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MONAZITE DEPOSITS IN CALCAREOUS ROCKS NORTHERN LEMHI COUNTY, IDAHO

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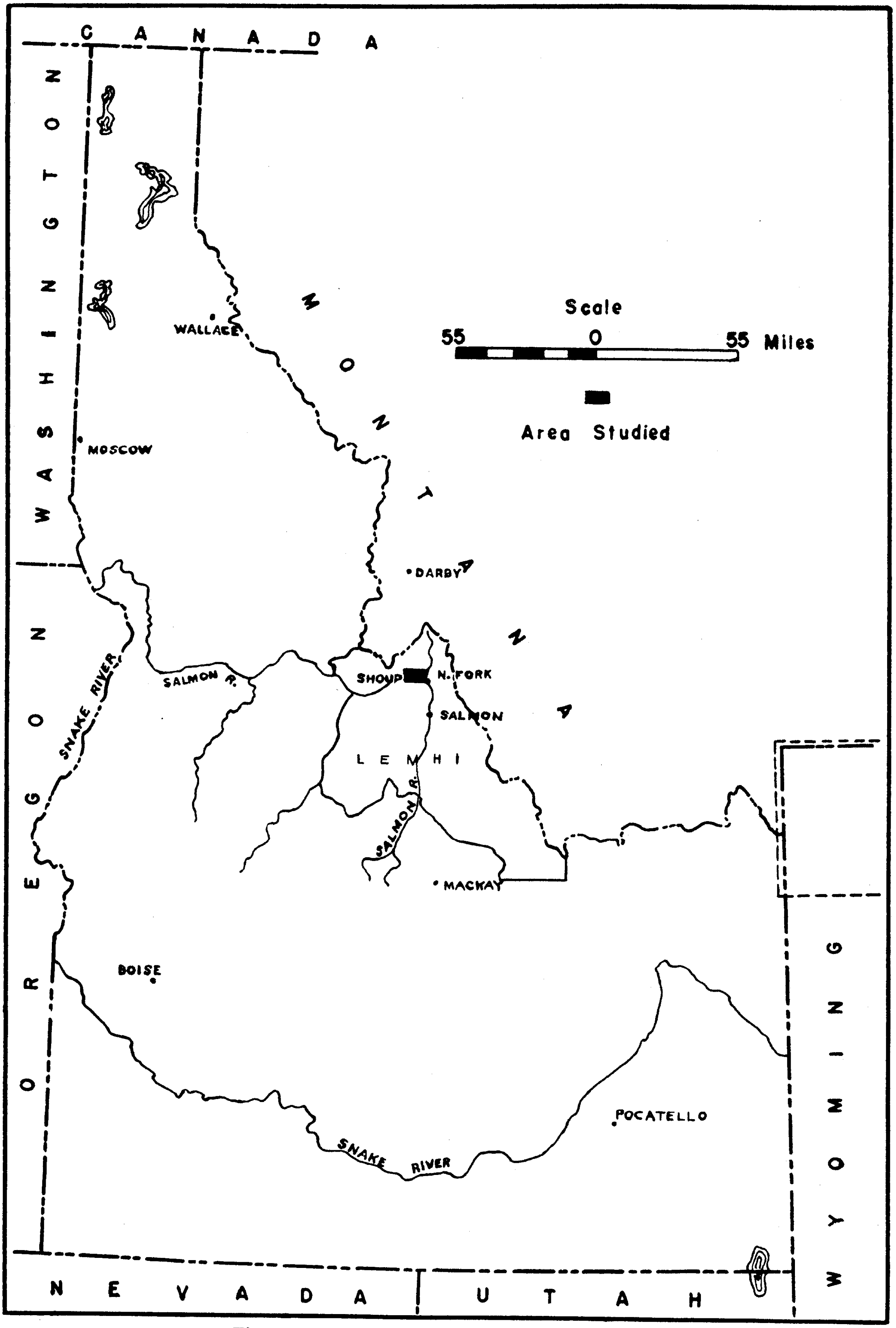

Figure 1. Index Map showing location of area

ABSTRACT

Between North Fork and Shoup, Idaho, immediately north of the Salmon River, several thin beds of marble are interbedded with the paragneisses and schists that belong to the vast assemblage of metamorphic rocks derived from the pre-Cambrian Belt series. Crystalline aggregates and disseminated crystals of the radioactive phosphate mineral monazite, occur sporadically within the beds of marble. Other minerals commonly associated with the monazite are actinolite, barite, siderite, apatite, ilmenite and magnetite. A genetic interpretation involves the migration of rare earth elements during metamorphism of sandy, argillaceous sediments of the Belt series to a more compatible environment of phosphatic limestone in which porphyroblasts of monazite were formed. Although relatively little is known at the present time concerning the value of these deposits, results of this investigation should encourage further exploration and development.

MONAZITE DEPOSITS IN CALCAREOUS ROCKS NORTHERN LEMHI COUNTY, IDAHO

INTRODUCTION

This report presents results of approximately three weeks field work during the summer of 1953 on several IN SITU deposits of monazite in marble in northern Lemhi County, Idaho. The purpose of the examination was to determine the extent, general geologic and structural relationships, mineralogy, genesis, and possible commercial value of the monazite occurrences.

Field mapping was considerably hampered by the lack of base maps on which to plot geologic data. Aerial photographs were available later during the writing of the report. From the photographs a base map of the area has been constructed upon which the monazite deposits and general geology have been plotted, and, although great care has been exercised to plot the data in correct locations, discrepancies in exact positions may be present.

LOCATION AND ACCESSIBILITY

The region in which the lodes of radioactive monazite occur lies immediately north of the Salmon River between the small towns of North Fork and Shoup, Idaho, in the northern part of Lemhi County (See index map). The area studied is contained in T 24N., R 19E., T 24N., R 20E., and the southern 6 sections of T 25N., R 19E., Boise Meridian. Some of the deposits extend to the Montana state line and probably continue to the north, although no one has traced them into Montana.

The road from North Fork to Shoup is a good graveled road that follows the gorge of the Salmon River along its north bank. Access roads to the north of the Salmon River road follow the valleys of Sage Creek, Indian Creek, Squaw Creek, Papoose Creek and Spring Creek. The Spring Creek road continues over the divide to Alta, Montana.

Salmon, Idaho, the nearest city, is 22 miles south of North Fork on U. S. Highway 93, which is a north-south arterial through eastern Idaho. Daily bus service is available between Salmon, North Fork and Missoula, Montana, but there is no public transportation from North Fork to Shoup. Darby, Montana, the nearest railhead, is 60 miles north of North Fork on Highway 93. It is served by the Northern Pacific Railroad.

Most of the monazite deposits are on hillslopes that are not reached by roads but that could be reached by extension and improvement of the present access roads.

PREVIOUS WORK AND HISTORY

Very little geologic work has been done previously on the rare earth mineral occurrences in this area because it is only recently that the deposits were discovered.

In 1952 Butler(1) compiled a listing of known deposits containing thorium and uranium which included the thorium-bearing veins of Lemhi County, Idaho. The monazite occurrences in the area covered by the present report, however, are not veins. (See Monazite Deposits). In 1952 the J. R. Simplot Company leased a group of claims on Spring Creek and with bulldozers exposed monazite-bearing marble beds. The company has allowed the lease to expire. It is not known what field or laboratory work the Simplot Company accomplished. The Molybdenum Corporation of America leased a group of claims on Squaw Creek and was building an access road in August, 1953, in preparation for drilling and exploration of deposits in that area. The U. S. Geological Survey made an examination of the district for the Atomic Energy Commission in 1950. In this report very minor amounts of radioactive minerals were reported by Trites and Tooker(7) in the area of the present study. Three crystals of monazite were discovered by them in the Snowdrift pegmatite which is west of the H. R. Roberts' claim. No mention of the fairly extensive occurrence of monazite in marble was made in the above report.

The district is well known for past gold production from the now-abandoned mining camp of Ulysses north of the Salmon River. In 1910 Umpleby(8) reported that the output of gold to that date totaled about $600,000.00. After the shut-down of the Ulysses mine the area produced little mineral wealth. In the early days a gold dredge was in operation south of the Salmon River in the Moose Creek basin. Production of placer gold from the dredging totaled about $1,000,000.00, according to Umpleby.

TOPOGRAPHY AND DRAINAGE

Relief in this region is high. The Salmon River turns west at North Fork and cuts a deep gash across central Idaho. Dissection by the Salmon and its tributaries has produced steep-north-south ridges. The wide flood plain between Salmon and North Fork disappears at North Fork. Westward the river is confined in a narrow gorge with occasional widenings in the meander sweeps. The river's course is transverse to the trend of topography and structure. The river probably was flowing in approximately its present course but stratigraphically higher previous to the uplift in central Idaho. Rejuvenation caused the river to down-cut rapidly to its present level. Between North Fork and Shoup the gradient of the Salmon River is rather high - 10.8 feet per mile. The water flows turbulently but there are no waterfalls. The gradients of tributary streams, particularly in their upper portions, are high.

The elevation at the bottom of the Salmon gorge above Shoup is approximately 3,340 feet above sea level. The highest point within the area is near the Idaho-Montana line at an approximate elevation of 8,000 feet. The Divide, which forms the border between Idaho and Montana, is largely erosional in origin. The Continental Divide along the crest of the Beaverhead Mountains is approximately 12 miles to the east. Ulysses Mountain which is a prominent summit east of Indian Creek reaches an elevation of 7,680 feet.

CLIMATE

During the summer months the weather is warm and dry. In the gorge of the Salmon River temperatures may reach 100° F. In the winter the higher elevations receive a great deal of snow which begins to fall early in October. There is less snow along the river but low temperatures prevail. The annual average rainfall at the Indianola Ranger Station on the Salmon River is approximately 9 inches.

FLORA AND FAUNA

Most of the region is forested by scattered clusters of jack pine, yellow pine, Douglas fir, lodgepole pine and a variety of brush which forms thickets in the valleys. For the most part, however, the trees do not seriously restrict geologic observation. Soil cover is extensive, and, except for precipitous bare slopes along the Salmon River gorge, good rock exposures are few.

The animals are principally elk, cougar, bear and an assemblage of small creatures.

ACKNOWLEDGMENTS

The writer wishes to thank the owners of mining claims in this area for their assistance in locating outcrops and for access to their properties. These men include Mr. Kenneth White, Mr. Jesse Hutchinson, Mr. Oscar Westfall, Mr. H. R. Roberts, Mr. Wiley Evans, and Mr. Reese Esker. For able assistance in the field, acknowledgment goes to Mr. Fred H. Sturm, graduate student at the University of Idaho, and employee of the Idaho Bureau of Mines and Geology. Laboratory analyses of samples collected in the field were conducted by Mr. Lewis Prater and Mr. Ray Kurtak, both of the Idaho Bureau of Mines and Geology.

GENERAL GEOLOGY

INTRODUCTORY STATEMENT

On the geologic map of Idaho, 1947, the eastern border of the Idaho batholith in the area under consideration is placed about four miles west of North Fork. It is true that this point marks a distinctive change in lithology - from quartzite, east of the contact, to mica schist containing scattered large porphyroblasts of feldspar, immediately to the west. It is doubtful, however, that the contact, as mapped, represents the true margin of the Idaho batholith against Beltian quartzites. It is believed by the writer that the entire metamorphic rock assemblage within the area observed belongs to the Belt series.

The schists, which become progressively more feldspathic west of the contact, and grade insensibly into a gneissic complex, are interpreted as being metamorphic products of argillaceous, calcareous sediments of the Belt series. That is, the contact between quartzite and gneissose mica schist is one of different effects of metamorphism upon sedimentary rocks of varying composition. There is no evidence of intrusion either in the quartzite or in the schist near their contact. Some faulting may have occurred along the contact, but it was not intense. Nearly all the occurrences of monazite are in marble beds in the gneiss-schist complex; none is in the quartzite. The rocks which carry the monazite are principally marbles intermittently interbedded in the gneiss and the schist.

Igneous rocks include relatively small dikes of rhyolite, pegmatite, and a few basic types that cut the metamorphic complex. Some pegmatite dikes contain radioactive minerals, the most prominent of which is allanite. The mineral thorite has been tentatively identified in some pegmatites. It is doubtful that either mineral is present in sufficient quantities to be of commercial value.

Sedimentary rocks are minor in abundance and other than the fact that some monazite is found in tributary stream gravels, have no importance in the present investigation. Alluvium mantles the floors of the Salmon River and the larger tributaries. Small benches and terraces above the present stream levels are paved with alluvial materials of varying mixtures. No further mention will be made of the sedimentary rocks.

METAMORPHIC ROCKS

Quartzite

Between North Fork and Buster Gulch excellent outcrops of Beltian quartzites are exposed in valleys tributary to the Salmon River and in road cuts. The rock is a medium to dark brown color, fine to medium textured, exceedingly hard and distinctively bedded. In outcrop the bedding planes are prominent and are responsible for the slab-shaped quartzite fragments that compose the abundant talus slopes. Bedding is also displayed on a smaller scale by thin dark bands of iron-rich grains. The rock is extremely siliceous; cementation by silica and recrystallization of the clastic quartz grains has made a product of high resistance to weathering and attrition.

Microscopically, the rock is composed of quartz, 80 per cent; biotite, 10 per cent; feldspar, 5 per cent; accessories, 5 per cent. In thin sections examined, quartz grains measure about 0.2 mm. across. Much of the original shape of the clastic grains has been destroyed. Contacts between the grains are highly irregular and sutured. Strain shadows are evident on many grains. The biotite, which occurs as small shreds between the quartz anhedra, is not clastic mica but has developed during metamorphism from interstitial argillaceous material. The feldspar is predominantly clastic grains of plagioclase, which are not abundant. The quartzite, therefore, is only slightly arkosic.

Gneiss Complex

From Buster Creek west to Spring Creek and north of the Salmon River to the Montana state line, a vast and hetergenous series of meta-sedimentary rocks predominates. Umpleby (9) interpreted the rocks in the eastern portion of the above area to be intrusive granite of Tertiary age. The balance of the area he mapped as metamorphic basement rocks of Archean age.

The writer was unable to discover true intrusive granite as mapped by Umpleby or to substantiate his dating of Archean for rocks in the western part of the district. In the absence of any indication of intrusion, variations in rock type are best explained by regional metasomatic metamorphism of sedimentary rocks of Beltian age of varying compositions. In a westerly direction there is a notable increase in feldspar and gradation from mica schist to mica containing porphyroblastic feldspar to granitized paragneiss. This may be explained as border effects of the Idaho batholith which is still a considerable distance westward; or by employing another interpretation it is possible that these rocks are an outer zone of the batholith which becomes more feldspathic to the west because granitization was more complete in the region of central Idaho. Emanations from sources postulated or unknown have in any event been an important factor in the feldspathization and granitization of the gneissic complex.

In a survey of the east slope of the Bitterroot Range in Montana about 50 miles north of the North Fork area Lindgren[2] proposed that the gneisses that form the steep flank of the range overlooking the Bitterroot Valley are tectonic in origin. He states that a flat, normal fault is responsible for the eastern slope and that the gneiss and associated schists were cataclastically formed from pre-existing igneous rocks. The gneisses that Lindgren described can be traced to the south into the area of the present study where there is no evidence to support his hypothesis.

Ross[4] in a more recent survey of the area Lindgren described in the Hamilton quadrangle Montana, disagrees with Lindgren's concept. Ross[5] states:

> "Reexamination of the evidence in the field and laboratory leads to the conclusion that the gneiss bordering the batholith in the Hamilton quadrangle more nearly resembles a sedimentary than an igneous rock, both in general aspect and in details of texture and composition. It is a stratified rock that has been recrystallized, but has retained even the minor features of its original lamination. Feldspars and other minerals have been developed in it probably as a result of permeation by emanations from the batholith during intrusion. The rocks from which the present gneissic mass developed differ among themselves in their details of composition. They are thought to have been components of the Ravalli group of the Belt series, with their characteristics now obscured by partial granitization. So many features of sedimentary rocks are present that the concept of the gneiss' derivation from an old granite is not regarded as acceptable."

In the North Fork-Shoup area no attempt was made in the present study to correlate stratigraphically the metamorphosed sediments of the Belt series with known members of the series a number of miles to the north. Recent work by the U. S. Geological Survey on correlation of Belt sediments over relatively short distances in the Coeur d'Alene mining district where metamorphism is comparatively weak has shown that extreme caution must be exercised and correlations attempted by earlier workers were sometimes inaccurate.

Wilson[9] measured a section of gneisses and schists near Shoup. This area was scanned only briefly from the road during the present investigation, because it lay several miles west of any reported showings of monazite. Wilson proposed that the massive gneiss 450 feet in thickness along Salmon River gorge is intrusive into the overlying metasediments of the Belt series. The marked agreement of structure and foliation between the intrusive gneiss and overlying metamorphic rocks was explained by Wilson as indicating that both types of rocks were metamorphosed contemporaneously sometime after intrusion. Wilson and Umpleby both describe a large erosional unconformity between the proposed intrusive gneiss and the overlying paragneiss and schist of the Belt series. If the Belt sediments were deposited on an eroded surface of the intrusive gneiss, it indicates that the intrusive gneiss was introduced into some much older rock that has been completely removed by erosion, or is, at least obscured from observation. Neither Wilson nor Umpleby postulate what the host rock might have been.

In the area covered by the present report - east of Shoup, there is no profound erosional unconformity exposed, nor is there indication of a very early intrusive orthogneiss as described. Tooker and Trites(7) follow Umpleby's interpretation of the geological history; namely, that sediments of the Belt series were deposited upon an already metamorphosed and contorted series of much earlier pre-Cambrian or Archean rocks.

Amphibolites

Interbedded with the gneisses are numerous zones of amphibolites of varying extent, thickness and composition. Rocks under this heading include hornblende, quartz, mica schist, hornblende schist, actinolite schist and a nonfoliate rock of spotted or blotchy appearance containing a high percentage of hornblende and epidote plus feldspar, quartz and mica. This latter rock is fairly common in the upper portions of the east fork of Spring Creek.

None of the amphibolitic rocks is interpreted as a product of contact metamorphism, nor do the rocks appear megascopically or microscopically to have been originally igneous rocks of basic or intermediate composition. Rather, the composition of the hornblendic rocks was determined in large part by original sedimentary content; the hornblendic facies were derived, therefore, from sediments of calcareous and dolomitic compositions.

Marble

Although marble is present in the metamorphic complex in relatively insignificant quantities, its importance is vastly greater than any of the other rocks because the monazite mineralization has been concentrated largely in the marble beds. Occasional scattered grains of monazite may occur outside the marble, usually in calcareous schists, which in many places grade into recrystallized limestones.

There are approximately 10 localities (See geologic map) where the marble beds are identified and in most of these monazite occurs locally somewhere along the extent of the bed. Inspection of the geologic map reveals a marked northwesterly trend of the marble outcroppings, which is the same trend found in other rocks in the complex. Because of soil mantle, or possible discontinuity of the marble beds, or both, no single occurrence could be traced for a great distance, i.e., over one-half mile; however, similarity of trend along the strike in the areas of Indian Creek, Papoose and Squaw Creek, suggests that the rocks in intermittent outcrop may belong to the same two or three beds.

It is also possible that the outcrops are lens-shaped bodies of recrystallized limestone in the same two or three stratigraphic horizons. Until additional exploration by trenching or drilling has proved the continuity of the marble beds, there is now no direct evidence for inferring their true extent.

The marble beds are easily recognized in the field by the rough, pitted surfaces, by color, which is commonly a medium gray locally stained with red or orange limonite, by hardness, and by megascopic accessory minerals which may be associated in the marble. These minerals include actinolite, barite, monazite, ilmenite and siderite. The marble beds usually project a few inches above the bordering walls of schist or gneiss, due to the slightly greater resistance of the carbonate rocks to weathering. None of the marble examined was more than slightly dolomitic. All specimens fizz vigorously in cold, dilute hydrochloric acid. In addition to the above minerals, microscopic examination reveals garnet, zoisite and abundant apatite. The apatite undoubtedly accounts for the high phosphate content of monazite-free marble (See monazite deposits).

All reports by earlier workers in this area failed to mention the marble beds. The occurrence of bedded marble, which conforms to the regional structure, strengthens the theory that the associated rocks - gneisses, migmatites, schists, and amphibolites of the complex, are of sedimentary origin and not an igneous one.

IGNEOUS ROCKS

Igneous rocks within the area studied are minor in abundance and are principally of two types; namely, rhyolite and alkaline pegmatite dikes.

Rhyolite Dikes

Dikes of rhyolite crosscut the metamorphic rocks in a number of localities, but in most places the dikes are not over a few feet wide. There is apparently an increase in the number of these dikes to the west in the vicinity of Shoup, because Wilson[9] mentions their abundance in that locality. The largest rhyolite dike mapped outcropped on the north side of the Salmon River road and was traced to the northwest through the claims of H. R. Roberts (See map). The average width of the dike was approximately 300 feet. The tan-colored, resistant rhyolite forms a topographic ridge with an exceedingly knobby surface due to selective weathering which has also imparted a cavernous and pitted structure to exposed cliff walls. Under the microscope thin sections of the rhyolite show an abundance of glassy matrix material in which imperfect crystals of quartz and potash feldspar are embedded. Excellent spherulites in the glassy groundmass were noted.

Intrusion of the rhyolite dikes occurred later than the metamorphism of the sedimentary host rocks as there is no evidence of the metamorphism of the dikes. The rhyolite intrusions do not follow regional structural trends. There is no evidence that the rhyolite dikes supplied the mineralizers carrying rare earth elements which were deposited in the carbonate beds, because monazite in the marble occurs as abundantly away from the rhyolite dikes as near them; nor is there any trace of rare earth elements within the dikes.

Pegmatite Dikes

Rather commonly throughout the district, except in the quartzite, pegmatite dikes intrude the metamorphic rocks. There are two main types of pegmatite dikes; one being composed principally of potash feldspar and quartz and resembling closely a binary granite. Such a pegmatite, about 50 feet in width, forms a northeast-trending ridge at the confluence of Squaw Creek and Papoose Creek. Locally small spots within the dike are highly radioactive. Local radioactivity is due to scattered grains of allanite, a black, shiny silicate containing cerium and other rare earth elements.

The other type of pegmatite dike, one of which outcrops a few hundred yards west of the H. R. Roberts prospect, is more continuous but narrower than the pegmatite described above. It is known as the Snowdrift prospect and was formerly owned by G. E. Shoup of Salmon, Idaho. The distinguishing features of this dike are the coarse books of muscovite mica, coarser grain size in general and zoning within the dike. Tooker and Trites(7) found three large grains of monazite in this pegmatite, but no monazite was observed in it during the present study. If this pegmatite and others similar to it contain monazite, it is possible that they furnished aqueous rare earth-bearing solutions that migrated through the metamorphic complex and crystallized as monazite in the beds of marble. Field evidence shows that heavy monazite loci in the marble beds may be far removed from the pegmatite, whereas, marble beds adjacent to pegmatites may be barren of monazite. A critical view must, therefore, be taken of this theory at the present time.

Muscovite has been mined on a small scale from the Snowdrift pegmatite. The production figures are not available. It is doubtful if the books of mica are large enough to produce sheet mica of commercial grade but they might provide a source of scrap mica.

GEOLOGIC STRUCTURE

The structure of the area is exceedingly complex. A study of the structural relationships of the rocks near monazite deposits and a cursory examination of structure along road cuts was made. Lack of time and particularly the lack of base maps in the field prevented a thorough structural study. Some structural features, however, will be discussed below.

Faulting

Minor faults are everywhere present within the area. These were noted in the study of the monazite-bearing marbles, which are commonly offset a few tens of feet. Faulting of this magnitude would not hinder mining operations.

Larger faults may be responsible for the apparent lack of continuity of the marble beds over large distances. The presence of these faults is postulated because direct evidence of faulting is not visible. As mentioned above, other reasons why the marble beds are apparently not continuous include cover by soil mantle, and/or an inherent and original lens shape of the marble beds.

Several faults of large but undetermined displacement cross the Salmon River gorge at a small angle, and may have been partially responsible for the course of the river. The trend of the faults is west-northwest. Their traces are marked by steep scarps which were probably formed as the result of removal by the stream of soft material in the fault zone. In sharp bends of the gorge where the fault zones leave the present valley and are exposed in the banks, bleached areas of fault gouge and breccia mark their traces. Such zones are visible along the Salmon River road cuts about one mile upstream from the mouth of Spring Creek. In this vicinity it will be noted that the river follows an erratic course. The reason for the "goosenecks" is probably that the stream follows one fault zone and then abandons it to cut across to another, roughly parallel, fault zone.

Another fault zone that is topographically marked determines the course of Squaw Creek from its mouth upstream to the junction with Papoose Creek. This fault strikes northwest. A steep scarp on the west side of the stream and parallel to its course is a particularly striking feature on aerial photographs.

A major fault is indicated in the valley of Donnelly Gulch, which is a northern tributary of the Salmon River, shown near the eastern margin of the geologic map. Again, direct evidence of a fault may be obscured by surface cover, but the distinct change in dip of the quartzite beds east and west of Donnelly Gulch is strongly suggestive of faulting. East of the fault zone the well-bedded quartzites dip approximately 10° northwest and strike N. 20° E. In good exposures on the west wall of the gulch the quartzite bedding dips 35° SW and strikes N. 55° W.

The strike of the fault is approximately N. 10° W. From aerial photos, Sturm(7) mapped an east-west trending linear structure approximately four miles in length, that he interpreted as a fault trace. It crosses Indian Creek near the mouth of one of the tributaries, Cow Gulch.

Folding

The metamorphic rocks between Dump Creek and Sheup are complexly folded. From the south side of the Salmon River looking north at the steep canyon walls, isoclinical and high over-turned folds may be traced by eye. The magnitude of these folds in the gneisses and schists is approximately 200-400 feet from crest to trough.

Attempts at reconnaissance mapping of these structures were not practical because their structural attitudes were not visible at close range, and surface cover except in the Salmon gorge obscured much of the bed rock.

The small folds such as outcrop in the river gorge are apparently subsidiary ones on the flanks of a major anticlinorium and synclinorium. This relationship is suggested on the geologic map. Generally east of a line which trends northwest and parallels Squaw Creek for part of its extent, the regional dips are more or less consistently westward. West of this generalized line the regional dips are predominantly eastward. The line may mark the trough axis of a large synclinorium. The strike of the large fold axes passes about through the monazite-bearing marble north of Dutchler Peak. The divergent strikes and dips in this deposit on Spring Creek are in contrast to the generally uniform structural attitude in the rest of the marbles. The structural complexity of the marbles may be the result of their position approximately astride the synclinorium axis.

In the vicinity of Sheup, Wilson(9) noted the presence of what he called "a great regional anticline northwest trending which contains many subordinate folds." It is possible, therefore, that the west limb of the synclinorium mentioned in the paragraph above is the same as the east limb of the anticlinorium described by Wilson. It may be significant that to date discoveries of monazite deposits have been only within the synclinorium.

MONAZITE DEPOSITS

As far as the writer has been able to ascertain, the occurrence of monazite in marble and highly calcareous schists is not only unusual but unique. All references to the petrogenetics of monazite state that the mineral occurs in acid pegmatites, or as an accessory mineral in granitic igneous rocks. In the area being considered the monazite is apparently a metamorphic product that developed as porphyroblasts in phosphatic calcareous rocks. Additional discussion of the postulated origin of the monazite will be given later in this chapter. First, however, individual deposits or groups of deposits will be described, beginning with the most westerly.

CLAIM DESCRIPTIONS

Monazite Queen Claims

On the geologic map these deposits appear near the headwaters of the west fork of Spring Creek only a short distance south of the Idaho-Montana Divide. The claims are owned by Oscar A. Westfall of North Fork. The deposits are at a high elevation, in rugged steep gullies on the flanks of the Divide and lie approximately one mile east of the Alta, Montana, road. The claims may be reached only on foot.

Two prospect holes, several hundred feet apart, contain monazite which occurs in the northwest-trending marble and adjacent calcareous schists. The strike and dip of all the rocks is N. 35° W. and 60° NE. In the southern prospect about three feet of broken, tan marble which contains rather large grains of actinolite and monazite, is bordered on the hanging wall by two and one-half feet of white bull quartz containing inclusions of schist, and on the foot wall by biotite schist which contains small layers and lenses of carbonate. Monazite was readily visible in the shattered marble and to some extent in the highly weathered carbonate mica schist. A cut sample, 10 feet in width (Sample No. 3) across the face which included both marble and schist assayed 2.16 per cent combined rare earth oxides plus thoria, and 1.01 per cent phosphate. In the northern prospect hole, which is probably on an extension of the same beds, although this relationship could not be definitely established, the marble bed is three and one-half feet in width. In addition to monazite and some pyrite, the marble contains an unknown mineral that occurs as scattered, small, black, exceedingly shiny specks. On the east side of the marble is a zone three feet wide of brick red, crumbly, friable, sandy material that was probably originally a highly pyritic, sandy, calcareous schist. Under the hand lens close inspection of this strongly decomposed rock reveals abundant well-formed crystals of monazite. Separate samples were cut of the marble and on the oxidized zone. Results were as follows: (Sample No. 2) marble, 1.50 per cent combined rare earth oxides plus thoria, 1.04 per cent phosphate; (Sample No. 1) oxidized zone, 21.0 per cent combined rare earth oxides plus thoria, and 8.5 per cent phosphate.

The true extent of the Monazite Queen marble is not known. The distance between the north and south prospect holes is approximately 300 feet. Judging from the continuity of marble beds that are better exposed in other parts of the district, it is probable that the Monazite Queen deposits are more extensive than the present exposures would indicate.

Silver King Claims

This group of 15 claims is also owned by Oscar A. Westfall. The outcrops of marble, some of which are monazite-bearing, are located near the headwaters of the east fork of Spring Creek, north of Dutchler Peak. The lower claims may be reached by a dirt road, the last mile of which is in very poor repair.

In 1952 the J. R. Simplot Company of Boise, Idaho, leased the claims and began prospecting with bulldozers. After uncovering several outcrops showing monazite the prospecting was abandoned and the leases allowed to expire.

Where the road ends, bulldozer cuts have exposed along the north bank of the gully a narrow zone of monazite-bearing lime silicate rock. Because the soil cover is particularly thick near the bottom of the stream gully, the bed cannot be traced for more than a few feet along its strike. In the face of the bulldozer cut, where a Brunton reading could be made, the strike is S. 45° W. and dip 65° SE. The exposure reveals locally massive monazite.

The exposure is approximately 5 feet in height and the zone containing massive monazite about one and one-half feet wide. The original marble has locally been almost entirely replaced by honey-colored monazite with lesser amounts of actinolite and ilmenite. The outcrop is radioactive as recorded on the Geiger counter, but not highly so, probably because of low thorium content in the monazite. The walls of the massive band of monazite consist of strongly weathered, sandy, biotite schists. No monazite was observed in the schist. A sample two feet wide (Sample No. 6) was cut across the strong monazite zone and a short distance out from it onto the schists in hanging wall and foot wall. The assay results showed 4.46 per cent combined rare earth oxides plus thoria, and 2.14 per cent phosphate.

Across the stream gully, about 500 feet to the northeast and approximately 75 feet higher than the outcrop just described, a bed of blue marble containing scattered grains of actinolite and barite is exposed in the floor of a bulldozer cut. No monazite was found in this place. The strike of the marble is S. 55° W., and, although the dip could not be determined, the similarity of strike and thickness of the bed along the same trend suggests that the marble on either side of the stream may be part of the same bed.

About 300 to 400 feet above the stream gully and one-fourth mile east of the two exposures of marble mentioned above, four major benches or terraces have been cut one above the other, en echelon, by prospecting bulldozers. The lowest of the cuts reveals nothing but soil and highly weathered and decomposed mica schist and gneiss. In about the center of the next higher cut there are three beds of marble, which are closely folded, strongly altered, and grade into the surrounding decomposed mica schist. As suggested in the chapter on "Structure" it is through this area that the axis of the synclinorium trough probably extends, and if it does, complex structural attitudes might reflect its trace. No monazite was observed in the marbles exposed by this cut.

The best showings of monazite are in the third terrace which is connected to the second by a ramp. Marble exposed in the floor of the ramp contains disseminated grains of monazite which appear to become more abundant near the third level. Toward the northeastern end of the third cut a face of decomposed marble 6 feet wide has been exposed by the bulldozer. Abundantly scattered through the marble there are small specks of monazite that may be seen with the aid of a hand lens. No actinolite was observed. The strike of this bed is north-south and the dip 65° west.

Twenty-five feet to the west along the same face of the same cut there is a zone 5 feet in width that was probably originally impure marble but has been replaced by actinolite, biotite and quartz. No monazite was apparent in this zone. The strike and dip was N. 10° W., 70° W.

Twenty feet west of the exposure just described along the same cut an outcrop of blue and tan marble 8 feet in width forms a spur or ridge in the cut. The bed strikes north-south and dips 75° W. Three feet of the hanging wall of the bed is virtually barren of monazite, but the remaining 5 feet of marble on the foot wall is heavily impregnated with large, anhedral, honey-colored crystals of monazite. Here the only other visible mineral is the calcite of the marble. Of the Silver King deposits this place seems to be the richest and the widest. Two samples were taken; one a grab sample from the muck pile from the last blast in the marble bed, and the second a cut sample 5 feet wide across the foot wall portion of the marble. The first sample (Sample No. 4) assayed 14.6 per cent combined rare earth oxide plus thorium and 8.8 per cent phosphate; the second (Sample No. 5) 17.7 per cent combined rare earth oxide plus thorium and 1.90 per cent phosphate. It was possible to trace the high monazite marble for about 50 feet before it was lost.

The fourth and highest cut is connected with the others by a ramp in which various schists and gneisses and some amphibolite are exposed. The general strike is N. 20° W. and the dips are variable. As far as the writer could determine, the fourth level contained no showings of marble or monazite.

Lee-Buck Claims

This group of approximately 12 claims lies in the upper reaches of Squaw Creek and by airline distance is not far to the east of the Silver King group on Spring Creek. These claims are the property of Oscar A. Westfall and associates. The discovery holes may be reached by driving to the end of the access road up Squaw Creek and from there by foot about one-half mile up a tributary canyon of Squaw Creek to the west. Other than location holes no work had been done on these claims at the end of August, 1953. At this time, however, the Molybdenum Corporation of America which leased these claims from Westfall started improving and extending the access road in preparation for prospecting and exploration. The prospects or showings can be divided into three main locations; namely, the upper and lower showings on the east side of the tributary canyon and the upper showings on the west side. This latter occurrence was not examined by the writer, but according to Sturm[6] it is one of the most promising of the group.

The lower showings on the west side are about 200 feet above the floor of the gulch, and in a small surface cut the bed of tan marble measures about 10 feet in width. The bed strikes N. 70° W. and dips 75° SW. One hundred feet south of the location hole the marble pinched to a width of 6 inches and then disappeared. To the north of the prospect the width remains fairly constant but surface mantle prevents tracing the bed for more than 100 feet. The marble is tan in color, coarsely crystalline, and contains, in addition to calcite, barite, siderite, a very black mineral with high metallic luster. It is this mineral that has been suspected of being columbite or niobium-tantalum bearing ilmenite. Westfall told the writer that composite samples of the black mineral from this and other places on the Lee-Buck claims have run exceptionally high in columbium when assayed by another company. Qualitative tests by the Idaho Bureau of Mines and Geology have not indicated high columbium content; in fact, the tests usually indicated no columbium at all. It must be recognized, however, that tests for columbium-tantalum are difficult and often inaccurate, especially in the presence of titanium when the results may be impossible to interpret.

A little monazite was visible in the marbles of the lower Lee-Buck property. A sample (Sample No. 11) across the 10-foot width of outcrop ran 0.28 combined rare earth oxide plus thoria and 1.07 per cent phosphate. Several small crosscutting faults offset the marble near the prospect hole but displacement was usually less than 10 feet.

The upper Lee-Buck showings are approximately one-quarter mile north of the lower cuts and about 350 feet higher. Several shallow prospect pits have explored the marble bed which strikes east-west. The foot wall of the marble which was penetrated by several pits, is composed of strongly weathered and decomposed feldspathic biotite schist and dips 50° S. The dip of the marble and the slope of the hill to the south are approximately the same. It is probable that the marble bed here forms the dip slope at least upon the upper portion of the hill. There are local high-grade spots of monazite in this tan to buff-colored marble which is probably between 3 and 5 feet in thickness. A sample (Sample No. 12) cut across 6 inches of marble containing disseminated honey-colored crystals of monazite ran 1.06 per cent combined rare earth oxide plus thoria and 1.34 per cent phosphate. In addition to monazite other minerals in the marble include moderate amounts of actinolite, ilmenite and barite.

Kenneth White-Jesse Hutchinson Claims

These claims, which are within the area marked "B" on the areal geologic map, are, in general, owned jointly by the two men named above.

At the time of the field work by the Idaho Bureau of Mines and Geology, the main discovery and most of the location work on these claims had been concentrated on an outcrop just east of the divide crest between Papoose and Squaw Creek. Since that time it has been learned by correspondence that additional discoveries have been made within this area. These, of course, have not been examined and consequently cannot be discussed. Primary consideration, therefore, will be given the outcrop mentioned above.

To reach this prospect it is necessary to follow the road up Squaw Creek two miles from the Salmon River to Papoose Creek, then take the Papoose Creek road to its end where a bulldozer road climbs steeply up the east slope of the canyon to within several hundred feet of the outcrop. Only trucks and four-wheel drive vehicles can negotiate the last one-half mile.

The outcrop forms a prominence or ledge about 15 feet below the hill crest. Two prospect pits have exposed one bed, or possibly two closely-spaced beds, of marble with an aggregate width of approximately 5 feet. The strike and dip of the marble which is consistent with the structural attitude of the decomposed gneiss, between and below the marbles, is N. 30° W. - 40° SW. Lying concordantly and directly above the upper bed of marble, there is a thick zone of milky white bull quartz. This zone of quartz which is resistant to weathering continues above the marble for over 200 feet to the north along the strike, although the thickness of the quartz decreases in that direction. To the south of the prospect hole both marble and quartz are difficult to trace. It will be recalled that at two other places so far described the marble beds were associated with white quartz, one the Monazite Queen, the other the upper cuts on the Silver King. The role or associations of the quartz with the monazite-bearing marbles is not clearly understood. From results of the study so far, it appears that the quartz bears no relationship to the monazite nor is it responsible for rare-earth mineralization of the marbles because there are numerous places where high-grade monazite is found in the marble without a trace of bull quartz.

The marble in this exposure is coarsely crystalline and locally completely replaced by actinolite with scattered spots of barite. Monazite occurs as disseminated grains and reportedly also as nearly solid massive clusters. Geiger counter readings were about two and a half to three times background. The thoria content, as determined by other assay agencies of most of the monazite in this district, is low, which accounts for correspondingly low readings on the Geiger counter.

From two samples cut across the two best zones exposed in this prospect, the first being three feet in width (Sample No. 9), the second (Sample No. 10) 13 inches, the following results were obtained respectively: 0.0 per cent combined rare earth oxides plus thoria and 1.42 per cent phosphate, and 3.84 per cent combined rare earth oxides plus thoria and 1.71 per cent phosphate.

To the north of this main prospect hole the marble zone can be traced along the strike intermittently on the surface for nearly one-half mile and possibly more. The monazite content over most of this extent is not known, although Sturm (6) dislodged a piece of marble for petrographic study from an apparently barren outcrop. Under the microscope he found that the marble contained numerous very small grains of monazite. Although no surface correlation is possible at this time, it is not unsound to speculate that thin or parallel marble zones continue into the upper Squaw Creek area and the Lee-Buck claims described above. If this is true, it would mean a more or less continuous linear extent of approximately three miles of marbles that are potentially monazite-bearing.

H. R. Roberts' Claims

North of the Salmon River about one-half mile across the highway from the Reese Ranch, a group of 7 claims owned by H . R. Roberts of Salmon, Idaho, and reportedly leased by Kenneth White, are of unusual interest because they include some very high grade pockets of monazite.

The claims contain two principal showings. The first lies a few hundred yards north of the pipe line shown on the areal geologic map. Because this outcrop is small not much could be learned from it. The second showing is more clearly exposed and will be described below.

The outcrop, or series of outcrops, may be easily reached on foot by following the trail up a prominent gulch northeast of the Reese Ranch for about one-thir mile where the trail bends sharply west and at a gentle grade ascends the south face of the slope for approximately one-half mile to reach the first cut. In this cut and for several hundred feet up the hill along the strike of the marble bed, there has been strong replacement of marble by actinolite and ilmenite. The width of the zone varies from 10 feet to 15 feet in this area. The strike of the marble and associated minerals is N 65° W and the dip 60° NE. Local patches of moderate radioactivity were indicated by Geiger counter within this area, but no monazite was observed. Downhill or southeast from the first prospect pit about 300 feet along the strike, intermittent outcrops of marble of unknown width which were virtually buried beneath heaps of decomposed sandy mica schist, revealed high concentrations of reddish monazite. In this vicinity on the foot wall of the marble there is a narrow vein containing pyrite, iron oxide and quartz. This is the southernmost exposure of the marble zone on the Roberts property.

North of the first prospect hole, it is approximately 150 yards along the strike of the marble to the crest of the hill where a three-feet width is exposed showing scattered grains of monazite. Continuing to the north down the north slope of the hill, the marble is exposed intermittently by shallow test pits in which monazite occurs fairly consistently. About 500 feet north of the crest a prospect pit larger than the others offers a full view of the marble. At this place the marble bed is two feet wide. The hanging wall consists of augen gneiss, the foot wall of weathered, sandy biotite schist (See Plate 1). All the rocks strike N 50° W and dip 50° NE. The upper six inches of the marble bed is massive monazite; the remaining two feet is marble containing disseminated grains of monazite. The sandy biotite schist also contains a few grains of monazite. A sample, (Sample No. 7) two and one-half feet wide cut across the marble bed, produced the following results: 21.5 per cent combined rare earth oxides plus thoria and 11.6 per cent phosphate. A check sample, (Sample No. 8) cut in nearly the same place assayed 14.0 per cent combined rare earth oxides plus thoria and 4.73 per cent phosphate.

Another prospect pit about 200 feet north of the one last described shows the marble interbedded with schist and gneiss, but at this place no monazite was observed. A curious feature was noted here, however, and that was the occurrence of large, black nodules in the marble which in shape and size resemble nodules of flint, but are actually composed of massive ilmenite. The Roberts marble may be traced along the strike for considerable distance farther north, but because there are no prospect pits the presence of monazite cannot be established.

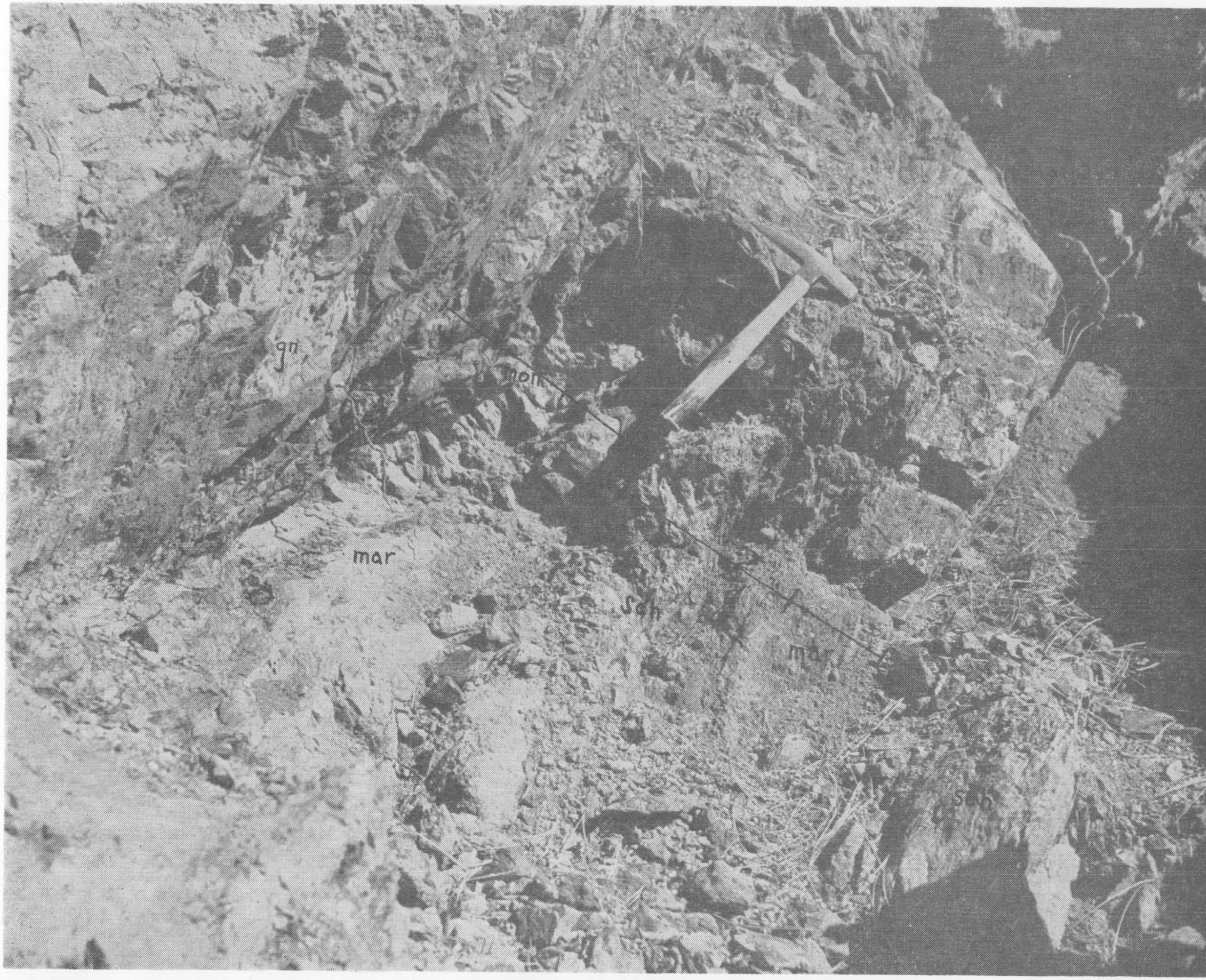

Plate 1. Prospect pit on H. R. Roberts property. gn is gneiss forming the hanging wall: mar indicates beds of marble: mon. is massive monazite in the marble: sch is mica schist between the marble beds. This is very typical of exposures of monazite bearing marble throughout the area.

Wiley Evans-Reese Esker Claims

The claims of Evans and Esker are grouped along Indian Creek and along the north side of the Salmon River between Moose Creek and Dump Creek. Some claims within the boundaries shown on the map may have a slightly different ownership arrangement. The claims along Indian Creek will be considered first.

About one and one-fourth miles up the Indian Creek road from the Indian Ranger Station on the east side of the valley at various elevations there are two or possibly three roughly parallel zones of marble. These are poorly exposed, usually narrow, two feet or less, and can be traced continuously for only short distances because of covering by soil. The average strike of the zones is N. 30° W. and the dip averages 60-80° SW. Although yellowish monazite was visible in local patches in these beds, cut samples assayed nothing in rare earth oxides. The country rocks which trend in the same direction as the marbles are a complex series of augen gneiss, banded gneiss, mica schist with feldspar, and sandy mica schist. In a road cut just downstream from the confluence of Cow Gulch and Indian Creek, three thin, poorly defined beds of marble may be seen interbedded in the black, highly contorted schist. They are probably extensions of the beds noted on the hillslopes. No monazite was observed in the above exposure.

Along the west side of Indian Creek about 500 feet above the stream a bed of marble, usually not over two feet in thickness outcrops intermittently for a distance of at least one-half mile. Because the soil covering is thin on this steep hillslope, bedrock can be exposed quickly with a prospecting pick. There seems little doubt that the bed is continuous. The strike is N. 65° W and the dip is 45° SW. Although monazite is not present everywhere along the strike of the marble, there are local pockets of high-grade, honey-colored monazite. Accessory minerals in the marble include barite, actinolite, pyrite, ilmenite and siderite, which are irregularly distributed. Near the southern extension of this bed the strike changes abruptly to S 10° W. The structural relationship is not clear, but, in the absence of evidence of faulting, it is probable that this point marks the nose of an anticline plunging southeast. The country rock is gneiss and schist which strike and dip concordantly with the marble.

Approximately one-quarter mile north of the northern end of the marble bed just described another series of marble outcrops is exposed near the headwaters of the western tributary of Cow Gulch. These marbles which are poorly and only intermittently exposed strike approximately N. 75° W and dip 50° SW. The width, as measured in two small prospect holes, was one and one-half feet. Disseminated honey-colored monazite is irregularly and locally distributed in the marble. The hanging wall is principally gneiss, the foot wall is quartzite and quartzitic schist. Similarity in strike suggests that this zone may be an extension of the marble on the east side of Indian Creek (See geologic map). It may also be the northern part of the marble described in the last paragraph, but with a more northwesterly strike, because of displacement by faulting and folding. Other principal minerals in the marble include barite, actinolite and ilmenite.

Between the mouths of Dump Creek and Moose Creek but on the north side of the Salmon River, Reese Esker and Wiley Evans own several claims called the Radiant Group. These claims have been prospected by a series of shallow pits about 300 feet above the river along precipitous rocky walls of the Salmon River gorge. Geiger counter readings on zones of sandy biotite schist interbedded in banded gneiss and augen gneiss gave results up to four times background count. Samples of the radioactive material were taken for laboratory testing. They all assayed nothing in rare earths or thorium oxides. Tests for other radioactive substances were also negative. A curious feature was noted during the sampling of these rocks; namely, that relatively high count was obtained when the rock was tested in place before sampling, but that the same rock after being dislodged and broken into pieces to fit in the sample sack, gave practically no more than background count.

The strike and dip of the schist and gneiss zones near the prospect pits is N. 15° W., 50° SW.

Also on these claims there are crosscutting pegmatite dikes several feet in width. These are light gray or white in color and are composed principally of plagioclase feldspar and quartz. Locally the dikes show abnormal radioactivity probably due to presence of the mineral allanite.

MINERALOGY OF THE MONAZITE

Monazite was first identified in 1823 by A. Levy. Although he named the mineral turnerite, in honor of the Englich chemist, E. H. Turner, in whose collection the first specimens were found, the mineral was the same as the one that now bears the name "monazite".(3)

Monazite is an hydrous phosphate of the rare earth elements cerium, lanthanium, and didynium $(CeLaDl)PO_4$. It also usually contains small amounts of thoria (ThO_2) and silica (SiO_2). Monazite crystallizes in the monoclinic system. It is a subtranslucent to subtransparent mineral, has a resinous luster and varies in color from light yellow to amber to pink or reddish. It is brittle and possesses an uneven fracture. Distinctive is the cleavage parallel to (100) and good basal parting. The angle of intersection of the cleavage and parting is nearly 90°. This network of planes of cleavage and parting are usually easily seen in hand specimens. Monazite possesses a hardness of 5. to 5.5. Microscopically the monazite is colorless or very slightly pleochroic. (See Plate 2).

In the marbles under consideration monazite forms large euhedral to subhedral crystals. Occasional grains observed in the gneiss are subangular

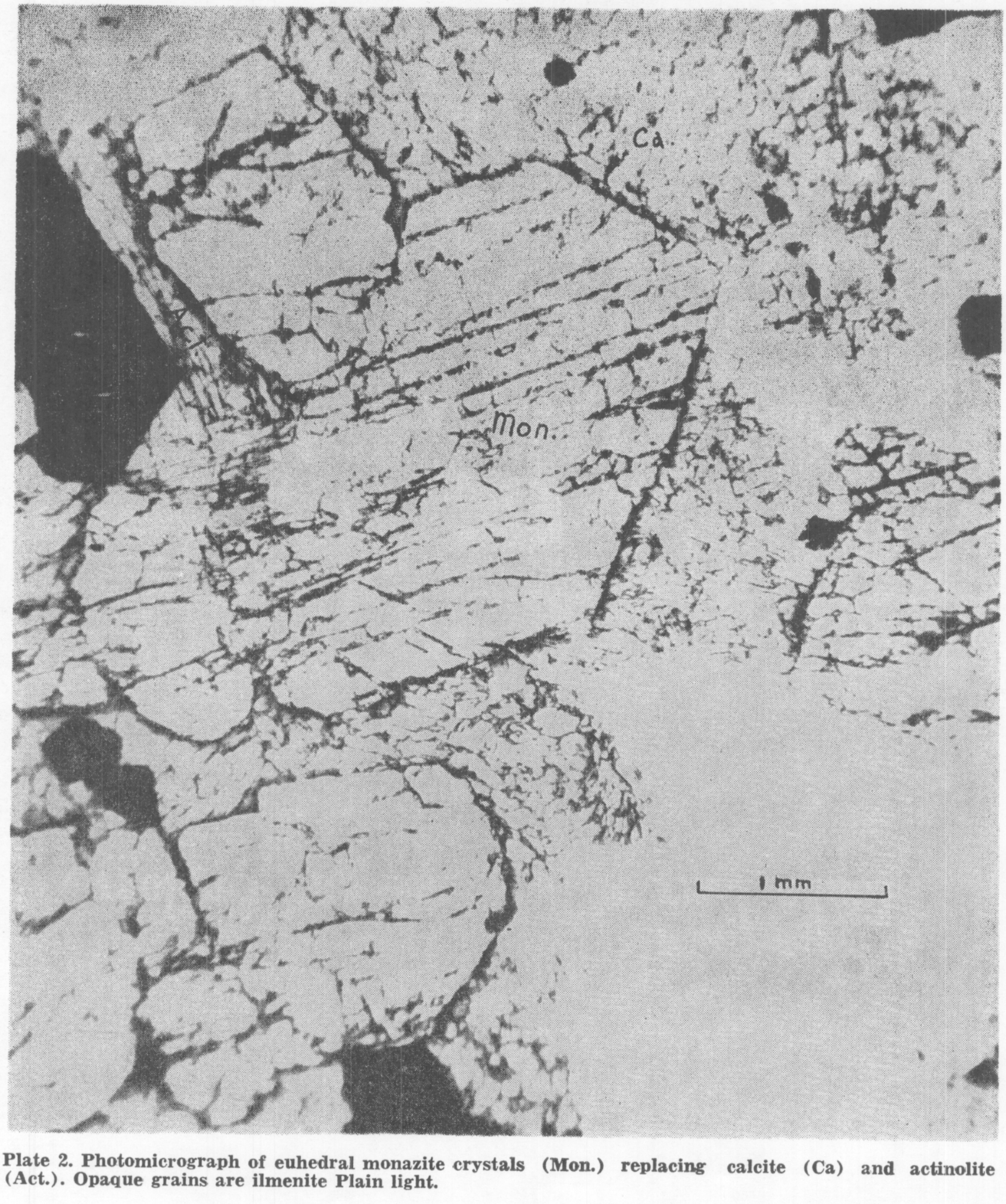

Plate 2. Photomicrograph of euhedral monazite crystals (Mon.) replacing calcite (Ca) and actinolite (Act.). Opaque grains are ilmenite Plain light.

to subrounded. The optic sign is biaxial (+), The index of refraction of grains is approximately 1.76, B 1.77, r 1.78. These are lower than indices generally quoted for monazite. It is probable that the lower indices are caused by lower than average content of thoria.

For the most part in the area under study monazite occurs in close association with metamorphosed calcareous sediments, usually impure marbles. Other minerals in addition to calcite that may be found with the monazite include actinolite,barite, ilmenite (Nb-bearing?), siderite, apatite, garnet, magnetite, specularite, and pyrite.

Microscopically and megascopically the position of monazite in the paragenesis is fairly readily determined. In most specimens examined the apparent order of the formation of the minerals is as follows: calcite, barite, apatite, siderite, magnetite and ilmenite?, actinolite, monazite, and then more ilmenite and magnetite. The paragenetic position of ilmenite and magnetite is not clear, although those minerals apparently formed at two distinct times, i.e. both before and after the formation of monazite.

GENESIS OF THE MONAZITE DEPOSITS

During discussion of igneous rocks in this report it was stated that the rare-earth elements were probably not carried in solutions associated with magmatic intrusion and deposited in the favorable crystallized limestones. Reasons discrediting this theory have already been presented.

It is now necessary to assemble the facts and to propose a theory of the genesis of the monazite that best fits these facts. Listed below are most of the field and laboratory observations that have a bearing on the problem:

1. Most of the monazite occurs in beds of marble.

2. The structure of the marble is concordant with the gneisses and schists above and below.

3. No reliable control of monazite concentration by structure has yet been discovered.

4. The beds of marble are thin but fairly continuous.

5. Monazite occurs sporadically in the marble. The reason for such selectivity is now known.

6. The pure marble is phosphatic. A composite sample from many localities assayed about 4.0 per cent P_2O_5. The mineral apatite $(CaF)Ca_4(PO_4)_3$ is very common in the recrystallized limestones and is probably the source of the phosphate.

7. Most of the minerals in the marble associated with the monazite are relatively low-temperature forms with the exceptions of ilmenite and magnetite.

8. The metamorphic rocks were formerly sediments of the Belt series.

9. Porphyroblastic formation of some monazite grains in actinolite which has replaced the marble is evident.

10. There is nowhere else another reported occurrence of monazite in marble with which to compare these deposits.

With the above facts in mind, there are two possible explanations for the location of the monazite in marble - the first, however, is not considered as acceptable as the second:

1. The monazite was deposited directly in fairly pure calcareous sediments of the Belt series in the form of clastic grains, that were rearranged by currents in the water and due to their high specific gravity formed in localized pockets. During regional metamorphism the carbonate minerals and some lime silicates crystallized before the monazite grains which later formed porphyroblasts and replaced the earlier metamorphic minerals.

Although remotely possible, this explanation has serious faults which need not be enumerated here.

2. The second theory proposes that the rare-earth bearing mineral or minerals were deposited as clastic grains in the argillaceous and arenaceous sediments of the Belt series. The high specific gravity of these minerals probably caused their concentration to a greater or less extent. During regional metamorphism of the sediments these minerals were dissociated and the rare earth elements which could not profitably be used by the minerals in the gneisses and schists were forced to migrate. An estimate of the distance of migration of the rare earth ions cannot be given. When the fugitive rare earth ions entered a bed of phosphatic marble, they found a compatible environment and combined with the available phosphate to form porphyroblasts of monazite. This probably took place fairly late in the metamorphic cycle as the monazite replaces many of the earlier formed minerals.

The reasons for local nature of concentrations of monazite in the marble may be two; namely, that those places of high-grade monazite in the marble were simply closest to the pockets of clastic, rare-earth bearing minerals in the nearby argillaceous, arenaceous sediments; or that the migrating rare-earth ions followed structural channelways in the metamorphic complex, and where those channels intercepted a bed of marble the strongest replacement of the carbonate bed took place.

COMMERCIAL ASPECTS

In the present state of development it is difficult to predict whether these deposits of monazite will be commercially valuable. Considerably more exploration will be necessary before it would be wise to plan a large-scale operation for the extraction of monazite.

If the mining of monazite is commenced, it would be largely an underground operation. It is true some of the mineral could be extracted by surface trenching along the beds, but this would soon prove uneconomical. Considerable tonnage for a number of years could be developed by crosscuts driven into the hillslopes below known ore shoots. If the monazite-bearing zones extend deeper than the general level of the tributary streams it would be necessary to sink shafts.

It is not unsound from the surface exposures examined to speculate that within the area there is a bed of monazite-bearing marble that is 300 feet long, 200 feet deep and 3 feet wide. If this bed of marble contains 10 per cent monazite by weight, and the present market price of approximately $350.00 per ton for 55 per cent combined rare earth oxide plus thoria is used, a calculation shows that from this block of ground 16,000 tons of ore will be removed with a value of $44.00 per ton. After subtracting from this figure the cost of mining, milling, transportation charges to the Lindsay Light and Chemical Company in Chicago, Illinois, it is still probable that the mining operation would prove profitable.

Those prospects that appear most worthy of development at the present time are the upper cuts on Spring Creek-Silver King Claims, the upper exposures in the Lee-Buck Claims, and the H. R. Roberts prospects.

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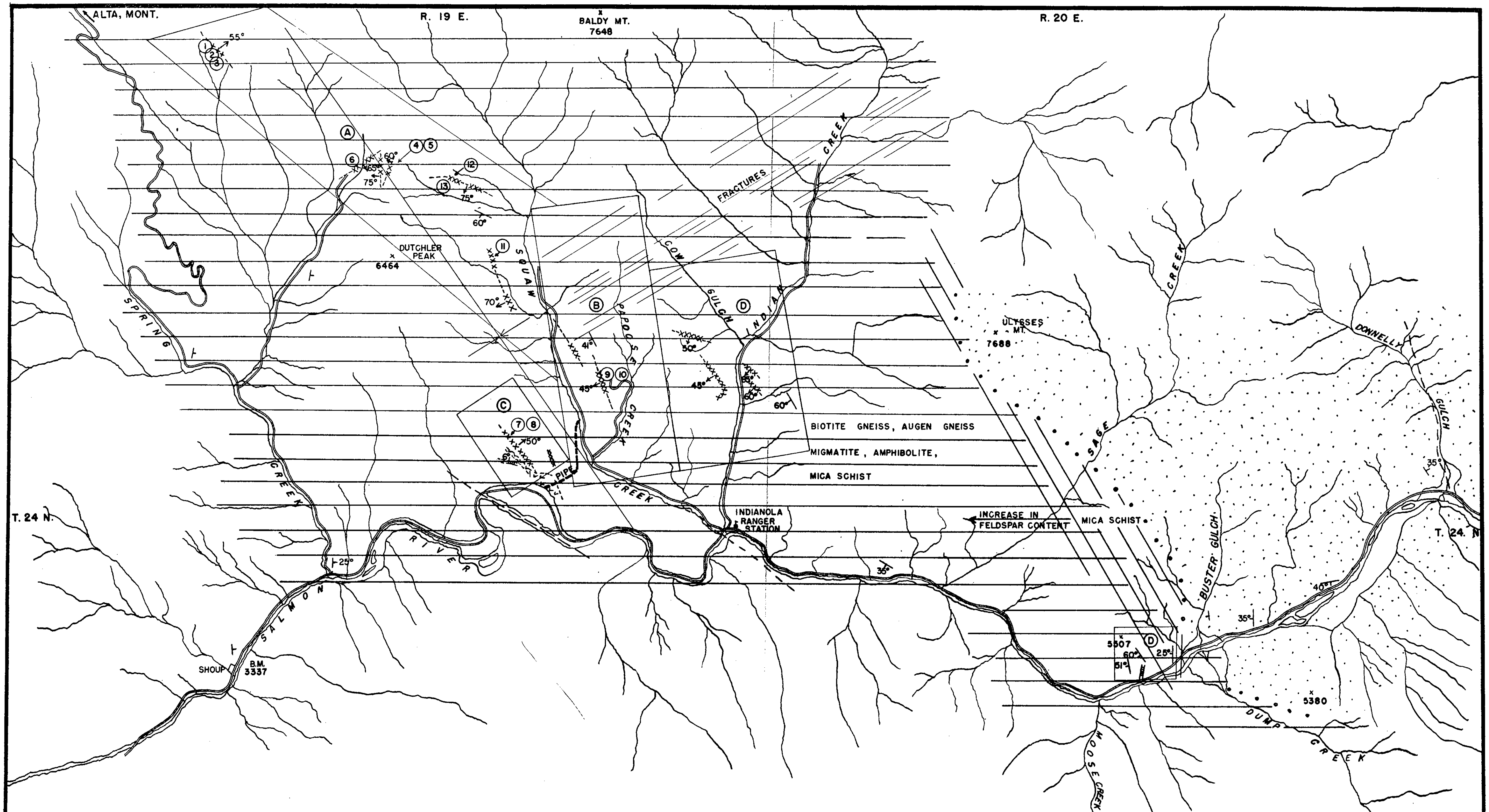

ASSAYS

No.	Width	P_2O_5 %	Re_3O_4 %	Remarks
1.	3.0'	8.5	21.0	Oxidized zone - Monazite Queen
2.	3.5'	1.04	1.5	Diss. monaz. in marble - M. Q.
3.	10.0'	1.01	2.16	Shattered marble and schist - M. Q.
4.	Grab	8.8	14.6	Muck pile - Silver King - 3rd terrace
5.	5.0'	1.90 ?	17.7	Marble with strong monaz.- S. K.- 3rd ter.
6.	2.0'	2.14	4.46	Monaz. in actin.- in bottom of gulch - S. K.
7.	2.5'	11.60	21.5	Monaz. in marble - H. R. Roberts
8.	2.5'	4.73	14.5	Monaz. in marble schist - H. R. Roberts
9.	3.0'	1.42	0.0	Actinolite and marble - Ken. White
10.	1.1'	1.71	3.84	Actin., marble, monaz. - Ken. White
11.	10.0	1.07	0.28	Lower Lee Buck claim
12.	6.0'	1.34	1.06	Monaz. in marble - Upper Lee Buck claim
13.	Soil	0.86	0.20	Upper Lee Buck claim
14.	Composite	3.89	0.00	Specimens of pure marble from several outcrops - P_2O_5 contained in apatite

BELT SERIES
PRE-CAMBRIAN

QUARTZITE

BIOTITE GNEISS, AUGEN GNEISS MIGMATITES, AMPHIBOLITE MICA SCHIST, -UNDIFFERENTIATED

MICA SCHIST LOCALLY GNEISSIC

MARBLE AND MONAZITE LOCALLY

AGE UNKNOWN

PEGMATITE DIKE

RHYOLITE DIKE

OBSERVED AND INFERRED CONTACT

INFERRED FAULT

FRACTURES

OWNERSHIP-GENERALIZED

- (A) OSCAR WESTFALL
- (B) KENNETH WHITE-JESSE HUTCHINSON
- (C) H.D. ROBERTS
- (D) REESE ESKER-MILEY EVANS

FIG. 2

N

19½°

AREAL GEOLOGIC MAP

PART OF THE MINERAL HILL DISTRICT

IDAHO

Scale in miles.

1 ½ 0 2

December 1, 1953

Agatin T. Abbott

24A