conifers abound in the mountainous areas. The climate is semiarid to arid; therefore the region is sparsely settled because habitable areas are dependent upon surface-water supplies.

The region was a geosyncline during much of the Paleozoic and Mesozoic eras and great thicknesses of sedimentary rocks accumulated. In Late Jurassic time, the Nevadan orogeny accompanied the uplift of the Sierra Nevada Mountains, which bounds the province on the west. Erosion has exposed the granitic core of this range. During Late Cretaceous and early Tertiary, folding and thrusting of the Laramide orogeny deformed the sediments in a southward-trending zone that extends from Canada to Mexico.

The principal intrusive rocks range from Jurassic(?) to Miocene(?) in age. Younger plutonic rocks are found in the eastern part of the province, whereas those in the west appear to be related to the Sierra Nevada batholith. Extrusive volcanic rocks, varying in composition from rhyolite to basalt, are Tertiary to Recent in age.

High-angle faulting subsequent to the Laramide orogeny determined the present topography of long graben valleys partially filled with alluvial debris from the intervening mountains. Some of the faults are still active, as evidenced by local displacement of alluvial fans along the flanks of some mountain ranges.

Miocene and Pliocene lakebeds and water-laid tuffs containing low-grade uraniferous zones with local concentrations are large areas worthy of investigation which were not previously recognized as potential sources of uranium. The location of several such deposits is shown on figure 113. Figure 114 shows a typical example of the geologic environment for the uranium deposits described.

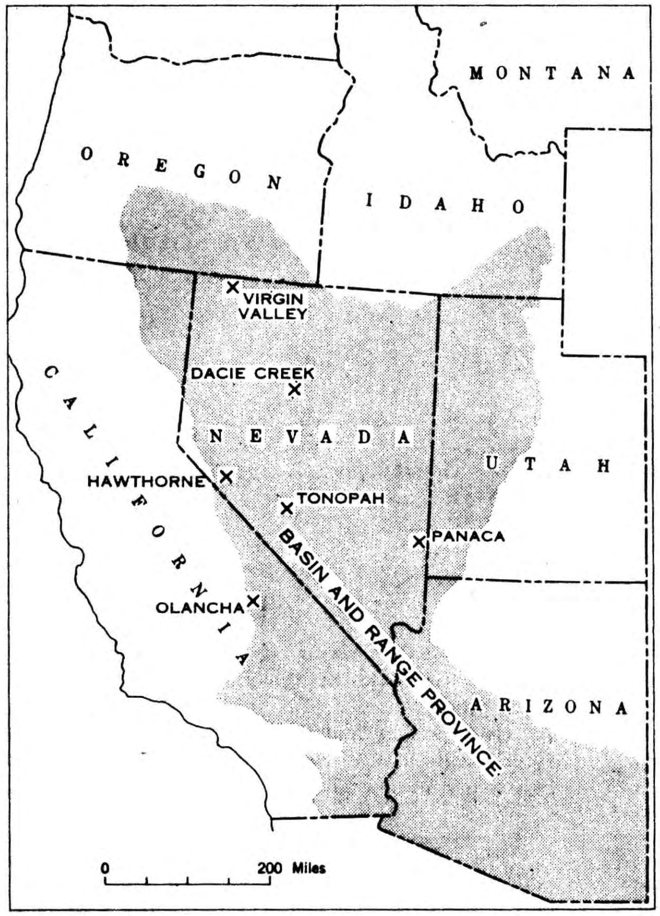

FIGURE 113.—Index map showing uranium deposits in clastic rocks of the Basin and Range area.

DESCRIPTION OF INDIVIDUAL DEPOSITS

TONOPAH, NEV.

Geography.—Tonopah, in the southwestern part of the State, is in a region of typically arid desert climate and physiography. Vegetation consists of sparse sage and greasewood, and mean annual precipitation is less than 10 inches. Relief is moderate, with elevations ranging from 5,600 feet in the intermontane valleys to 7,160 feet at the crest of Butler Mountain.

Geology.—The geology of the Tonopah area has been described by Spurr (1905) and Ferguson and Muller (1949). Recently discovered uranium occurrences lie about 3 miles west of the central part of the Tonopah district in the lacustrine Siebert tuff (Miocene) of Spurr (1905). Weak shearing associated with this better uranium area may be the surface expression of northward-trending normal faulting which largely preceded deposition of the Siebert of Spurr (1905). The lacustrine tuffaceous beds, host rock of the uranium, are flat lying and are covered in part by a thin mantle of soil and Recent alluvium. (See fig. 115.)

The Siebert tuff of Spurr (1905) consists of more than 600 feet of uniform finely stratified rhyolitic pyroclastic rocks and diatomaceous-earth lakebeds and are late Miocene in age. They rest unconformably upon older Tertiary lavas and are conformably overlain by andesitic and rhyolitic flows and welded tuffs. To the northwest, Pleistocene basaltic flows overlie these rocks with angular unconformity. The water-laid tuffaceous host rock for the uranium deposit is interbedded with discontinuous lenses of uraniferous opal and collophanite which are usually less than 1 foot thick. Ferruginous sandstone is exposed near the north end of the radioactive area. The relation

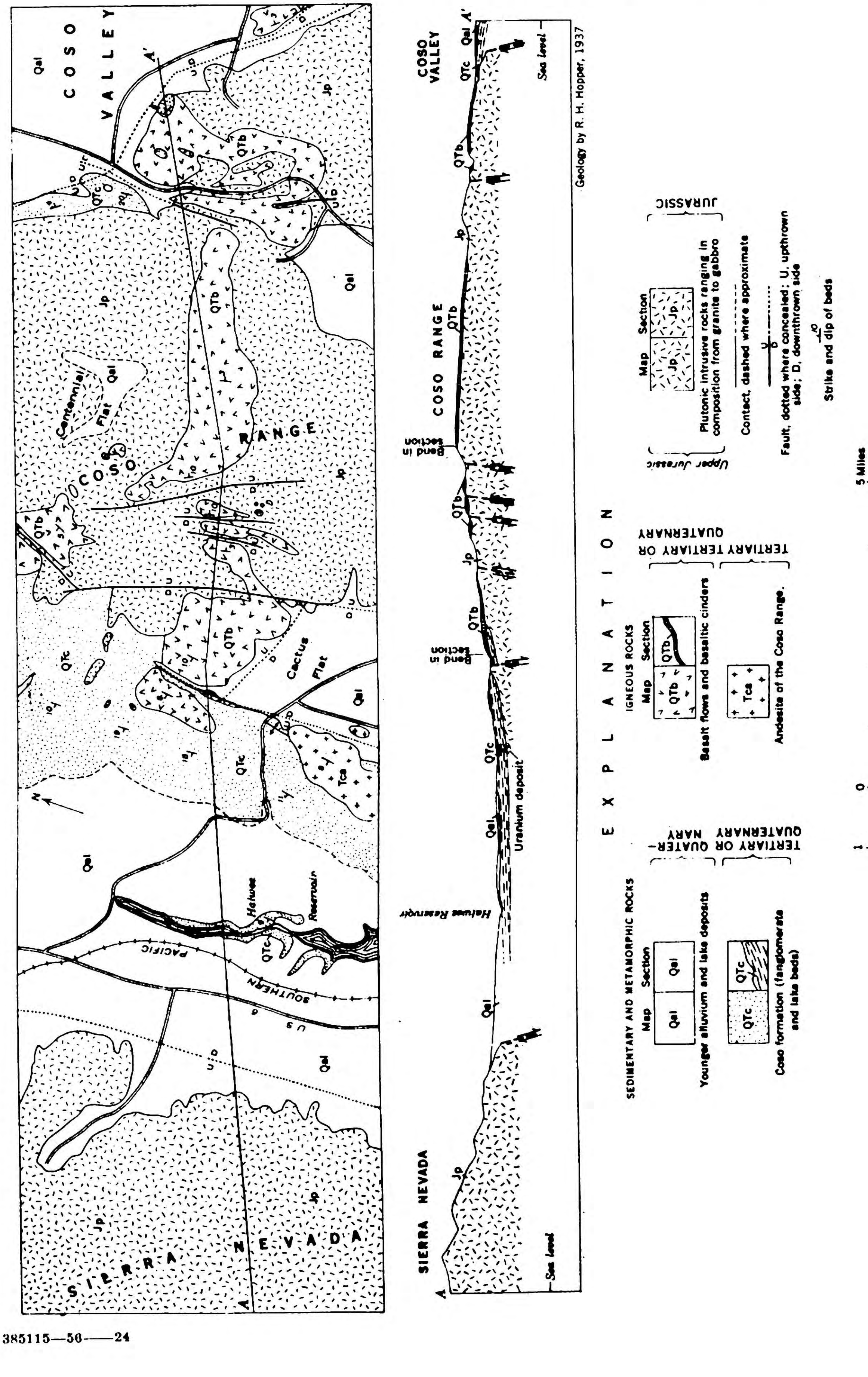

FIGURE 114.—Geologic map and section of Olancha area, California. (Geology by R. H. Hopper 1937.)

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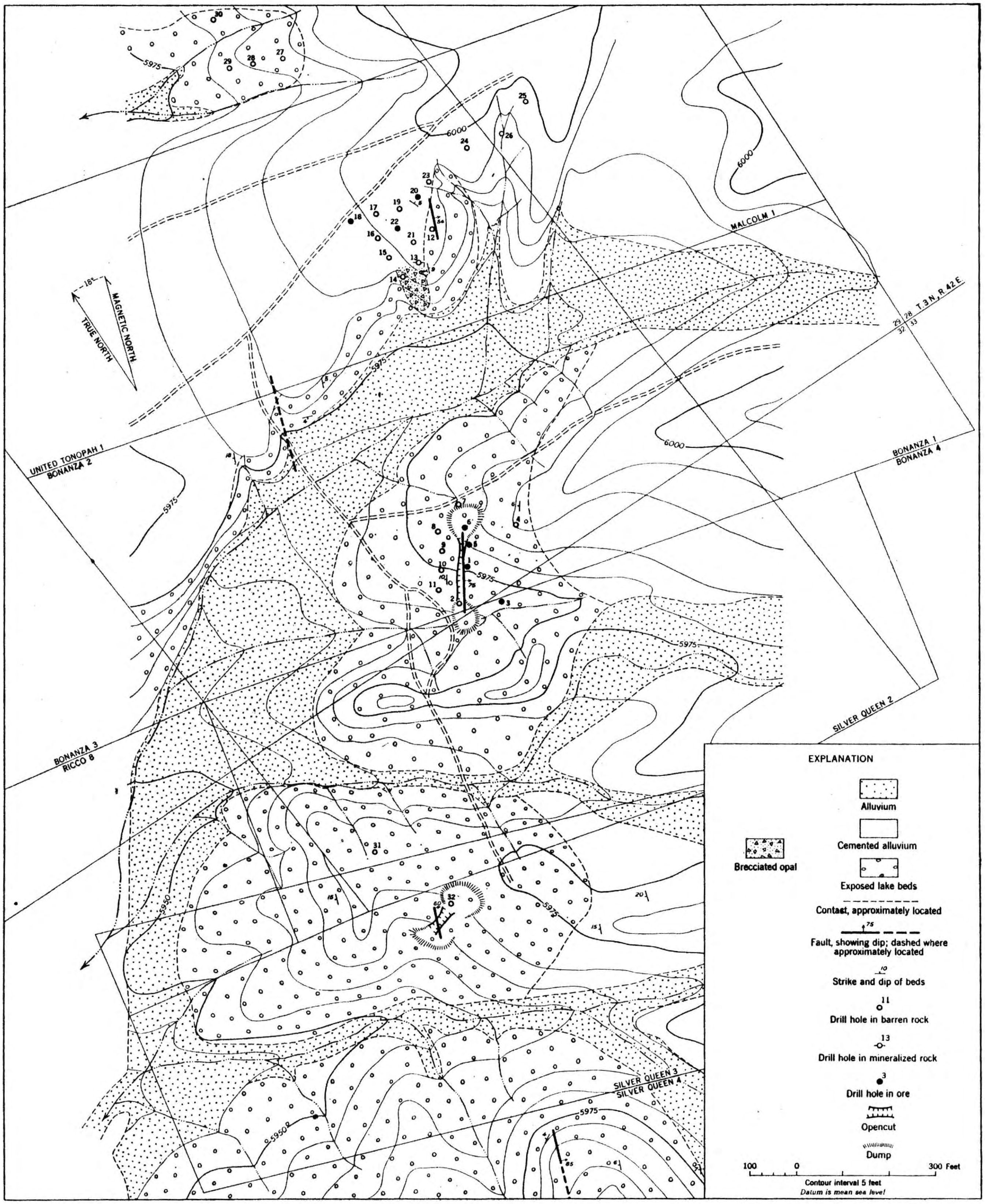

FIGURE 115.—Geologic map of Silver Queen group, Tonopah mining district, Nevada.

between this rock and the tuff is unknown, but the sandstone may represent shore or delta deposition.

Ore deposit.—Anomalous radioactivity extends over an area about 1 mile wide and 8 miles long and within this area are local concentrations of higher radioactivity. Gamma-ray logging of a few boreholes indicates radioactivity to a depth of 40 feet along northward-trending weak vertical shearing and iron staining. No distinctive uranium minerals have been identified at this locality, although yellow radioactive coatings are found on collophanite and opal. Samples contain as much as 50 percent collophanite intimately mixed with bentonitic clay, and preliminary tests indicate that most of the uranium is contained in the collophanite. No vanadium has been reported.

Evidence exists that the uranium is of hydrothermal origin. It may have been concentrated along the northward-trending shear zone, which shows conspicuous iron staining in contrast to the normally white beds. The geologic map of the Tonopah quadrangle shows that a strong northward-trending fault typical of the Basin and Range province disappears under the Siebert tuff of Spurr (1905) near the north end of the anomalous area (Ferguson and Muller, 1949). Weak northward-trending shearing present in areas of better mineralization may be the surface expression of this fault. Recurrent movement along the fault, subsequent to deposition of the Siebert of Spurr (1905), may have accompanied late Pliocene (or younger) volcanism, and the uranium minerals may have been introduced along the fault zone at that time. If the isoradioactivity map (fig. 116) is superimposed upon the geologic map (fig. 115) the relation of radioactivity to structure is readily apparent.

Another suggestion is that the entire tuffaceous horizon contains small amounts of uranium, which has been leached during normal erosion and reconcentrated in the present mineralized beds. This concept is supported by evidence of widespread anomalous radioactivity and by the possibility of base-exchange adsorption of uranium from ground water by naturally activated bentonitic clays. Recent field study and careful sampling indicate that the uranium is probably of hypogene origin (see figs. 115, 116).

OLANCHA, CALIF.

Geography.—Olancha is near the south end of Owens Valley, immediately east of the Sierra Nevada. Owens Lake, now partly filled with a thick accumulation of evaporites, sand, and volcanic debris, occupies the central portion of the valley just north of Olancha.

The region is characterized by extremely rugged topography along the east front of the Sierra Nevada, deep valleys partly filled by alluvial fans and volcanic debris, and deeply dissected sedimentary rocks of Paleozoic age which form the Panamint and Argus Ranges to the east. The climate is as varied as the topography. The high Sierras receive heavy snowfall during winter, but annual precipitation in the Panamint Valley, 50 miles to the east, averages less than 5 inches.

General geology.—The older rocks of the Argus and Panamint Ranges were folded, faulted, and intruded in pre-Tertiary time. In the area mapped (fig. 114), structures of Cenozoic age involve Jurassic (?) and Tertiary (Quaternary?) rocks. Block faulting of relatively recent movement uplifted the Coso Range and depressed Owens Valley. Movement after volcanism has displaced the lava sheets as much as 600 feet along the west flank of the range.

The Coso formation of Schultz (1937) is essentially flat lying; minor variations in dip from 10° to 20° are due to tilting by the relatively recent faults. Movement along some of these faults has continued to the present time.

Lake sediments and tuffs of the Coso formation of Schultz (1937) in which the uranium minerals occur have been described by Knopf and Kirk (1918). The formation is either late Pliocene or early Pleistocene in age and consists of alluvial gravels, fanglomerates, tuffs, pumice, and lacustrine sediments. It has an exposed thickness of approximately 500 feet in the area mapped, where it rests upon an erosion surface cut in the granitic rocks of the Coso Range and is conformably overlain by basaltic lava flows. The basal 300 feet consists of reddish arkose, sandstone, and gravel derived from granite in the Coso Range. Above these, about 200 feet of well-stratified thin-bedded white and light-buff lakebeds are interbedded with white rhyolitic tuff, pumice, and green clay beds. The volcanic material is well sorted and was probably laid down in a lake. Fish bones have been found in the lake sediments.

East of the uranium deposits in beds of the Coso formation of Schultz (1937), basalt flows rest directly upon Late Jurassic(?) granite of the Coso Range. These ore-bearing beds may abut the Quaternary fault zone which bounds the east front of the Sierra Nevada, but Recent alluvium covers this contact.

Ore deposits.—Uranium minerals occur in green bentonitic clay beds in the tuffaceous horizon of the Coso formation of Schultz (1937). Three zones of caliche, separated by a sequence of lake sediments and tuffaceous beds, lie above the ore-bearing beds (fig. 117). These zones range in thickness from 2 to 6 feet and consist of well-indurated coarse angular grains of arkose cemented by caliche. The uranium-bearing strata usually occur 30–40 feet below the lowest caliche zone.

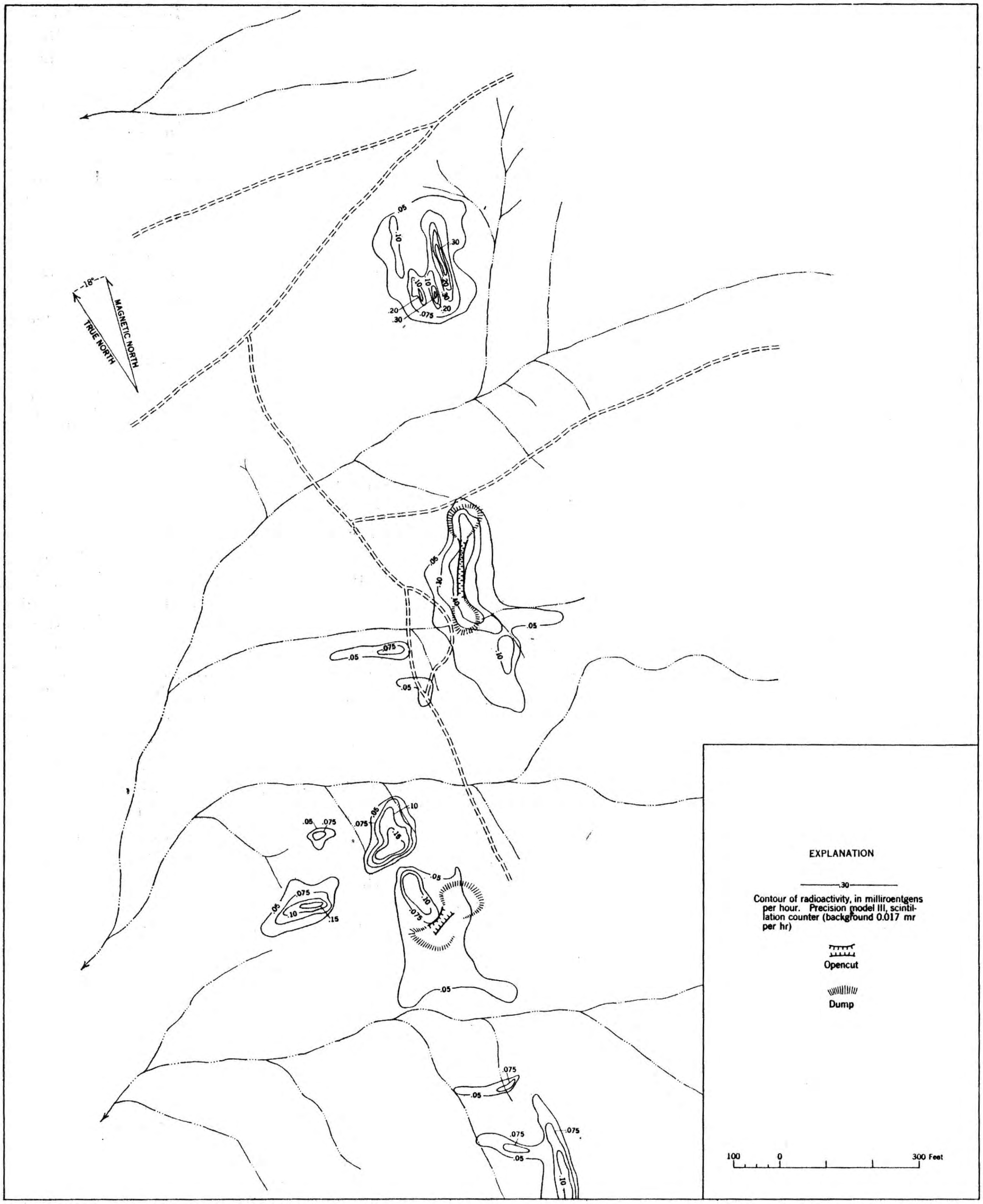

FIGURE 116.—Isoradioactivity lines of Silver Queen group, Tonopah mining district, Nevada.

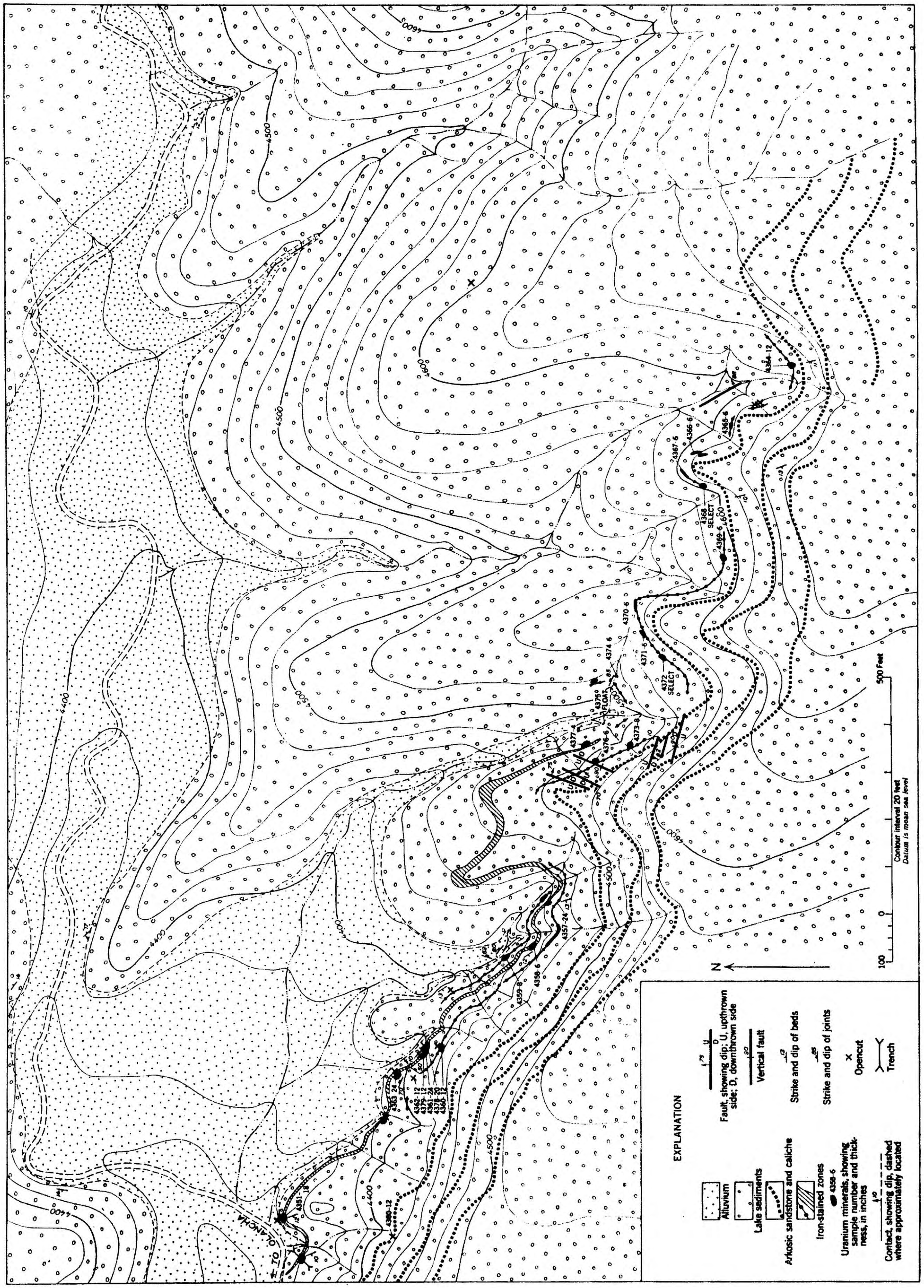

FIGURE 117.—Geologic map of uranium deposits in the Olancha area, Inyo County, Calif.

Three persistent radioactive horizons 8–24 inches thick are found in a 20-foot zone which crops out for 2,000 feet along the south side of an eastward-trending canyon which has been cut in the soft tuffs. All 3 of the radioactive layers are within, or contiguous to, prominent bands of iron oxide staining which range from 1 to 4 feet in width.

Radioactive minerals are autunite and uraniferous opal which fill tiny fracture planes in bentonitic clay beds and fine sandstone. Some layers of strongly radioactive sandstone show no discrete uranium minerals. No channeling or carbonaceous trash was observed. About 1 mile north of the uranium deposit anomalous radioactivity indicates the presence of uranium in the bentonitic beds that have been mined for clay. A pumice deposit about 1 mile south of the uranium locality exhibits weak radioactivity. Jurassic(?) granite which crops out 2½ miles to the east is not abnormally radioactive nor are the basal arkosic sandstones of the Coso formation of Schultz (1937).

The uranium may have been deposited syngenetically with the tuffaceous material and later leached by ground water and reprecipitated in the bentonitic clay beds. Evidence supporting this concept is the lateral extent of the radioactive outcrop and the uniform mineralization of thin clayey beds. The presence of the caliche-cemented arkosic beds above the ore zone, however, would hinder downward migration of vadose water. Absence of carbonaceous plant debris suggests that the bentonite has an adsorptive effect.

It is also possible that the deposit is of hypogene origin. Hydrothermal solutions rising along fault zones exposed east of the deposit may have been trapped by the clayey horizon, with resultant deposition of uranium minerals. Pyrite, presumed to have been deposited with the uranium, may have oxidized to form the iron-stained bands which now accompany the more intense radioactivity. This theory of origin is supported by the recent discovery of uraninite veins cutting granite at a deposit approximately 2 miles south of the area described.

OTHER DEPOSITS

Virgin Valley, Nev.—A uranium occurrence in the Virgin Valley of northwestern Nevada (E. E. Thurlow, written communication) is similar to those discussed above.

Rocks of the area consist of early Pliocene water-laid vitreous tuff and diatomaceous-earth beds, capped locally by basalt flows and lake-terrace gravels. Silicified rhyolite dikes have intruded the tuff series. The tuff and diatomaceous earth beds contain numerous discontinuous lenses of opal.

Uranium minerals are carnotite and a fluorescent yellow mineral believed to be schroeckingerite. Carnotite occurs principally as fracture coatings in the opal, and schroeckingerite(?) is disseminated in the diatomite and tuff.

Dacie Creek, Nev.—The Dacie Creek area is situated in northwestern Lander County, Nev. The deposit occurs in a topographic basin near the source of Dacie Creek which is surrounded by mountains of rhyolite and andesite capped by basalt flows. The host rock is thin-bedded water-laid tuff overlain by rhyolite. Thin lenses of opal conform with the bedding of the tuff.

Uranium minerals have not been identified. Both rhyolite and tuff show anomalous radioactivity, with the highest anomalies confined to minor fractures in the tuffs. The bedding is nearly horizontal with many small fractures throughout, but no major faults have been mapped in the immediate area.

Hawthorne, Nev.—This deposit is in the Garfield Hills about 10 miles southeast of Hawthorne. The host is a medium- to fine-grained tuffaceous sandstone, a member of the Esmeralda formation of Tertiary age. The area is capped by andesite and basaltic flows. What appears to be a small rhyolite plug is in fault contact with the uranium-bearing sandstone northwest of the deposit.

Carnotite is concentrated along closely spaced vertical fractures exposed by a cut approximately 200 feet long. Many pebbles and boulders in Recent alluvium are coated with yellow secondary uranium minerals.

Panaca, Nev.—Carnotite(?) occurs in a thin bed of soft water-laid tuff in the Panaca formation of Pliocene(?) age in Lincoln County, Nev. This formation consists of stratified water-laid tuffs that range in grain size from silt to medium-grained sand. Occasional thin layers of coarser material are found near the contact with underlying sedimentary rocks of Cambrian age or earlier volcanic rocks of Tertiary age. The beds are essentially flat lying, but near the contacts with older rocks they may dip as much as 4° toward the center of the valley. No post-Panaca deformation was observed.

The formation has been assigned to the Pliocene on the basis of mammalian fossils, but it may actually belong in late Pliocene or early Pleistocene, as deposition followed a period of mid-Pliocene orogeny (H. E. Wheeler, oral communication).

The bed in which the uranium occurs is a thinly laminated very fine-grained tuff containing minor amounts of carbonaceous material. The horizon has been exposed for 200 feet and ranges from 6 inches to 2 feet in thickness. Although there is no apparent alteration or silicification of this bed, occasional lenses of opal occur stratigraphically above it.

CONCLUSIONS

Lake sediments and associated water-laid tuffs of Miocene and Pliocene age which contain uranium are large areas worthy of further investigation.

Carnotite, tyuyamunite, and schroeckingerite(?) as well as uraniferous opal and collophanite are locally concentrated in these deposits; in some, no uranium minerals have been identified. The uranium minerals in all the deposits described generally are not in radioactive equilibrium, and the uranium content as determined by radiometric assays is usually lower than by chemical analyses. This would suggest recent formation of the uranium minerals.

Structural control is not readily apparent in any of the deposits, but small fractures and faults may have localized mineral concentrations.

REFERENCES CITED

Ferguson, H. G., and Muller, S. W., 1949, Structural geology of the Hawthorne and Tonopah quadrangles, Nev.: U. S. Geol. Survey Prof. Paper 216, 55 p. [1950].

Hopper, R. H., 1947, Geologic section from the Sierra Nevada to Death Valley, Calif.: Geol. Soc. Amer. Bull. 58, p. 393–432.

Knopf, Adolph, and Kirk, Edwin, 1918, A geologic reconnaissance of the Inyo Range and the eastern slope of the southern Sierra Nevada, Calif.: U. S. Geol. Survey Prof. Paper 110, 130 p.

Schultz, J. R., 1937, A late Cenozoic vertebrate fauna from the Coso Mountains, Inyo Canyon, Calif.: Carnegie Inst. of Wash. Pub. 487, pt. 3, p. 75–109.

Spurr, J. E. 1905, Geology of the Tonopah mining district, Nevada: U. S. Geol. Survey Prof. Paper 42, 295 p.