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GEOLOGY AND URANIUM OCCURRENCES

NEAR LAKEVIEW, OREGON

by

Robert E. Cohenour

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GEOLOGY AND URANIUM OCCURRENCES NEAR LAKEVIEW, OREGON

INTRODUCTION

Purpose and Scope

The geologic investigation near Lakeview, Oregon, was undertaken by the U. S. Atomic Energy Commission to study the unique occurrences of uranium found there and to provide an appraisal of the uranium resources of the area.

Some of the information for this report was gathered by AEC personnel since mid-1956 as a result of routine examinations. An area of about 208 square miles was mapped for the purpose of the resource study (pt. 1).

GeographyLocation and Accessibility

The area studied is in southwestern Lake County, Oregon, approximately 15 miles northwest of Lakeview, the county seat (fig. 1).

A branch line of Southern Pacific Railroad from Alturas, California, terminates in Lakeview, providing daily rail freight service. The community is served by scheduled daily air service from a modern airport located several miles west of town.

The mapped area is reached from Lakeview by traveling west 4 miles on State Highway 66, thence north on a graveled county road for 6 miles to the mouth of Thomas Creek and the junction with the Special Service road maintained by the U. S. Forest Service. Access is generally restricted during winter months.

Physiography

The region of south-central Oregon is the northernmost part of the Basin and Range province. It is a broadly undulating plateau 4,000 to 5,000 feet in elevation and broken by a series of north-trending faults which diminish northward. Unlike the tilted fault block mountains which distinguish the Basin and Range province in Nevada and Utah, the structures here are generally horsts and grabens. Fuller (1931) recognized seven major depressions from Klamath Falls, Oregon, eastward to McDermitt, Nevada. These depressions are typically broad, flat valleys bounded on either side by fault scarps ranging from a few hundred to over 2,000 feet in height.

Figure 1. Index map of the Lakeview, Oregon area showing mines and prospects

The Abert Lake-Chewaucan Marsh-Summer Lake graben is a large triangular-shaped depression, covering some 800 square miles and is bounded on the west by Winter Rim and on the east by Abert Rim. Both of the latter features are spectacular escarpments abruptly rising 2,000 feet above the (graben) valley floor. Southward lies Goose Lake graben--a less spectacular feature bounded by a southern part of the Fremont Mountains on the west and by the Warner Range on the east and is separated from the larger graben to the north by a chain of low mountains. Summer, Abert, and Goose Lakes are remnants of an extensive Pleistocene lake which formerly occupied the graben depression. Wave-cut benches and perched gravel bars several hundred feet above the present valley floors indicate the former level of this ancient lake.

Within the area studied the average elevation of the Southern Fremont Mountains is 6,000 feet above sea level. Cougar, Grizzly, and Gilmore Peaks and Shoestring Butte are the highest topographic features present. The lowest point is on lower Thomas Creek at 4,900 feet and the highest point is Cougar Peak at 7,925 feet giving a maximum relief of 3,025 feet. Colman Rim, a prominent north-south basalt scarp approximately defines the western margin of the area.

Water Resources

Numerous springs maintain perennial flow in several creeks in the area which drain southeasterly into Goose Lake. Most of the courses of the major streams and their tributaries are controlled by a northwest and northeast conjugate fault and fracture system which results in a rectangular drainage pattern. Mountain meadows spaced along the stream courses of less gradient create bogs which hinder logging and mining operations.

Numerous hot springs are present along the base of the Warner Mountains in the vicinity of Lakeview, where they mark the trace of the Goose Lake fault. The waters have temperatures as high as 200° F and are sulfurous.

Climate and Vegetation

Lakeview has an average annual precipitation of 13.27 inches mostly as snow during winter months. The climate is moderate with temperatures seldom exceeding 90° F in the summer or below 20° F in the winter.

The Warner Range marks the approximate eastern limit of forest cover in southernmost Oregon. The area studied is located within the borders of the Fremont National Forest where large stands of pine and other conifers are present. At lower elevations the vegetation consists of juniper, sagebrush, and a variety of grasses.

Nature of Rock Exposures

Exposures of basalt and more indurated siliceous rocks are generally good especially where they occur in steep relief. In places of more subdued topography even the harder rocks do not readily crop out. The softer volcanic sediments are exposed only in road cuts and cut banks bordering streams. A heavy soil mantle is present nearly everywhere and in places it has accumulated to depths of more than 30 feet.

Map Coverage and Field Work

The sole topographic coverage of this area is the Klamath Falls sheet (NK10-6) of the Army Map Series at a scale of 1:250,000 covering an area from 118° to 120° west longitude and from 42° to 43° north latitude with a contour interval of 200 feet. A planimeter series of base maps, made from aerial photographs and on a scale of 1:63,360 is available from the U. S. Forest Service. Field data was recorded on aerial photographs and later transferred to base maps. Field mapping was facilitated by use of a mobile recording scintillometer which proved useful in distinguishing different rock types through minute variations in background radioactivity.

Previous Work

The first geological reconnaissance of southern Oregon was made by I. C. Russell and was published in 1883 in the Fourth Annual Report of the U. S. Geological Survey. G. A. Waring (1908) discussed the geology and ground water of the Abert-Goose Lake area around Lakeview, Oregon. Later A. C. Waters (1927) reported on the Glass Buttes in northwestern Lake County, and the following year the results of R. J. Russell's (1928) studies in the Warner Range of northeastern California were published. In 1931, R. E. Fuller discussed the geomorphology and volcanic sequence of Steens Mountain in southeastern Oregon. Recently in 1958 H. A. Donath in an abstract discussed faulting in central Lake County, Oregon. Short discussions by N. V. Peterson (1958-1959) relating to the uranium deposits near Lakeview, Oregon, have appeared in the "Ore-bin," a publication of Department of Geology and Mineral Industries of Oregon. In 1959 G. H. Haddock in an unpublished thesis from the State College of Washington discusses the geology of the Cougar Peak volcanic area. The area covered by his study comprises the southwestern portion of plate 1.

Acknowledgments

For information concerning the drilling programs at the White King and Lucky Lass mines acknowledgment is made to Howard Dutro

and Phillip Wein, formerly geologists of Lakeview Mining Company. Many people have been helpful in supplying data for this report; both company records and private opinions of our friends and colleagues are gratefully acknowledged.

VOLCANIC STRATIGRAPHY

Tertiary Volcanic Rocks

South-central Oregon is characterized by a great thickness of volcanic rocks and pyroclastic sediments of Middle and Late Tertiary age. Extensive faulting, rapid facies changes, and gradational contacts within the volcanics make accurate correlations between rock types difficult.

The oldest rocks exposed are andesitic pyroclastics and flows of the Cedarville Formation. Locally disconformable upon the Cedarville Formation are several hundred feet of Warner Basalt. Sparsely distributed pyroclastic sediments fill topographic low in the Warner Basalt and are generally divisible into the Camp Creek and Augur Creek Formations. Intruding the older volcanics are dikes and plugs of both basaltic and rhyolitic composition. Poorly-consolidated lake beds, which are angularly unconformable on the older volcanic rocks, are local in distribution.

Cedarville Formation (Late Oligocene to Middle Miocene)

Russell (1928) mapped the Warner Range from its southern extremity northward to the Oregon-California border. He described 7,500 feet of exposed volcanic rocks from the type section at Cedarville, California, and divided the sequence into a lower, middle, and upper series. The lower series comprises 3,700 feet of andesitic agglomerates (50 percent), tuffs (30 percent), intercalated flows (15 percent), and non-volcanic sediments (5 percent). The middle series, though basaltic in appearance, is comprised of 150 to 200 feet of andesite flows, which reach 500 feet in thickness at other places. The upper series consists of 3,600 feet of andesitic tuffs (40 percent), agglomerates (40 percent), intercalated flows (15 percent), and sediments (5 percent).

A partial section (2,220 feet) of the Upper Cedarville Formation was measured at a site 10 miles south of Lakeview. The section contains andesite flows (60 percent), interbedded tuffs (20 percent), agglomerates (15 percent), and sediments (5 percent). The section is about 30 miles north of the type section and was assigned to the Upper Cedarville series on the basis of reconnaissance mapping. The compositional variations from the type section are particularly noteworthy and indicate the rapid lateral facies changes which occur within the formation; especially the striking increase in andesitic flows.

The oldest rocks exposed within the area are probably equivalent in time to the Upper Cedarville series. However, owing to a scarcity of exposures, a reliable correlation could not be made. Locally the series may be subdivided into two broad units based on physical appearance. The older is represented by well indurated, steeply-dipping sedimentary rocks; whereas the younger unit is typically a light-colored, soft, pyroclastic and sedimentary series and represents uppermost Cedarville.

The oldest unit exposed in the area is in secs. 27 and 34, T. 37 S., R. 18 E., on the southwest side of Thomas Creek. This unit consists of dark-purplish-brown and greenish-brown siltstones, sandstones, and conglomerates. The beds range in thickness from 2 to 36 inches. All components of the strata appear to be volcanic origin, and are mostly andesitic in composition. Approximately 200 feet of these sediments are exposed. Though the top of the unit is concealed for a stratigraphic distance of several hundred feet, the indurated dark-colored volcanic rocks of the next stratigraphically higher unit are exposed. The higher unit consisting of silicified, vitric, lithic and crystal tuffs, agglomerates, tuff breccias and welded tuffs, generally stands out in bold topographic relief. The top or bottom of this series is not exposed and no accurate thickness could be measured. However, on the east flank of Cougar Peak over 2,000 feet of tuffs are exposed. The beds are from a few feet to as much as 100 feet in thickness and are various shades of brown, purple, red and yellow. The rocks are predominantly andesitic and rhyolitic in composition. The textures are fragmental with angular rock fragments set in a matrix of fine volcanic material. Flow banding is absent but compaction banding is common.

The younger, upper volcanic unit, exposed northeast and north of Thomas Creek, is typically a series of light-colored, soft, pyroclastic and sedimentary beds. Individual beds range from less than a foot to 20 feet in thickness. An aggregate thickness in excess of 800 feet is exposed in the northwestern part of the area of Drum Hill. The series consists mainly of air and water lain tuffs and tuff breccias with lesser amounts of volcanic sands and silts. A widespread thick unit of well bedded lacustrine sediments underlie the east slope of Coleman Rim (Haddock, 1959, p. 13), but is almost completely covered by residual soils. At Drum Hill, near Dairy Creek Guard Station, channeling and convolute folding in mud flows are conspicuous. Haddock (1959, p. 13) reports the presence of logs up to 2 feet in diameter buried in the sediments, which have decomposed leaving hollow molds. Volcanic bombs, lapilli, layers of pumice, and scoria fragments are present in some horizons. Deposition was rapid and a nearby source for the volcanic material is evident. On the basis of composition some units could be classed as arkosic sandstones or graywackes.

The basalts, which unconformably overlie a thick sequence of volcanic sediments, are similar in stratigraphic position to basalts in the

Warner Range east and southeast of the Lakeview area. The gross stratigraphic similarity between the volcanic rocks of the Warner Range and the Lakeview area caused recent investigators to assign the volcanic sediments to the Cedarville Formation, and the capping basalts to the Warner Basalt.

R. W. Chaney (Russell, 1928, p. 405-6) considered the flora from the type Upper Cedarville Formation to be equivalent to the Late-Middle Miocene flora of the Mascall Formation of central Oregon.

Peterson (1959, p. 14) found a vertebrate tooth in the lowest part of older tuffs and states, "...later identified by Dr. J. Arnold Shotwell of the University of Oregon as being from a Diceratherium, a rhinoceros of John Day age (Early Miocene)." Several fossil leaves from the same locality have been identified and compared to species in the flora that appears to be Middle Miocene (Hemingfordian) age by Jack A. Wolfe of the University of California. Wolfe adds that an Early or Late Miocene age for these leaves would not be impossible, and adds that, "fossil leavers were collected from several localities within the younger tuffs and the one species identified is known elsewhere from Late Miocene and earliest Pliocene."

Warner Basalt (Middle Pliocene)

A number of thin olivine-basalt flows overlying the Cedarville Formation were named the Warner Basalt by Russell (1928) from the type locality in the southern Warner Range. He traced the flows northward to Abert Rim, eastward to the Steens Mountains, and westward through the "Gardens" area of northeastern California.

Within the area studied the Warner Basalt forms resistant caps on fault-block ridges and is unconformable with the underlying strata. Individual flows range from 5 to 30 feet in thickness but are generally less than 20 feet thick. The total basaltic series over most of the area is less than 100 feet thick. Outside of the area the flows have accumulated to thicknesses of approximately 700 feet. Pillow-like structures are locally present in the lowermost flow.

The basalts are mostly shades of gray to black. Many of the flows have vesicles ranging from small round openings to large flattened pockets. Rarely, pipe-like tubes are present at the base. The uppermost flow is commonly amygdoloidal with some of the vesicles filled with zeolites, calcite, and opal. Blocky jointing is prevalent, but typical columnar jointing is rare. Numerous springs occur at the contact of the basalts and the underlying Cedarville Formation, especially in fault zones.

For the most part, the basalts are fine grained and exhibit an intersertal to ophitic texture. Locally, lath-like phenocrysts

of plagioclase up to 5 mm. in length are seen and rarely small granules of olivine up to 2 mm. are present. The rocks have a striking uniformity of mineral composition, which approximates the following: labradorite (55 percent), olivine (20 percent), augite (15 percent), magnetite (5 percent), and glass base and accessory minerals (5 percent).

Another basalt displaying a diktytaxitic texture (meaning "net arrangement" -Fuller, 1931, p. 116) is present in the area but was not differentiated in mapping from the other basalts. This unit contains the same minerals as the other basalts but is characterized by a network of plagioclase crystals, in part ophitically enclosed by augite, but with a large percentage of interstitial voids. A diabasic dike crops out at the heads of Thomas and Drews Creeks in the southwest portion of the area and is the feeder for the diktytaxitic basalt in that area. Haddock (1959, p. 60) postulates that the diktytaxitic basalt was probably formed by escaping gaseous substances from a partially crystallized diabasic magma, which removed a portion of the interstitial material.

The Warner Basalt was considered by Russell (1928) to be of Upper Miocene or Lower Pliocene age. However, recent studies of the Warner Basalt have shown that it occupies the same stratigraphic position as the Steens Mountain Basalt which is of Middle Pliocene age (Axelrad, 1944, p. 248). On the basis of stratigraphic position and similarity between nearby (type) Warner Basalts and those of the Lakeview area, an age of Middle Pliocene is assigned.

Rhyolite Breccia (Late Pliocene)

In the southwest part of the area over a square mile of highly brecciated, silicified rhyolite is exposed; it forms the eastern portion of a larger mass of rhyolite breccia which extends northwesterly for 6 miles to Quartz Mountain. The unit ranges from a few feet to over 400 feet in thickness (Haddock, 1959, p. 32). The rock is pale-gray to pale-yellow and is generally replaced by chalcedony and opal and moderately iron-stained. Nodular and botryoidal structures are abundant, but flow banding is rare. Minor amounts of biotite and magnetite were observed in hand specimens. The breccia is the host rock for the cinnabar mineralization which took place at Quartz Mountain. Haddock (1959, p. 32) states: "It is possible that this is an altered area of andesite vitrophyre, as the contacts between the two rock types are indistinct and some of the less altered fragments look like andesite, or it may be related to the rhyolite intrusions." The rhyolite breccia is sufficiently radioactive to encourage prospecting but to date no ore has been exposed in prospect trenches. Field relationships show that the rhyolite breccia is younger than the Warner Basalt; therefore the breccia is tentatively considered to be of Late Pliocene age.

Andesite Vitrophyre (Late Pliocene)

Andesite vitrophyre (Johns, 1949) is exposed in the southwest part of the area where it covers at least 10 square miles. Cougar Peak and Blue Mountain are volcanic cones comprised of the vitrophyre and probably are the source of the surrounding andesitic flows. The cones are nearly symmetrical; the slopes are steep and are covered with blocky and platy rubble. The entire mass of vitrophyre appears mainly as a rubble heap; no rock was observed to be in place. The cones are very permeable and several large springs emerge from basal talus at the contact with the underlying more impermeable rocks.

The flows are platy to blocky and in places flow-banding was observed. Haddock (1959, p. 34) reports: "...the flow lineation radiates from the top of Blue Mountain....where a large mass of andesite vitrophyre, with vertical joints and banding, rises in cliffs over 100 feet high. It appears to be a plug which was forced upward while in a very viscous state."

The andesite vitrophyre is a light- to dark-gray glassy rock containing abundant phenocrysts of plagioclase and a few biotite crystals in small grains approximately 1 mm. in diameter. The vitrophyre weathers to a dull light-gray color in contrast with the darker hues and vitreous luster of the fresh rock. Locally, rocks with pumiceous and vesicular texture were observed.

Haddock (1959, p. 34-36) reported the composition to be: oligoclase, $Ab_{70} - Ab_{80}$, 15 to 25 percent, hornblende, 1 to 3 percent; magnetite, 1 to 5 percent; biotite, 3 to 5 percent; glass, $N = 1.495$ to 1.50 , 70 to 80 percent. He also stated: "The oligoclase occurs both as broken crystals and as strongly zoned phenocrysts. The hornblende is largely decomposed and forms dark red and brown alteration products. Biotite occurs as fresh euhedral plates which are strongly pleochroic from light orange-yellow to black. The magnetite is irregularly distributed in streaks and clusters. Most of the glass has been devitrified to form cloudy spherulites."

There is no paleontologic evidence for use in dating the vitrophyre. However, the vitrophyre overlies the Warner Basalt of Pliocene age and is tentatively assigned to Late Pliocene.

Camp Creek Formation (Pliocene - Pleistocene)

Volcanics, locally called the Camp Creek Formation, are exposed in the pit walls and floor of the White King mine, where they consist of a volcanic conglomerate which in places contains some thin, lenticular basalt flows. The conglomerate consists of rounded vesicular basalt boulders and cobbles, ranging from 1/4 inch to 3 feet in diameter, set in a well indurated matrix of volcanic debris.

Rarely angular fragments of banded rhyolite, up to several inches in length, are found. The unit is light-yellowish brown to brown and may be as thick as 100 feet.

Inasmuch as neither the top nor the bottom of the unit was observed, and contact relationships were either intrusive or faulted, the exact stratigraphic position of the unit is unknown. The presence of banded rhyolite fragments and vesicular basalt boulders suggests that the Camp Creek volcanics are younger than the Warner Basalt and the period of rhyolite intrusion. The problem, however, is not easily resolved inasmuch as molybdenum minerals of the metallization phase which was associated with the intrusion of the rhyolite are present within the Camp Creek Formation.

The unit exposed in the pit is in fault or intrusive contact with other rock units. However, on the basis of deep drilling in the eastern pit area, it is thought that the Camp Creek is unconformably overlain by the Augur Creek Formation.

Quaternary Sediments

Augur Creek Formation (Early Pleistocene)

The Augur Creek Formation overlies the Camp Creek Formation and is exposed only in the White King mine. It consists of alternating beds of decomposed ash and clay; friable graywacke and sandstone; and pebble conglomerates. Individual beds are less than 3 feet thick. The top and bottom of the formation are not exposed, but from the examination of drill cuttings, it is estimated that the thickness of the unit may be in excess of 200 feet. The ash and sandstone beds are light yellowish brown to white, whereas the clay and conglomerate beds are shades of light gray to blue gray. Conglomerate beds are shades of light gray to blue gray. Conglomerates and clays predominate in the lower portions of the unit but the reverse is true in the upper portions where ash and sandstone are more abundant. The beds are poorly indurated and except for the clay horizons are very porous. The coarser clastic fraction is a good aquifer and together with the incompetency of the clays renders underground operations in this unit very difficult.

The age of the Augur Creek Formation is thought to be very Early Pleistocene on the basis of stratigraphic position, lack of induration, very slight dips, and the absence of major faults.

Lacustrine and Fluvial Sediments (Pleistocene-Recent)

Along the western flanks of the southern Fremont Mountains are a series of poorly sorted lacustrine and fluvial sediments consisting of gravels, coarse sands, and some gritty sands. The beds are poorly indurated and crumble readily in the hand. They strike

nearly north and dip gently to the east where they overlap older effusive rocks. In Goose Lake Valley, the beds dip under the very recent, flat-lying valley fill. The beds are mostly free of carbonaceous trash and plant debris. Reportedly, pieces of molar teeth of Pleistocene mastodons have been found.

INTRUSIVE ROCKS

Diabasic and Basaltic Intrusions (Middle Pliocene)

The diabasic intrusions, one between Grizzly Peak and Fish Lake, the others at the head waters of Thomas and Drews Creeks, are present in the southwest part of the area. All are dike-like in outline and trend generally northwest. The longest intrusion crosses upper Thomas Creek and is slightly over 2 miles long; the others are about 1 mile in length. The widest part of the Drews Creek intrusion is less than half a mile, and the others are only a few hundred feet in width. None of the intrusions have well defined parallelism in their opposing walls.

Haddock (1959, p. 71) reported the modal composition of the Drews Creek diabase to be: labradorite, Ab_{40-45} , 55 percent; augite, 35 percent, olivine, fo_{75} , 5 percent; and ilmenite-magnetite, 5 percent. The rock is black and weathers to pea-size pellets. The Thomas Creek intrusion contains a pegmatitic facies reported as: labradorite, Ab_{30-45} , 40 percent; augite, 40 percent; ilmenite-magnetite, 10 percent; zeolite, 10 percent; and apatite, trace. He also stated: "Labradorite is strongly zoned and largely altered to zeolite; the original total was about 50 percent of the rock. Ophitic augite crystals over 1 centimeter diameter are brown to purplish-brown in thin section, and have 2V varying from 54° to 60° . Ilmenite forms skeletal crystals....Slender apatite needles occur in the labradorite crystals." The labradorite inclusions are slightly larger than the matrix crystals and, because of differential weathering, stand fairly high in relief. The diabase weathers readily to produce a friable rock; good hand specimens are rare. A chilled selvage zone ranging from several to over 100 feet in width is exposed for approximately a quarter of a mile along the Thomas Creek intrusion. The texture of the zone is extremely fine grained and in places thin flow banding, resembling stratification, is present.

The diabasic intrusion near the head of Drews Creek is well exposed in cross-section, and shows the gradation of the diabasic texture of the parent mass vertically upward to a diktytaxitic texture. Many of the basalt flows possess a diktytaxitic texture and are undoubtedly closely related to the diabasic intrusions which suggests a local origin for some of the basic flows.

Many basalt dikes present in the area trend northwesterly and are essentially vertical. They range from a few feet to over 50

feet in width and a few can be traced for more than a mile in length. The dikes are nearly identical in composition and are generally fine grained, black, and contain a few olivine phenocrysts up to 1 mm. in diameter. In the southeast portion of the area (Haddock, 1959, p. 17) the dikes have trachytic texture and a composition of: plagioclase, An_{50} to An_{60} , 45 percent; augite, 10-15 percent; olivine, iron rich, 5-10 percent; magnetite, 10-20 percent; glass, 10-15 percent. The olivine is present in well rounded phenocrysts, and is locally altered to iddingsite.

A small, basalt plug in the SE $\frac{1}{4}$ sec. 28, T. 37 S., R. 18 E., is approximately 450 feet in diameter. Columnar jointing pointing radially outward from a central highly jointed zone suggests chilling of a volcanic neck.

The consanguinity of the basaltic flows with some of the dikes and intrusive rocks indicates that they are nearly the same age. The dikes and intrusions are therefore considered Middle Pliocene in age which corresponds with the age postulated for the Warner Basalt of this area and of the type area, the Warner Range.

Rhyolite Intrusions (Late Pliocene)

At least 18 rhyolite plugs were mapped in the Lakeview area. The intrusions are roughly circular or oval in plan and range from 80 feet to over 4,000 feet in diameter. All except two of the intrusions are concentrated in an area less than a mile in width extending 14 miles northwesterly from lower Thomas Creek to Dairy Creek. Though this alignment parallels the main structural trend, locally several groups of plugs favor the northeasterly trend. Two plugs on either side of upper Cox Creek in the northeast corner of the area as a unit trend northeasterly; however, the larger oval-shaped plug is elongated in a northwesterly direction.

The plugs are composed of glassy flow-banded rhyolite. The light-colored rhyolite ranges from hues of gray and blue gray to white. Flow-banding is prominent and locally thin gray bands are accentuated by differential weathering to give an embossed surface. The bands are highly distorted and occur as swirls and intricate crenulations throughout the mass. The overall crude trend of the bands is parallel with the direction of flow which in all cases is steep to vertical. The lack of orientation of the bands indicates a highly viscous state at time of intrusion. There is little or no thermal alteration of the intruded sediments but the intrusions have chilled borders of perlite ranging up to 3 or 5 feet in thickness. In places small pin-hole cavities lined with secondary siliceous material favor the lighter colored streaks within the bands. The rock generally breaks along the banding and in some places is fractured in several directions resulting in blocky rubble composed of curving platy fragments.

The texture of the rhyolite is essentially the same in all occurrences and consists of an aphanitic groundmass of feldspar and biotite microcrystals and glass enclosing larger crystals of sanidine and lesser amounts of orthoclase. Feldspars comprise about 70 percent of the rock; glass about 25 percent; and biotite, unidentifiable microlites, and secondary minerals about 5 percent. Sanidine is the most abundant feldspar and occurs as phenocrysts and microcrystals in the groundmass. A few large grains of orthoclase are present. Sodic plagioclase in the albite-oligoclase range is tentatively identified in the groundmass. Glass, micro-biotite flakes, and microlites fill spaces between the feldspars in the groundmass. Secondary kaolin, limonite stains, and chlorite is present. In some places (Haddock, 1959, p. 69) the rock consists of 99 percent glass ($N = 1.488$) and 1 percent microlites.

Primary uranium minerals have been found near one of the rhyolite intrusions and are believed to have been derived from late-stage volcanic activity of the deep-seated parent mass.

Except for 15 miles across the down-faulted Goose Lake Valley, rhyolite intrusions have been mapped from the northern Warner Range (Russell, 1928) northwesterly to Dairy Creek, a continuous belt over 50 miles in length. Waters (1927) found Late Tertiary rhyolite flows in the Glass Buttes area of northern Lake County, Oregon. Similarly, in the Bottle Creek District of northern Humboldt County, Nevada (Roberts, 1940, p. 8-9) a volcanic succession similar to the Lakeview sequence (tuffs - basalts with diabase dikes - rhyolite) is present. In Steens Mountain (Williams and Compton, 1953, p. 30) two elongate rhyolitic plugs, approximately three-quarters of a mile in maximum length intrude the Middle Pliocene Steens Mountain Basalt.

Russell (1928) did not assign an age to the rhyolites of the Warner Range but indicated that they are post-Warner Basalt. Waters (1927) considered the Glass Buttes rhyolite to be post-Pliocene age. Conclusive evidence that the rhyolites intrude the Warner Basalt in the Lakeview area was not found; however, elevations of several of the intrusions surrounded by basalt suggest an intrusive relationship. The rhyolites are tentatively assigned to the Late Pliocene.

STRUCTURE

The most obvious feature of the region from the vicinity of Klamath Falls eastward to Steens Mountain is the pronounced northwesterly trend of the major structural elements. The lineation is reflected in folds, faults, intrusions, topography, and drainage. A subordinate northeasterly fault system is less obvious.

Two distinct fault troughs or grabens are present in central Lake County: the Abert Lake-Chewaucan Marsh-Summer Lake graben

and the Goose Lake graben. Each is bounded by a system of north-trending normal faults with vertical displacements up to 2,000 feet. Donath (1958, p. 21) investigating the Abert Lake-Summer Lake graben, mapped two principal sets of faults, one of which strikes N. 35° W., and the other N. 25° E., that form a rhombic pattern. He states (p. 21): "The angle between the two sets suggests conjugate shears related to a vertical intermediate principal stress axis. Such an orientation of principal-stress axis would result in strike-slip movement on the shears."

Noting the discrepancy between the theoretical strike-slip movement and the observed normal fault movements, he suggested later normal faulting along earlier formed fractures. The earlier shears probably resulted from strong east-west compressive forces which arched the region and gently folded the surface. The normal faulting came as a result of the relaxation of the compressive forces and the crustal readjustment.

Faults

Within the mapped area, normal faulting of relatively small displacement is extensive and generally coincides with the attitudes of the major faults. The most obvious fault system has a northwest strike and a northeast dip, and is the major control of the present topography and stream drainage. Vertical displacements are usually less than 200 feet; but in places, especially along Thomas Creek, Cottonwood Creek, and Mesman Creek, scarps measure 1,100 feet, 1,600 feet, and 2,000 feet, respectively. Only vertical or steeply dipping normal faults were observed in this system.

The presence of a less distinct fault system paralleling the northeast regional structural pattern is indicated by secondary drainage features and by the horizontal displacement of the ridge-forming Warner Basalt. Vertical displacements are small, and the movement along the steeply dipping faults is mainly normal, although there may be some strike-slip movement.

It is difficult to interpret the sequence of normal faulting as each set displaces the other with equal regularity. It is probable that they were formed simultaneously.

Folds

At the time of the regional arching, the surface was subjected to minor folding. Russell (1928) described a broad north-south anticlinal fold trending through Long and Surprise Valleys, crossing the northern Warner Range and continuing northwesterly through Goose Lake Valley into Oregon. Waring (1908) recognized an anticlinal

structure extending from Silver Lake through the southern Fremont Mountains into Goose Lake Valley. Peterson (1958, p. 112; 1959, p. 15) has more precisely located the axis of the fold within the area studied as just east of Augur Creek and trending N. 35° - 45° W.

The attitudes of rocks within the area strongly support Peterson's (1958) concept of the structure but dips are slightly anomalous due to superimposed faulting. A series of small rhyolite intrusions generally parallel the fold axis and are confined to the limits of the fold.

GEOLOGIC HISTORY

During Early and Middle Miocene time, south-central Oregon was subjected to intense volcanic activity. Several thousand feet of andesitic rocks mainly pyroclastics accumulated over an extensive area. Explosive eruptions of the nuee ardente type contributed the greater portion of the material in a series of coalescing deposits. Minor flows of dark lava spread over the surface during short periods of relative quiescence. In Late Miocene time vulcanism subsided and the highlands were eroded, and the depressions formed were filled with shallow lake and stream deposits, reducing the relief to a near planar surface.

In very Late Miocene or Early Pliocene time the region was subjected to east-west compressional forces which arched the area into a gently undulated plateau. The east-west pressure relaxed in a short time and gravitational forces acting upon the terrane caused minor vertical movement along conjugate northwest and northeast oriented fracture systems which had developed under the compressive forces.

The stronger, northwest fault system provided channelways through which basalts were extruded in Middle Pliocene time. In a relatively short time the area was covered with a moderate thickness of basalt.

Additional readjustments of the crust along the northwest and northeast fault systems broke the basalt veneer and formed a series of nearly parallel ridges separated by shallow troughs. Sporadic acidic eruptive material and erosional debris collected in the valleys.

Rhyolitic intrusions, grossly utilizing the northwest fractures but locally the northeast fractures as channelways, penetrated the older rocks and in places broke to the surface and formed rubble cones and minor flows during Late Pliocene.

More active adjustment of the terrane in Pleistocene, possibly because of the removal of molten rock from depth plus the additional burden

of the basalt flows on the surface, resulted in deeper rifting and the development of the spectacular horst and graben structures. Additional movement was also recorded on the smaller ride-forming structures.

Minor eruptions continued to the end of the Pleistocene contributing mostly acidic ash falls, which together with erosional material, partially filled topographic lows. Erosion of the highland and deposition in low areas has continued to the present time. A recent minor movement disturbed the lacustrine sediments being formed in Goose Lake.

ECONOMIC GEOLOGY

History

Gold and Cinnabar

Lake County has been the source of small amounts of gold and cinnabar production since the 1860's. Gold has been mined from small prospects throughout the Warner Range, and a short-lived gold boom in 1905 resulted in the establishment of the High Grade mining district on the Oregon-California border about 15 miles southeast of Lakeview. Some gold has also been mined near Paisley, Oregon, since 1860 but production was not significant. No gold has been mined since the beginning of World War II.

At Quartz Mountain, a small cinnabar prospect was opened during World War II but closed soon after the war ended. In 1956-57, when mercury prices rose, the property was reopened and small amounts of mercury have been produced.

Uranium Deposits

Uranium was discovered on the White King and Lucky Lass claims near Lakeview in the spring of 1955. Within a short time after these discoveries were made prospecting was intense, and several additional occurrences were reported. However, none of the later discoveries have proved commercial.

Nearly all the discoveries occur within or adjacent to the belt of rhyolite intrusions which trends northwesterly across the mapped area along Thomas Creek. Several discoveries are of primary origin and appear to be related to the rhyolite intrusions. The remainder are secondary and were formed by the redeposition of uranium from eroded parts of the primary deposits.

White King Mine

Location and History

The White King mine is in sec. 30, T. 37 S., R. 19 E., Willamette Base and Meridian, in the southern Fremont Mountains (fig. 1). The mine is approximately 20 miles northwest of Lakeview and is readily accessible by graded graveled roads.

The property consists of 16 claims: White King Nos. 00, 0, and 1 through 14; and a 40-acre patented tract. The patented tract is along the northwestern end of a swampy mountain meadow on Augur Creek at an elevation of 6,400 feet.

In 1955 W. H. Lehman while herding sheep in Augur Creek area gathered a few yellow specked rocks which he brought to Lakeview. Later in 1955, the rocks were checked by John Roush and Donald Tracy who determined that Lehman had discovered a uranium-bearing outcrop. Donald Tracy, following Lehman's directions, found the outcrop in June 1955. Subsequently, Lehman formed a partnership with his uncle, W.H. Lehman, John and Wayland Roush, and Donald and Erma Tracy, (all from Lakeview, Oregon) and together they located the White King claims on June 21, 1955. Limited exploration by drilling proved encouraging and in September 1955, the claims were leased to Thornburg Brothers, Inc. Shortly thereafter the Thornburgs combined interests with Murchison, Richardson, and Bass of Texas, and formed the Lakeview Mining Company for the purpose of exploiting the property.

Extensive drilling by the Lakeview Mining Company indicated an ore body trending southeasterly about 1,200 feet and plunging approximately 40° from the mineralized outcrop. Subsequently, a shaft was started in October 1956 and in the following months a depth of 320 feet was attained.

Construction of a mill started in April 1958, on a site north of Lakeview and the mill commenced operations on November 29, 1958. The first delivery of "yellow cake" to the U. S. Atomic Energy Commission was in February 1959.

A new three-compartment shaft was started in May 1958 about 100 yards east of the Number 1 shaft in an attempt to increase the rate of production. Excessive surface and ground waters had always posed a serious problem requiring constant pumping and special drainage ditches on surface. In January 1959, a stope from Number 1 shaft caved as a result of saturation of the strata by percolating surface waters. A small open pit was started in March 1959 to recover the ore lost in the caved portion of the mine. In April 1959, the Isbell Construction Company of Reno, Nevada, was contracted to mine the remainder of the ore body by open pit methods.

General Geology

The White King ore body is beneath a relatively flat mountain meadow formed in the trough between two parallel northwest-trending fault ridges. The excavation of the open pit revealed geologic data that previously was only inferred from scant underground workings (figs. 2 & 3).

The oldest rock in the pit is highly altered, uppermost Cedarville Formation. The unit exhibits two distinct facies--a clay facies, the Shoestring tuff; and a silicified facies named the Christmas Tree tuff by the operators. The Christmas Tree unit is a bright varicolored rock found in a fairly wide zone surrounding a rhyolite intrusion. Within the zone, varying degrees of silicified rocks are present depending largely upon the proximity of the rhyolite. Immediately adjacent to the intrusion is a zone 10 to 12 feet wide of silicified contact breccia. Next is a wide zone of massive silicified tuff which still retains its original pyroclastic textures. In the last and furthest zone the rock is only partially silicified, resulting in a boxwork of narrow siliceous ribs supporting soft, clayey material.

The Shoestring tuff or clayey facies is blue to green bentonitic clay which is found some distance away from the intrusive rhyolite. The original rock textures suggest that the rock was originally a volcanic agglomerate composed of fragments of basalt and acidic volcanic rocks up to several inches in diameter set in a matrix of finer volcanic debris.

Approximately 100 feet of Camp Creek Formation is exposed in the northern pit wall where it is intensely fractured and altered by the rhyolite intrusion. The rocks are in fault contact with the older volcanics. Unaltered Camp Creek is exposed in surface cuts about 500 feet southeast of the pit.

Intrusive rhyolite is exposed in the pit floor as a roughly crescent-shaped plug. The main body and its apophysis are very irregularly shaped and the contact plunges 40° SE. The rhyolite is fine-grained and is blue-gray in color with black banding.

Highly porous Augur Creek sediments are present in the pit walls where they are in post-intrusive fault contact with the older rocks. Warner Basalt is not present in the pit but drilling has disclosed that it occurs at depth southeast of the pit where it underlies rocks of the Camp Creek Formation(?).

The faults exposed in the pit are complex and locally indistinct. There appears to have been three periods of movement relative to the rhyolite intrusion: Pre-rhyolite northwest-trending faults along which the rhyolite was intruded; movement contemporaneous with the intrusion of the rhyolite which occurred along the earlier

Figure 2. Topographic and geologic map of the White King open pit mine, Lake County, Oregon.

RME-2070

Figure 3. Geologic cross-section of the White King mine, Lake County, Oregon.

faults and in the rocks in the vicinity of the intrusions; and post-rhyolite faulting, principally northeast-trending, which displaced the rhyolite, ore zones, and later sediments.

Scattered around the upper surface of the rhyolite are several small uranium ore bodies. The ore bodies range from small lenticular pods to rather large irregular bodies generally with a relatively smooth hanging wall and downward projecting spurs along fractures in the footwall. The larger ore bodies which may have been originally exceeded several hundred feet in length, have been broken and displaced by post-intrusive faulting. The uranium mineralization was controlled by, and localized in, the fault breccias.

An area underlain by ore which is roughly 600 feet wide and 1,200 feet long was outlined by drilling. The uranium ore is dark gray to black when wet and except for its radioactivity is indistinguishable from the barren, altered host rocks.

Mineralogy

The principal ore minerals are coffinite (uranium silicate-- $U(SiO_4)_{1-x}(OH)_{4x}$) and uraninite (uranium dioxide, ideally UO_2). The coffinite was identified by E. T. Schenk, mineralogist, U.S. Bureau of Mines, Reno, Nevada, from X-ray diffraction patterns, and both coffinite and uraninite were identified by D. R. George and R. U. Johnson (1957) of National Lead Company, Inc. A shallow halo of secondary uranium minerals is present near the surface and occurs as coatings along joints and fractures in a silicified tuff. They were identified originally as autunite, torbernite, abernath-yite, uranospinite, and novacekite. Later work by E. B. Gross and others (1958), re-identified the coatings as consisting mostly of heinrichite and metaheinrichite, two new minerals. These two minerals were first described from the White King mine and occurrences in the central Black Forest of Germany.

Associated minerals are realgar, orpiment, galena, stibnite, pyrite, jordisite (which alters to ilsemanite on exposure to air), and opal. Cinnabar is present in small amounts (U. S. Bureau of Mines assay report, Albany, Oregon, 1955) but is rarely seen. Most of the sulfides appear to have a random distribution except galena which occurs with heavy concentrations of uranium. Jordisite occurs with the uranium in places, but only in minor amounts.

The apparent paragenetic history of metallization is shown in the following chart:

Minerals	Early (High temperature)	Late (Low temperature)
Pyrite and SiO ₂	-----	
Jordisite	-----	
Uraninite and coffinite		-----
Galena		-----
Realgar, stibnite, cinnabar		-----

Genesis and Classification of the Deposit

The White King deposit is considered to be Late Pliocene or Early Pleistocene in age, because it is intimately associated with acid igneous rocks which intrude the Warner Basalt of Late Pliocene age. The writer believes that the ore body is an example of an epithermal type deposit. The mineral assemblage, namely uraninite, coffinite, jordisite, galena, pyrite, realgar, stibnite, cinnabar, quartz, and opal, is typical of epithermal deposits.

Early mineral evaluations based on information gained by drilling led to the assumption that a few persistent structures and some favorable stratigraphic horizons controlled the deposition of the ore. Subsequent underground and open pit mining has shown that the ore occurs not in a homogeneous ore body but as dislocated slivers, pods, and irregular masses. The ore vein, where locally persistent, may contain only small high-grade shoots that are surrounded by protore and waste rock.

The ore zones present within the mineralized ground are normally thinly tabular, nearly vertical, and have been offset many times by both horizontal and vertical movements. The grade ranges from less than 0.10 percent to more than 0.70 percent U₃O₈. The ore deposition has been principally controlled by the porosity and permeability attendant with fault breccias formed during and shortly after the intrusion of the rhyolite. Prior to post-ore faulting, the ore body had the outline of a simple stockwork-type deposit. The drilling further shows that the main channels for ore solutions were parallel with the contact of the rhyolite and the host rocks, and that the quantity of ore probably diminishes at depth.

Lucky Lass Mine

Location and History

The Lucky Lass group of four unpatented mining claims is in the N½ sec. 25, T. 37 S., R. 18 E. (fig. 1). The claims are approximately

3,000 feet west of the White King mine, and are at an elevation of 6,400 feet.

Following the discovery and location of the White King claims, a group of local residents began exploring the area utilizing an airplane equipped with a portable scintillation counter. On July 13, 1955, the Lucky Lass claims, covering an anomaly found from the air, were staked by Donald Lindsey, Robert Adams, Choc Shelton, and Clair Smith.

Shallow surface exploration uncovered commercial uranium ore. About 100 tons of ore were mined from a small open cut and stockpiled. In September 1955 the stockpiled ore was shipped to Vitro Chemical Company of Salt Lake City, Utah.

An exploratory drilling program by Lakeview Mining Company indicated the presence of additional ore. The open cut was enlarged during the summer of 1957, and the first ore produced was shipped to Vitro Chemical Company. However, the ore proved non-amenable to the Vitro mill circuit because of "frothing." Later, the balance of the ore mined was submitted to the Lakeview mill but was again proved to be non-amenable, and no further mining was done at the property.

General Geology

Secondary uranium minerals are concentrated in small, faulted, rectangular blocks confined to a major, northwest-striking fault zone (fig. 4).

The fault strikes N. 35° W. and dips about 75° NE. Displacement is probably on the order of 200 feet although uppermost Cedarville Formation is exposed in both the foot and hanging walls. The fault zone is nearly 10 feet wide and is composed of blocks of highly altered tuffs, tuff breccias, vesicular basalt boulders, and bentonitic, clayey fault gouge. Drilling has proved that ore extends to a depth of at least 200 feet.

The principal uranium minerals present are tentatively identified as autunite and novacekite, but in view of recent mineral identifications from similar ores of the White King mine, the tentative identification is subject to question. The minerals are found as fracture coatings and filling voids in the tuff and vesicular basalt boulders.

The ore appears to be a redeposition of uranium leached by ground water from a nearby primary source. The absence of primary uranium or associated sulfide minerals that characterized the White King ore body, strengthens the theory of supergene deposition. The northwest-trending fault provided a channelway for the ground water and a physical environment favorable to the deposition of

Figure 4. Topographic and geologic map of the Lucky Lass mine, Lake County, Oregon.

secondary uranium minerals. The deposition was promoted by the presence of adsorptive bentonite. As charged waters replaced spent waters, the enrichment progressed. The presence of copious quantities of water in the fault zone suggests that the cycle of deposition has been active to very recent times.

Marty K Prospect

The Marty K Nos. 1 and 2 claims are in sec. 14, T. 37 S., R. 18 E., approximately 3 miles northwest of the White King mine (fig. 1). The claims were located in July and August 1955 by Elmo Angele, Sam Lookholder, H. M. Jacobson, and C. F. Gilbert.

In 1955 the surface area of the anomaly was stripped and a small quantity of protore was developed. Limited drilling, amounting to about 200 feet, failed to penetrate significant mineralized rocks and very little additional work has been done.

The rock consists mainly of tuffs and tuffaceous agglomerates and ranges in color from white to ivory and green (fig. 5). All rocks present are assigned to the uppermost Cedarville Formation. In places the tuffs appear to be well stratified and dip from 22° - 60° SW. Pumiceous fragments were observed in some of the agglomerates. Most of the rock fragments in the agglomerates are andesitic in composition. A few steeply-dipping, northwest-trending stringers of jasper are present about 50 feet southwest of the uranium occurrence.

The uranium minerals are confined to a small area of approximately 80 square feet. Chemical assay of a selected sample yielded 0.288 percent U_3O_8 , whereas the same sample assayed 0.160 percent U_3O_8 by radiometric determination.

The only apparent structure in the deposit is a fracture in the altered tuffs which comprise the host rock for the disseminated autunite, which trends northwesterly and dips 86° N. The host rocks are highly altered, bentonitic tuffs. The tuffs consist mainly of green-tinted drab clays. The ore may be classed as "high-slime" mill feed. A plug of intrusive rhyolite crops out several hundred feet south of the uranium occurrence. The uranium present is considered to be of secondary origin, possibly having been reconcentrated by meteoric waters.

Lucky Day and Topper Claims

The Lucky Day and Topper group of claims are in secs. 26 and 35, T. 37 S., R. 18 E. (fig. 1), and were staked by Don Tracy in 1955 and 1956.

A secondary uranium mineral tentatively identified as autunite is erratically distributed in a minor northwest-trending fault zone.

Figure 5. Topographic and geologic map of the Marty K. prospect, Lake County, Oregon

Extensive costeaning has uncovered the structure for several hundred feet. The fault zone is only a few inches wide and contains bentonitic-clay gouge. Small seams of autunite, measuring only a few inches in length, are scattered through the gouge. The occurrence is midway between two small rhyolite plugs in andesitic tuffs of the uppermost Cedarville Formation. Moderately deep drilling by a former lessee penetrated only barren rock suggesting that the occurrence is shallow. The mineralized zone appears to represent the redeposition of uranium leached from a nearby primary source. No ore has been mined.

Los Oros and B.V.D. Groups

The B.V.D. and Los Oros groups of claims are in sec. 26, T. 37 S., R. 18 E. (fig. 1), several hundred feet northwest of the Lucky Day and Topper claims. The ownership of the claims is presently in litigation. The Los Oros group was staked by Edward Groh, and the B.V.D. group by James S. Delyea.

The principal prospect occurs in a similar, if not the same, northwest-trending fault as the Lucky Day and Topper group. The geologic environment and occurrence of secondary uranium minerals are identical.

Virtually no exploration on the claims has been done because of the problem of ownership.

S & M Claims

The nine claims of the S & M group are in sec. 12, T. 38 S., R. 18 E. (fig. 1). The claims were located by Roy Sandberg and Jim Meyers in November of 1956. A near surface occurrence has been explored by several small pits and shallow drill holes (fig. 6). A secondary uranium mineral identified as uranospinite (Hess, H. D., U. S. Bureau of Mines, Albany, Oregon) occurs in seams and joints in a white tuff of the uppermost Cedarville Formation. The mineralization was confined to a narrow zone paralleling a minor northwest-striking fault. The nearest exposed rhyolite intrusion is several hundred yards west. The mineralized zone represents the redeposition of uranium by circulating ground waters.

Hope Claims

The Hope Nos. 1-7 claims were staked by Roy Sandberg in sec. 23, T. 38 S., R. 18 E., on the northeast side of Helphenstein Creek. Except for a few outcrops of rhyolite, the area is masked by soil and mantle. Exploratory trenching exposed a light-gray

Figure 6. Topographic and geologic map of the S & M No. 1 Glaim, Lake County, Oregon.

to pinkish-white, brecciated rhyolite, red and green clay, and white to ivory tuffaceous agglomerate (fig. 7). Most of the fractures in the rhyolite have been recemented with silica. The red and green clays are alteration products of volcanic ash. The coloration occurs as intertongues and swirls within the bentonitic clay; no apparent textural differences were detected within the clay that could have affected the random localization of the red or greenish coloration. The agglomerates, tuffs, and mixtures of both are generally light colored and soft.

The only structure evident in the workings is a north-west fault that dips steeply to the southwest. The rhyolite on the hanging wall is highly crushed and manganese stained. The footwall block is mainly dense, impervious red and green bentonitic clays.

Uranium mineralization was localized within the highly crushed manganese-stained rhyolite. No uranium minerals could be identified and a select sample from the most radioactive spot yielded 0.046 percent U_3O_8 .

The volcanic rocks exposed on the claims are part of the uppermost Cedarville Formation. There are no exposed intrusive rhyolites in the vicinity of the claims. The anomalous radioactivity is tentatively considered to be due to a concentration of uranium ground waters.

CONCLUSIONS

The possibility of finding additional epithermal uranium deposits in the volcanic rocks of the Lakeview area is fair to good. Additional detailed geologic mapping will be necessary to evaluate the area adequately.

Investigations show that the uranium mineralization was closely related to intrusive rhyolites. The intrusive rhyolites within the Lakeview area trend in a belt 1 mile in width diagonally through the area for at least 15 miles from southeast to northwest.

Basaltic rocks, both intrusive and extrusive, are not known to contain any significant amounts of uranium minerals within the area. However, faulting of basalts to the zone of vadose (practically no circulation) waters may afford an environment whereby uranium deposits may form.

Physical and chemical characteristics of the rocks and fault zones that form the conduits through which the metal-bearing magmatic waters passed were most important in the localization of the ore bodies. Originally, the rocks must have been sufficiently competent to fracture, and to have been of such mineral composition to allow

Figure 7. Topographic and geologic map of the Hope claim, Lake County, Oregon.

formation of an abundance of clay clogging material to restrict and force percolating ore solutions into various routes. This situation coupled with relatively rapid temperature and pressure (hydrostatic) changes promoted the dispersal of uranium minerals into many, small, usually widely separated bodies.

Cooling and shrinkage of rocks within an area that has undergone extensive volcanism will further cause disruption of strata and enclosed ore bodies.

The foregoing conditions emphasize the futility of correlation and outlining or extending ore bodies by a drilling program. Drill-hole spacing would by necessity have to be so closely spaced as to become an economic impossibility relative to the size of ore bodies which may be expected. Ore bodies may be of a fair size up to several thousand tons but continuity of the ore should not be expected.

Uranium ores within the Lakeview district are amenable only to small mining operations. The genesis of the uranium in the district closely resembles that of most mercury deposits. As in mercury deposits, large, well managed, open pit or underground operations will generally not be successful based on mining ore stringers.

In prospecting for uranium in a volcanic area with an average rainfall similar to the Lakeview area, anomalies may be expected in siliceous and silicified rocks, but the best ore bodies are most likely to be found in soft tuffaceous rocks. Siliceous rocks tend to stand in relief and are more readily accessible to surficial radiometric detection, whereas tuffaceous rocks erode readily and the contained ores are deeply covered by alluvium and soil.

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