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TUNGSTEN MINERALIZATION AT THE IMA MINE, BLUE WING DISTRICT, LEMHI COUNTY, IDAHO.*

ALFRED L. ANDERSON.

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rapid drop of the solid block beneath them. This might explain opeming of layers in the Arizona ore bed during mineralization.

Cameron observes that early quartz and adularia deposited at ab the same time in all the Star Peak ore deposits, and that differences in subsequent mineralization might be explained by differences in the times at which renewed deformation produced new channels by fracturing the earlier vein matter. Progressive changes in composition of solutions would in that case produce variations in the metallic content of ore in varoous deposits, because, while change in composition o solutions might have been smoothly progressive, time of opening of fra fractures to receive them varied from deposit to deposit, depending as they did on complex conditions of local structure and strain.

Blue Wing Tungsten District, Idaho

Sources.-

Eugene Callahan and Dwight M. Lemmon (1941), Tungsten resources of the Blue Wing District, Lemhi Co., Idaho, U.S. Geol. Survey Bull. 931A.

Alfred L. Anderson (1948), Tungsten mineralization at the Ima mine, Blue Wing District, Lemhi Co., Idaho, Econ. Geol. vol. 43, p. 181-206.

Another district, the deformation and metallization of which considerably antedates those associated with the later Tertiary districts which have formed the bulk of examples offered so far is the Blue Wing tungsten district in east-central Idaho (Plate 1), of which the Ima mine is the principal producer.

Granite has invaded Beltian micaceous quartzites ~~inreclalated~~ intercalated with

thin slaty beds

Structure.- The general direction of fold axes in the Belltian rocks of this region is north-south;in the Blue Wing district a northwest anticline seems superimposed on the regional folding. In the core of the anticline,at the northwest end of the Ima mine (Fig.35A) a highly irregular body of granite intrudes the quartzites. The granite seems to have been guided in its emplacement by preexisting fractures longitudinal with respect to the northwest anticline;this is shown by the prong-like granite offshoots making southeast from the main mass and paralleling the dominant fractures associated with the arch. The granite forms the core of the anticline,enlarging with depth down its flanks and pitching southwest with its axis.

The crest of the broad arch carries a system of jogged fractures which carry the ore,and which in general trend northwest with the anticlinal axis. While the granite sends off prongs suggesting emplacement under guidance of northwest fractures,the mass itself is intensely fractured and faulted by members of the northwest system.

According to Anderson(1948,p.188) the granite formed my impregnation and replacement of quartzite by feldspar and quartz.It is "crackled" throughout with quartz veinlets,disseminated sulphides and fluorite.

The main Ima vein fracture,which has many turnings,pinches,swellings and branches (Fig.35A) strikes in its southeast segment at an acute angle to the anticlinal axis;here it traverses the northeast flank of the anticlinal rather than the crest. Toward the northwest the fracture approaches the crest;as it nears the granite which invades the crest,the Ima fracture splits into three branches,the ore shoots terminating at or near the granite. In the crestal portion of the anticline,the fracture,while reversing its dip in cross section, is in general about vertical.In its southwast segment,where the fracture

lies along the northeast flank of the anticline,it dips toward the axial plane.

The anticline is cut by a number of northeast cross fractures which dip either northwest or southeast.

Ore Deposits.- The deposits are quartz veins,with varying amounts of fluorite, orthoclase and rhodochrosite and carrying scheelite, huebnerite, pyrite, tetrahedrite, chalcopyrite,bornite, galena,sphalerite and molybdenite. Fluorite,molybdenite and scheelite are more abundant near the granite, rhodochrosite more abundant at a distance.

Anderson believes that the granitization that converted quartzite to granite represents an early,very intense phase of wall rock alteration forming an essential part of the mineralizing process. Both granitizing and ore-forming solutions rose up the highly fractured axial portion of the anticline. Mineralization decreased in intensity from the granite "hot center" outward,resulting in a zonal arrangement whereby ~~xxx~~ sulphides with microcline and molybdenite deposited in fractures ~~deposited in fractures~~ in or close to the granite,with tetrahedrite and other minerals at greater distances away. After sulphide deposition silica-rich solutions deposited tungsten mainly as huebnerite in the same zone close to the granite occupied by the earlier,complex sulphudes Outward,beyond the range of the sulphides simple quartz-tungsten veins formed.

Huebnerite formed by replacement of earlier minerals,including sulphides. Filling of open spaces dominates over replacement,however,except near the granite. The late,tungsten stage of metallization was marked according to Anderson by a general reopening of the mineralized fracture especially in the quartzite close to the granite but extending southeast from the granite. Tungsten-bearing solutions dropped their load in the reopened fractures.

Tectonic Notes.- As shown on the plan, Figure 35A, the veins are strongest in the quartzite close to where they quit against the granite. The granite upper surface pitches gently southeast with the axes of the anticline, so that the Ima vein-fracture enters granite below its ore shoots; in doing so fracture and vein split and weaken down the dip in the same way that they do on strike. Away from the granite, i.e. southeastward and upward veins are more numerous than near the granite, but are narrower and less persistent.

Granitizing solutions rose along longitudinal tension fissures in the competent quartzite produced by an early phase of the arching; this is shown by alignment of the granite along the axial plane of the arch and by the granite tongues extending southeast, parallel to the axial plane and in the crestal portion of the arch.

After the granite had formed to make a massive, renewed arching seems to have split the anticline above the granite as a log is pplit longitudinally with an axe. Splitting was strong next to the blade of the axe. i.e. the upper edge of the granite, and produced the Ima fissure system; farther away splitting decreased and produced only small, discontinuous fissures. The axe itself, the granite, was intensely fractured only near the edge of the blade.

The comparison with splitting by an axe, while not inept, is inexact, for the top of the granite is flattish and not edged. Splitting of strata above such a massive would take place, nevertheless, during uplift and arching. Cellular wood can split, a steel axe cannot. In the same way, the granite core of the Ima anticline was unable to stretch during uplift and consequent arching of the Beltian strata. The arching strata were cut by tension fissures antedating formation of the granite massive; rise of the latter would widen these fissures

to the greatest extent immediately above the massive while higher up in the arch much of the stretching could be effected by interbed gliding of the micaceous quartzite and its slaty layers, together with stretching of these rocks.

The above mechanics explain the widening of the vein-fractures close to the granite, dying out of the fractures within the granite, and the decrease in their size and persistence with distance from the massive.

The renewed arching which split the crestal portion of the anticline seems to have been accentuated at the time of quartz-tungsten mineralization. Anderson(1948, p.189) points out that some larger veins are mineralized fissures filled with quartzite rubble shows that pull normal to the fissure walls operated before or during vein formation.

The general course of the Ima vein parallels the northwest course of the Ima anticline; but the vein follows a zigzag course, most of the "doglegs" striking north-south, in the direction of axes of regional folding (Callaghan and Lemmon, 1941, p.8).

Ekkernkamp(1939, Fig.12) deformed a clay cake by arching, allowed it to sink back into an even plane, then arched the cake a second time, the axes of the second arching making, in various experiments, angles of 20°, 30° and 45° with the axis of the initial arching.

Figure 35B reproduces part of the experiment wherein the two axes of arching intersect at 30°. North-south fractures of the older system do not appear in the sketch unless ~~they were~~ reopened by the younger, transverse arching. A zigzag fracture pattern results, composed of segments of reopened north-south fractures joined by northwest ~~fractures~~ fractures produced by the younger arching. The composite fractures follow in general the northwest trend of the arch with which they are associated

It seems reasonable to suppose that the north-south segments of the Ima fractures represent older fractures connected with the regional folding along north-south axes and reopened by younger, northwest arching. Such reopened fissures are less favorably oriented with respect to the tensional pull exerted by arching than are the northwest fissures parallel to the anticlinal axis; this may explain the apparent preference of ore for the northwest segments of the composite Ima fracture system.

Casto Arch, Idaho

Sources.-

C.P.Ross(1934), Geology and ore deposits of the Casto quadrangle, Idaho, U.S.Geol.Survey Bull.854.

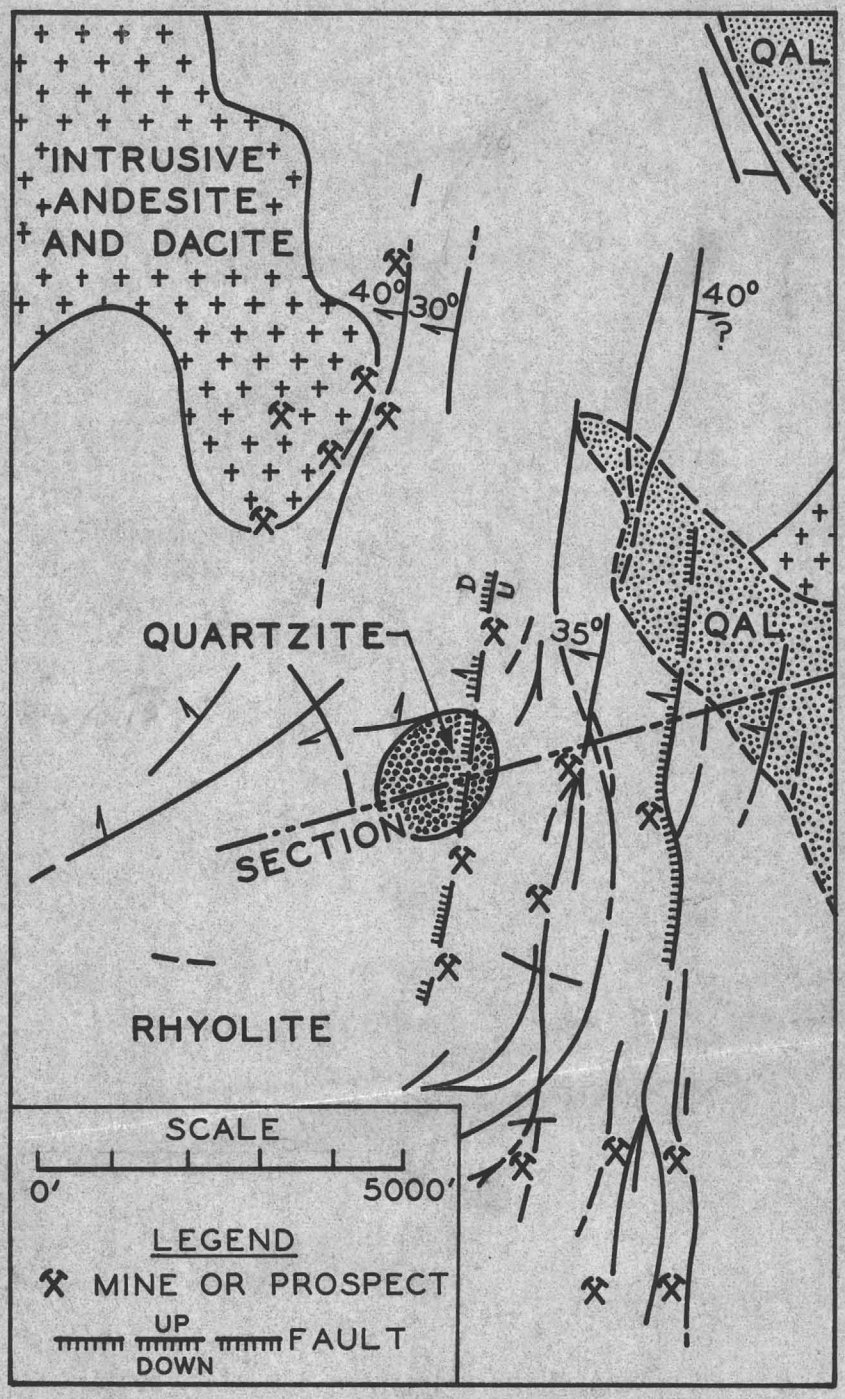
Thor H. Kiilsgaard(1948), Unpublished term paper, Graduate School, University of California.

About 60 miles northwest of the Ima tungsten district a straight northeast belt of granite of Miocene age forms the core of an elongated arch manifested by upfolding of overlying Challis Oligocene(?) volcanics. Granophyre dikes intrude the granite and its cover, striking for the most part with the arch axis and dipping southeast and northwest toward the axial plane. These dikes invaded longitudinal tension fissures formed during the earlier, pre-faulting stage of arching. The faulting stage is represented by a series of antithetic faults oriented like the dike fissures but with downthrows toward the axial plane of the arch. (Ross, 1934, p.77; Plate I).

According to Ross(1934, p.77)

"The faulting may well have proceeded concomitantly with the folding and prevented the full development of the arch."

This notion parallels closely the ideas of H.Cloos concemning graben formation on the crests of rising arches.



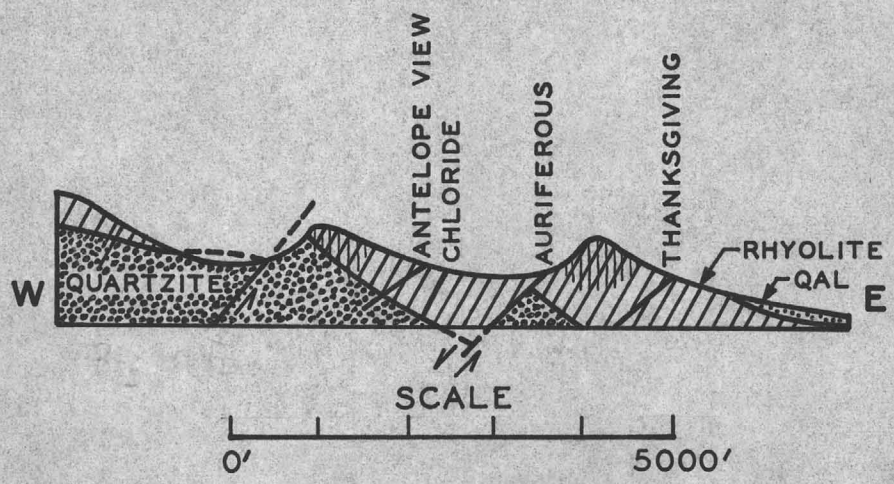
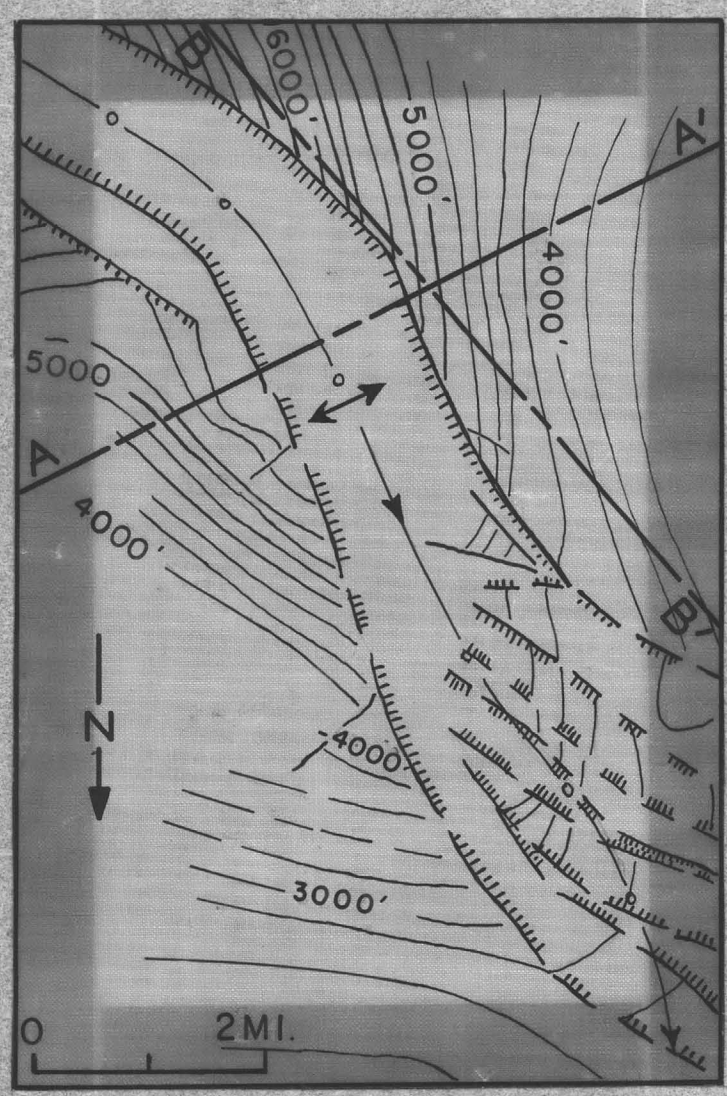


FIG. 22

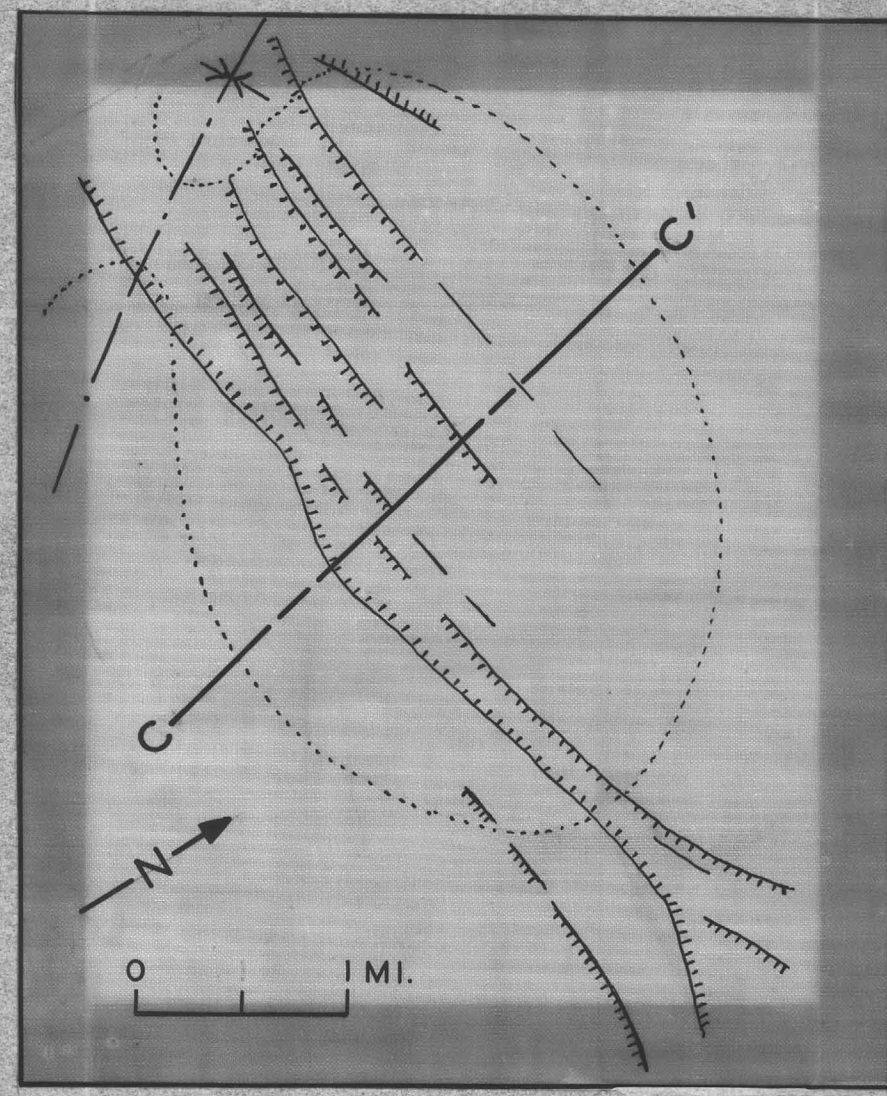
42.9

Print so 5000' = 1 inch

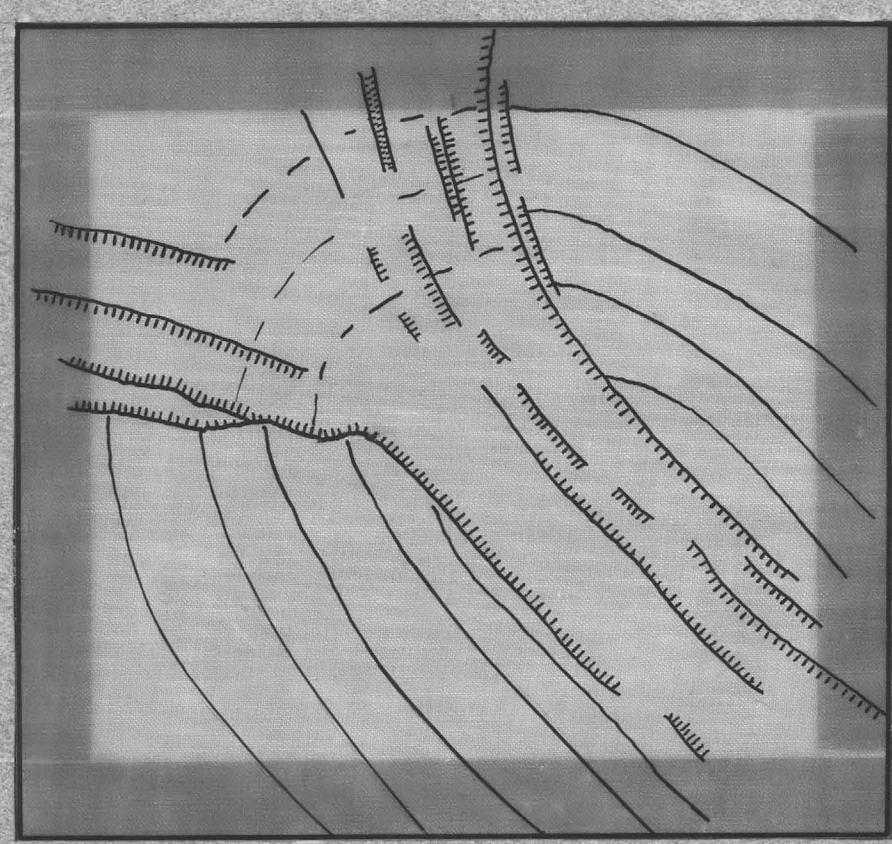
3½



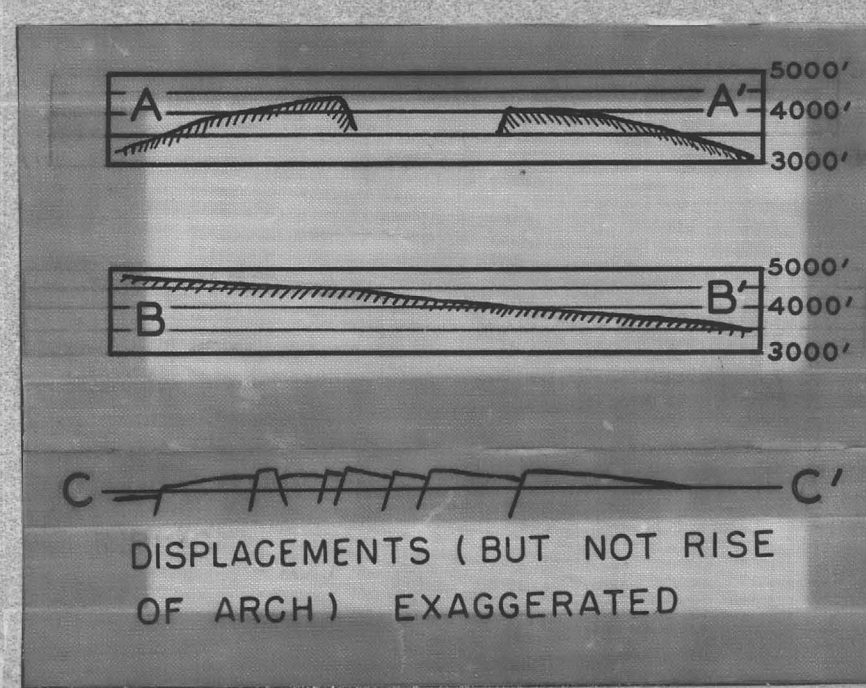
(A)



(B)



(C)



U
D NORMAL FAULT

5000' STRUCTURAL CONTOURS

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- 4" -

FIG. 14

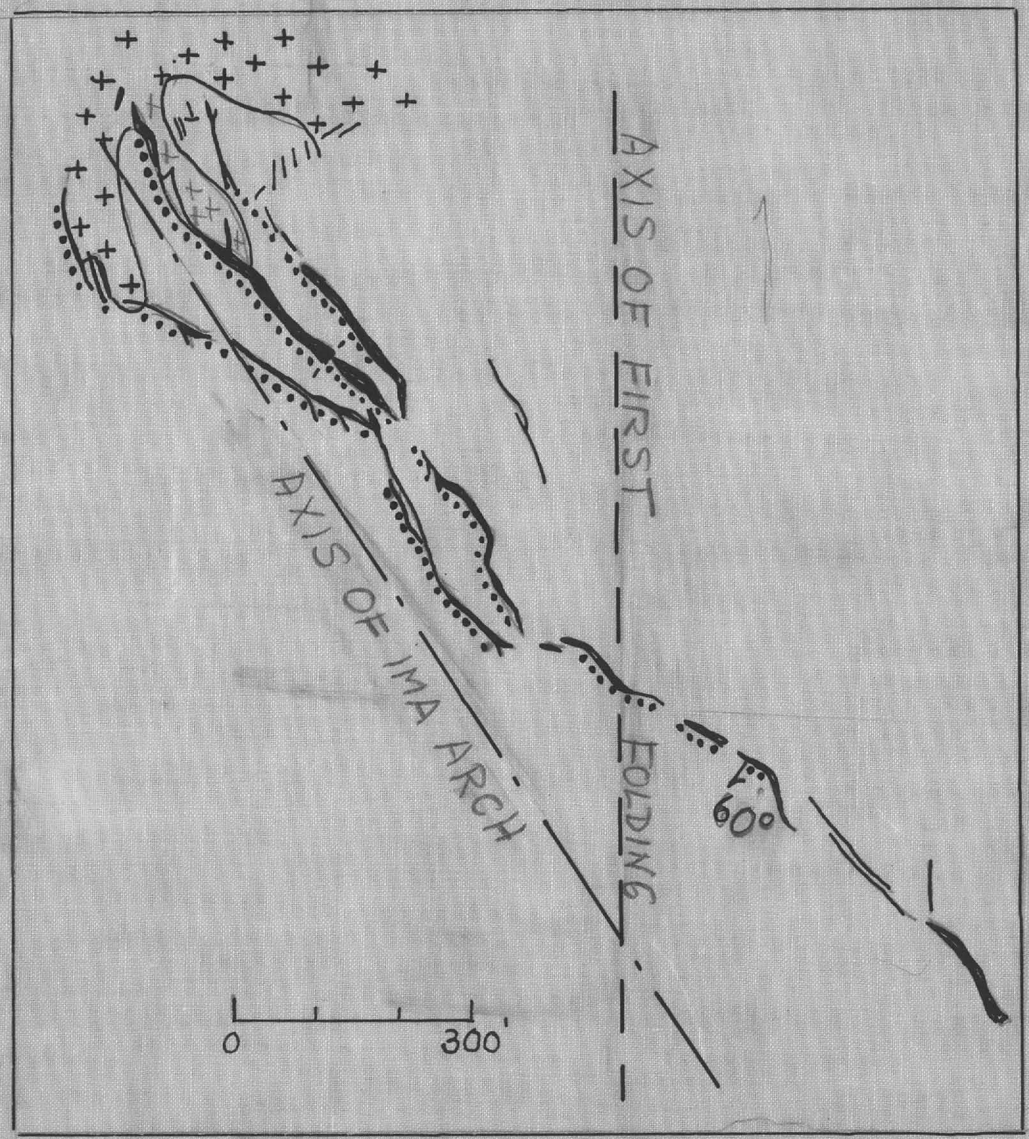


FIG 35A

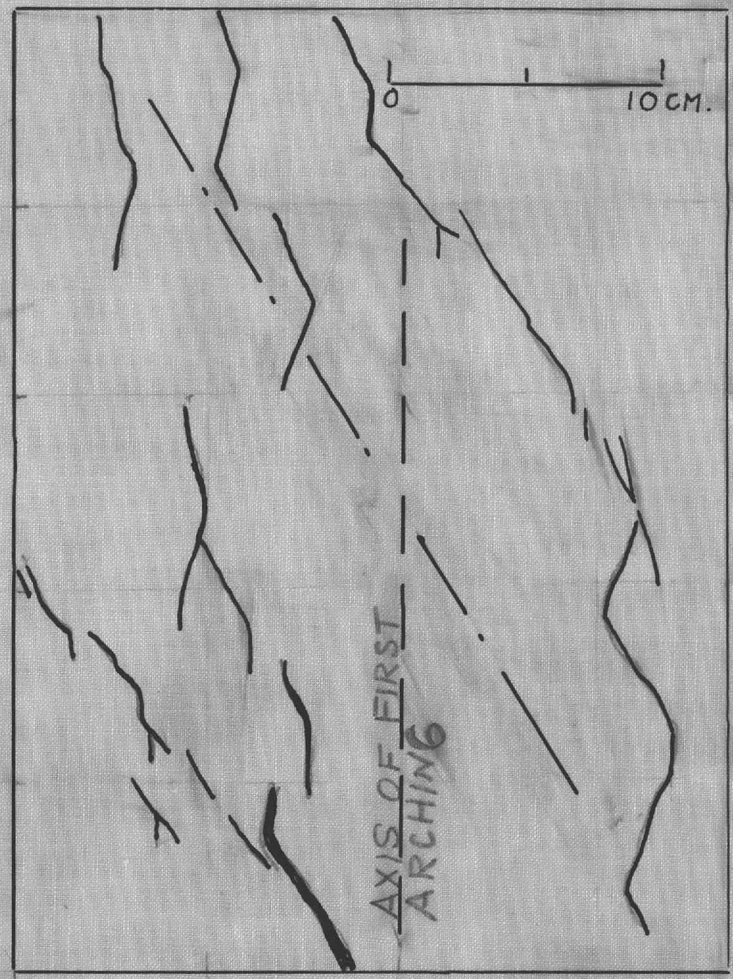
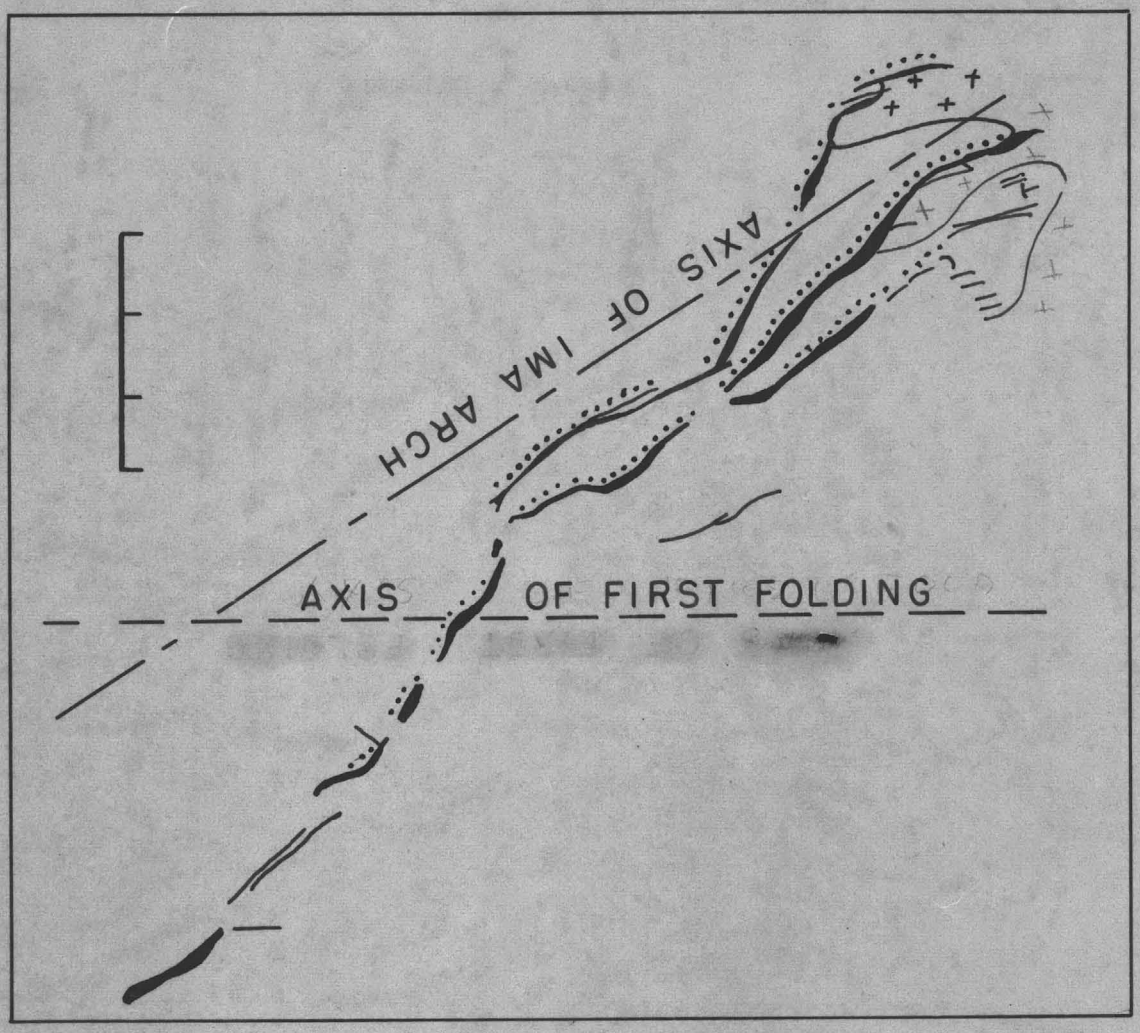
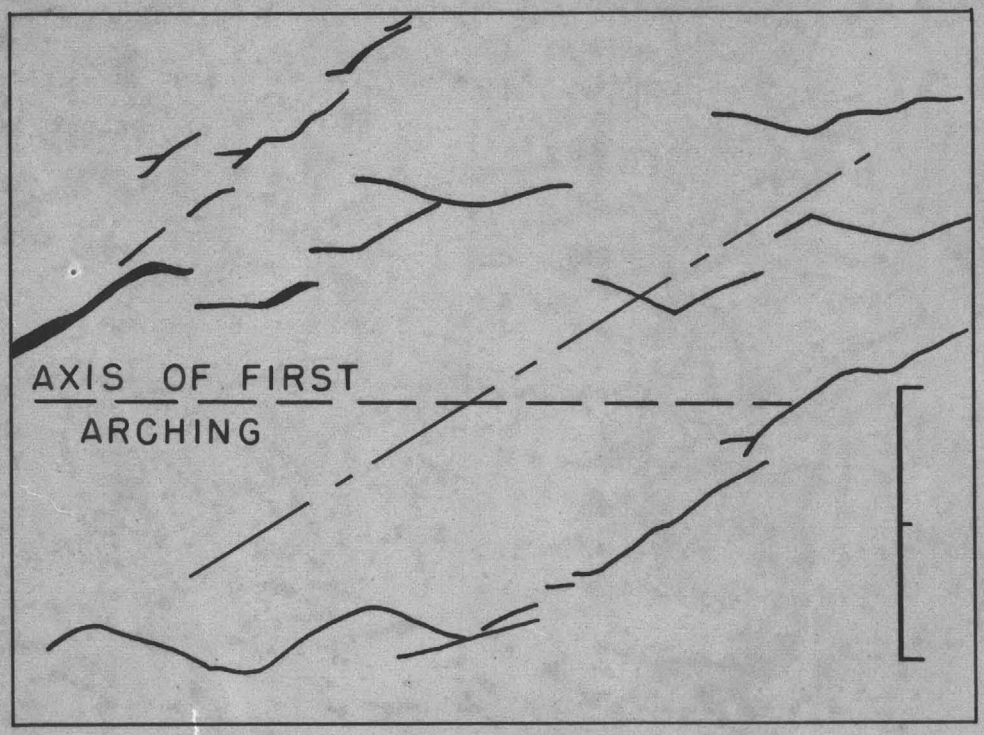
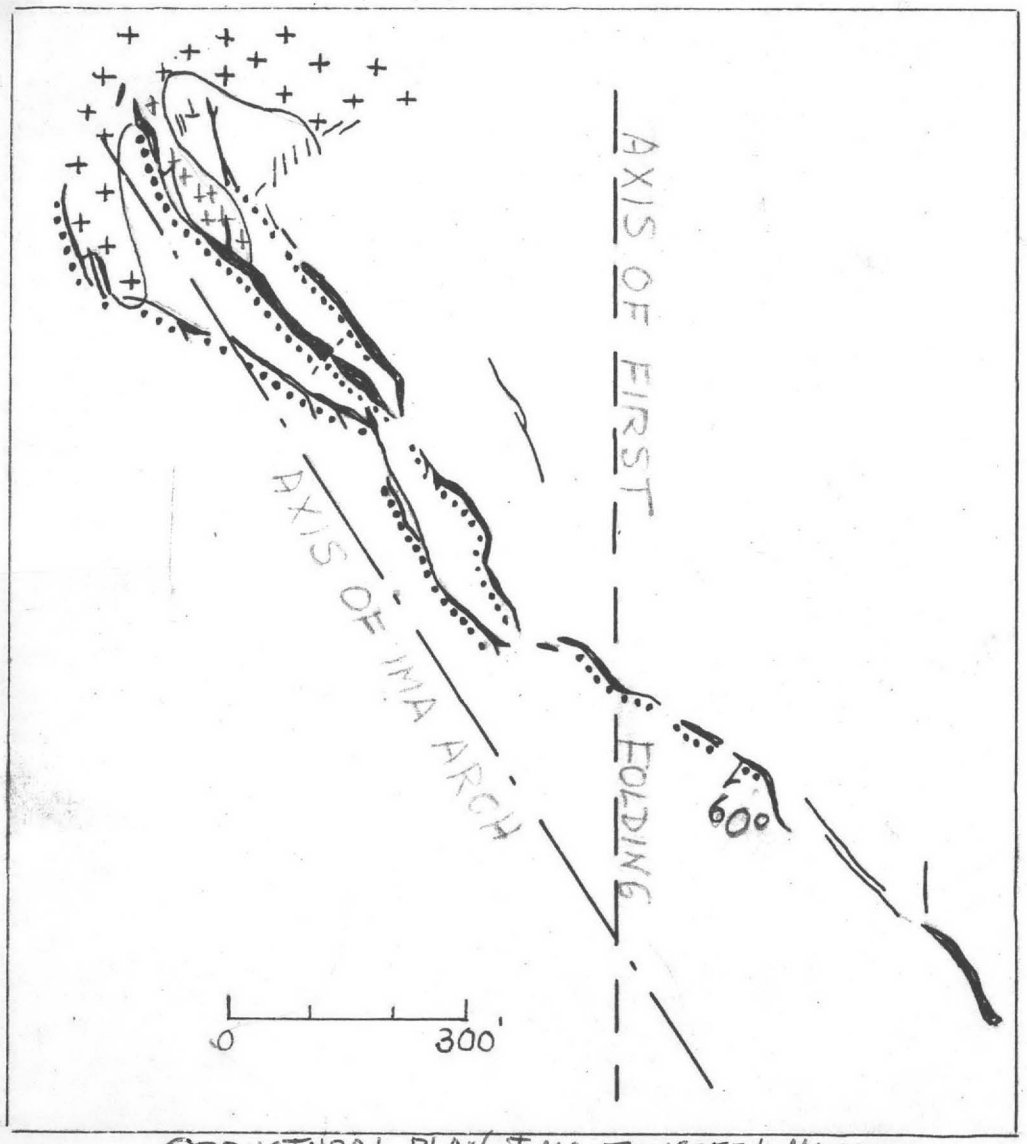


FIG 35B

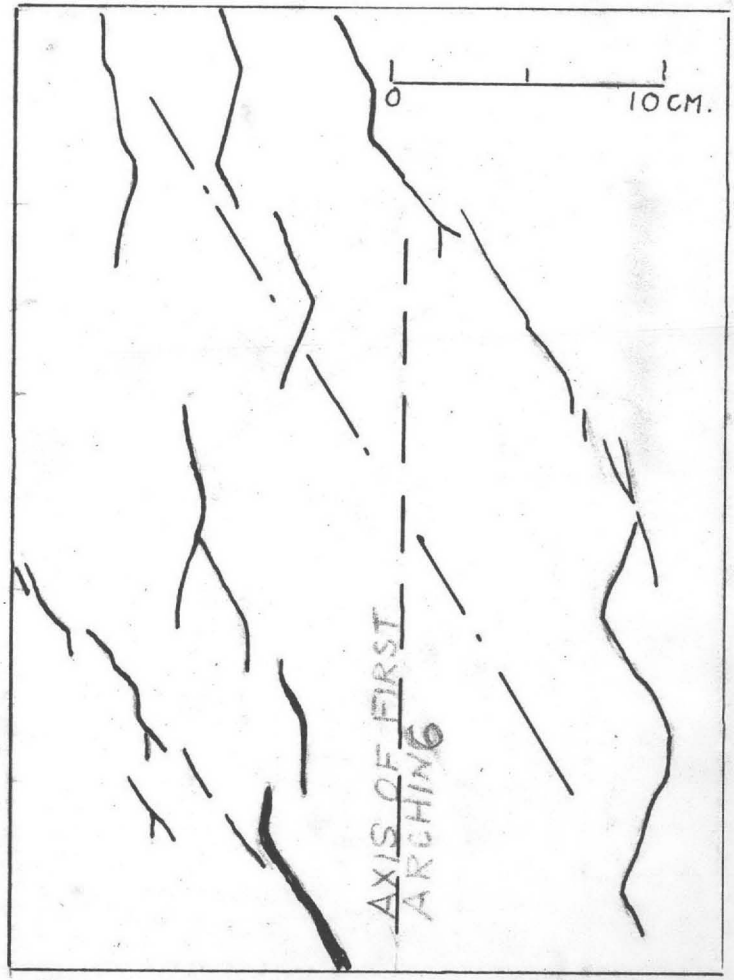

AXIS OF IMA ARCH
AXIS OF FIRST FOLDING


AXIS OF FIRST
ARCHING



STRUCTURAL PLAN, IMA TUNGSTEN MINE

FIG. 35 A



EKKERNKAMP EXPERIMENT, INFLUENCE OF PREEXISTING NOTCHES ON FRACTURE PATTERN DUE TO UPLIFT

FIG. 35 B

TECTONIC ANALYSIS
of the
BLUE WING DISTRICT, IDAHO

Wilson Blake
Min. Eng. 203b
May 6, 1961

TECTONIC ANALYSIS OF THE BLUE WING DISTRICT, IDAHO

INTRODUCTION

The following report is a tectonic analysis of the Blue Wing district, Idaho. This analysis was undertaken as a term project for a graduate seminar, Mining Engineering 203b. The project entailed reviewing the available literature on the district, and applying principles of structural geology and mechanics of rock deformation to determine the sequence of geologic events that culminated in the locallization of the ore body in its present position. This work was entirely from the literature without the benefit of either field or laboratory investigations.

REGIONAL SETTING

The Blue Wing district is primarily a tungsten camp, but there are base metals recovered as a by product- copper, silver, lead, and zinc. The district is on the west slope of the Lehmi Range, in T. 14 N., R. 23 E., and the sole producing mine of the district is the Ima Mine. (Plates 1 & 2) Production to 1940 was 1,210, 805 pounds of huebnerite (manganese tungstate) concentrates, and 4,669 pounds of sulfide concentrates. The milling ore runs .72% huebnerite, 4% sulfides, and 1.75 ounces of silver.[1]

The tungsten mineralization is centered about an irregular mass of granite exposed in the underground workings at the Ima Mine, and is confined to fractures along the crest of a prominant anticlinal fold of quartzitic strata belonging to the

Belt Series - thought to be Pre Cambrian in age. The fracturing is complex, but most of the fractures and fracture zones trend N.30-40° W., parallel to the axis of the arched strata. This trend was the same as the troughs of the Beltian and Cambrian geosynclines, which passed through this area. This is another example of the structural grain established in the Pre Cambrian influencing the later deformation.

ROCK FORMATIONS

There are essentially two rock types in the area, with only the Pre Cambrian Beltian series exposed on the surface. These outcrops are surrounded and isolated by a covering of alluvium.

The Beltian rocks were formed by the metamorphism of feldspathic sandstones and shales. They mostly consist of micaceous quartzite, 6 inches to 2 feet thick, alternating with thin slaty layers. Within the area surrounding the mine the rocks are uniform in character and lack beds of sufficiently distinctive appearance to be used as markers. The rocks have a cleavage which is in most places parallel to the bedding. Near faults and vein zones the bedding is obliterated in much of the hackly structure of the rocks. Most of the metamorphism in the Belt rocks is regional and antidates the intrusion of the granite and formation of veins, but in a zone a few inches wide on the borders of the granite fine grained biotite has developed in the granite.

The lack of variation in lithology and more stratigraphic units can be attributed to the fact that this area lies on the Cordilleran geanticline and has been a positive area since the rise of this geanticline after the Pennsylvanian.

The only igneous rocks visible within the mapped area are the granite and small pegmatite veins that accompany it, on and near the intermediate and lower levels of the Ima Mine, more than 300 feet below the surface. (Plate 3) There is a quartz diorite north east of the district on the opposite side of the mountain range, but whether there is any connection to this intrusion is not known.

The granite is pink and consists largely of orthoclase with abundant quartz, some plagioclase, a little biotite, and some muscovite. All the granite so far revealed in the mine workings contains quartz veinlets and disseminated sulfides and fluorite.

On the basis of a study of thin sections and textural relationships, A. L. Anderson [2] believes this to be a "granitized" body and part of the hydrothermal phase. This report is not concerned with this point as the same tectonics controlled the emplacement of the granitic body and ore deposit regardless of the genesis of the granitic mass.

The orthoclase and quartz of the granite have been unaffected by the mineralization but the plagioclase has been largely sericitized. The contact of the granite and the quartzite is very irregular. Its average dip between 2 levels is about 30° S. ,

and drill cores beneath the lower level indicate it is 18° S. The position of this contact with respect to the veins is of considerable economic importance as the ore shoots thus far mined have shown a zonal relationship outward from the contact. (Plate 6) Veins have been shown to extend downward through the sedimentary series into the granite and the change in wall rock introduces no change in the mineralization of the mine.[3]

STRUCTURE

The major structural feature in the district is an anticlinal upwarp in the Beltian series. (Plate 3) The axis of this upwarp is parallel to the regional trend, N. 30-40° W. The granitic body has intruded this upwarp near the center of the fold. Associated with this fold are premineral fractures which lie east of the crest and parallel the strike of the fold, dipping 60° SW into the center of the fold. There are post mineral fractures which cross these mineralized fractures trending N. 50° E. and dipping 50° N. These displace the veins, hanging walls shifted towards the west, presumably down. This structure has been brought about by at least two periods of deformation - an earlier uplift with possible intrusion, and a later uplift with mineralization.

Most of the veins are small and lenticular, and rarely exceed 100 feet in length and 2 feet in thickness. However a few close to the granite are relatively large. (Plate 3) At greater distances from the granite the veins are more numerous, much smaller

less continuous, and less promising.

The main vein at the Ima Mine, which has been exposed underground for 1,700 feet, penetrates the granite; but before reaching it splits into three branches, each of which diminishes in size as it extends inward from the granite contact. (Plates 4 & 5) The veins and branches pinch and swell abruptly on dip and strike and local swells reach a maximum thickness of 35 feet. The richer ore is found in the wider parts of the veins.

MINERALIZATION

In general there have been two periods of mineralization; an earlier period characterized by the tungsten, and a later period in which the sulfides were brought in. The mineralogy is varied and complex - quartz, fluorite, rhodochrosite, muscovite, sericite, microcline, siderite, and clacite in the gangue; and huebnerite, pyrite, tetrahedrite, chalcopyrite, shpalerite, molybdenite, gratonite, and scheelite in the ore.

There are a whole host of secondary minerals after these minerals in the oxidized zone, but production from them is trivial and not worth mentioning.

Some veins are banded and others have a coarse "salt and pepper" structure - sulfides and huebnerite sprinkled irregularly through the quartz. There is also brecciation in the wider portions of the veins.

The quartz is coarsely crystalline near the granite but tends to a comb habit away from it.

PARAGENESIS

As is frequently found in the tungsten camps of the Western United States as has been shown by Kerr[4], the primary sequence of mineralization is a dominant quartz-tungsten phase followed by a somewhat later epoch of mineralization containing sulfides. At the Ima Mine there is a difference of opinion as to whether the sulfides are early or late, but the majority of the geologists who have studied the deposit favor the later sulfide epoch of mineralization.

The general sequence as determined by Clabaugh[5] is; orthoclase, quartz, and mica in pegmatites; followed by quartz, pyrites, and molybdenite in veinlets; these veinlets are cut by quartz, fluorite, pyrite, and huebnerite in unbanded ore; followed by quartz, rhodochrosite, huebnerite, and sphalerite in banded ore; and finally quartz, fluorite, tetrahedrite, galena, and chalcopyrite also in banded ore, followed by siderite and calcite. (Plate 6)

ZONING

Most of the mineralization shows a zonal arrangement with respect to the granite. (Plate 6) Some pyrite is found in the granite and in early veins, but generally the sulfide deposition began near the margins of the granite and extended out laterally for not less than 2000 feet.

There is also somewhat of a zonal arrangement of the sulfides themselves. Higher zinc is found near the granite while the

lead increases towards the outer limits of the sulfide zone. The present commercial range of the by-product ore was within 1000 feet of the granite contact in 1944.

The huebnerite occurs in the quartz in and near the granite, but becomes relatively abundant outward, and continues for more than a mile from the granite. This is coincident with the outer limit of mineralization.

WALL ROCK ALTERATION

Quartzite is the chief rock involved, but the granite has also been altered, and to a much greater extent. Alteration in the quartzitic zone depends on the distance from the granite for intensity. It is much more evident in the larger more complex veins near the granite than away from it is the smaller simpler veins, and is hardly detectable near the margin of the district.

The altered rocks are bleached, and since the rocks are light originally, the alteration is not too conspicuous. Locally the alteration develops a strong schistisity parallel to the vein borders. Small pyrite cubes are dissemenated in the sericite zone. The alteration is chiefly sericitic, with the wall rocks more or less completely replaced by sericite.

The granite is similarly altered but more intensely. The K-feldspar resisted the alteration and appears fresh, but the plagioclase is almost entirely converted to sericite. The ferromagnesian minerals have been converted to sericite and pyrite. There are seams and veinlets of quartz, mica, and pyrite

that cut the granite, with molybdenite and sericite coating fracture surfaces.

TECTONIC HISTORY

Early History:

From the Proterozoic into the Cambrian feldspathic sandstones and shales were laid down in the Beltian and Cambrian geosynclines. These ancient troughs had trends of N. 30-40° W. During the Pennsylvanian the trough just extended into the region, but if any sediments were deposited they have since been entirely eroded away.

In the Triassic the land mass rose with the Cordilleron geanticline. The sediments were probably metamorphosed to their present state during this period of rising out of the geosyncline. Erosion was taking place as the geanticline uplifted. The region has been a positive landmass since this time.

Critical Period:

During the latter part of the Cretaceous there was a period of intrusion into the structurally high geanticline, as characterized by the Idaho Batholith.

In the late Cretaceous or very early Tertiary there was a gentle uplift due to the intrusion of the granitic cupola. There may have been an earlier period of folding contemporaneous with the rising geanticline which originated the fold, but due to its local extent as determined by the intrusion, it is believed that the local upwarp was initiated by the intrusion. There were some associated pegmatites and orthoclase bearing veins containing mica, pyrite, and molybdenite. These veins

antidate the formation of the fracture pattern since they are later cut by it. The granite does not follow the fracture pattern either which would indicate that the uplift was very gentle and fractures were not formed.

Some time in the early Tertiary there was a period of renewed uplift which was stronger, causing the formation of a longitudenal fracture pattern. The Ima vein was one of these fractures and the horsetailing of the vein was probably due to the fracture dying out as it abutted the granitic mass. This uplift must have been strong enough to crack the cupola and tap the ore chamber. The mineralizing solutions came up and utilized the longitudinal fracture pattern from the uplift. The first solutions contained quartz, fluorite, pyrite, and huebnerite in the unbanded ore. These spread out away from the granite and occupied small fractures parallel to the main fracture zone.

Uplift was continuing and the movement on the tension faults became normal. Next came quartz, rhodenite, huebnerite, and sphalerite in banded veins. The banding indicating a continual process of repeated opening and closing of the veins. The Ima vein formed during this period as the normal movement on the fault locallized openings for ore. (Plate 5)

There may have been a gap in time or a slow continual process, but next there was probably a sealing of the faults by the earlier mineralizing solutions. As uplift continued it became strong enough to refracture the veins causing brecciation

of the already formed ore body and providing openings for more ore solutions. Due to the normal faulting the openings locallized in the steeper portions of the veins, thus the Ima Vein is largest where the dip is steepest. The mineralizing solutions of this last phase of mineralization changed and were characterized by quartz, fluorite, tetrahedrite, galena, and chalcopyrite in banded ore. Repeated opening and closing of the fracture as uplift continued. The last gasp of the mineralizing solutions was probably a phase of siderite and calcite.

Uplift may have continued as there are post mineral fractures normal to the veins which fault the ore. There may have been an arching of the crest of the anticline which caused these fractures, or as at El Oro, Mexico, Wisser[6] relates the later faulting to the rising anticline expanding, and thus stretch- was normal to the longitudinal tension fissures. Here, as at El Oro, the footwall has moved to the east and up.

Erosion was contemporaneous with the uplift, and is continuing until the present. Umpleby[7], in his discussion of the Ima deposit calls attention to the truncation of the fissure veins higher up on the mountain by the Eocene erosion surface, and dates the tungsten-bearing veins as late Cretaceous or early Eocene.

TECTONIC ORE CONTROL

Primarily the ore body was structurally controlled by the normal movement on the fissure veins due to the uplift

at the time the mineralizing solutions were coming up the fissures. (Plate 5) The Ima vein was the recipient of the largest ore body because it was the particular longitudinal fissure that tapped the ore solutions and localized the ore.

GUIDES FOR FUTURE EXPLORATION

In trying to extend the ore body or search for new ore bodies in the district we must use the ore guide established at the Ima Mine - favorable longitudinal fractures along the crest and flanks of the anticline where underlain by the granite.

The development at the mine thus far has been on the north side of the canyon. There are prominant mineralized outcrops on the south side, and since the granite appears to be dipping that way, further exploration in that area might be fruitful. There is also the possibility that there are also complementary longitudinal fractures on the western limb of the anticline, thus a diamond drill hole from the intermediate level to test this hypothesis might be a good possibility and risk.

Due to the alluvium covering most of the area, geophysical methods could be used to trace out the extent of the granite. A simple gravity method would be able to do this. A resistivity method could be tested on the known ore body and if sufficient anomaly was achieved, then up or down the anticline where the granite underlay it would be good localities to use this test. If that particular test didn't give sufficient enough anomaly other methods could be tried.

A final area that should be prospected is the granitic body itself. Since the mineralization was continuing on down into the granite, and since the solutions had to come up through the granite, there is the possibility that there may be areas within the granite that localized ore.

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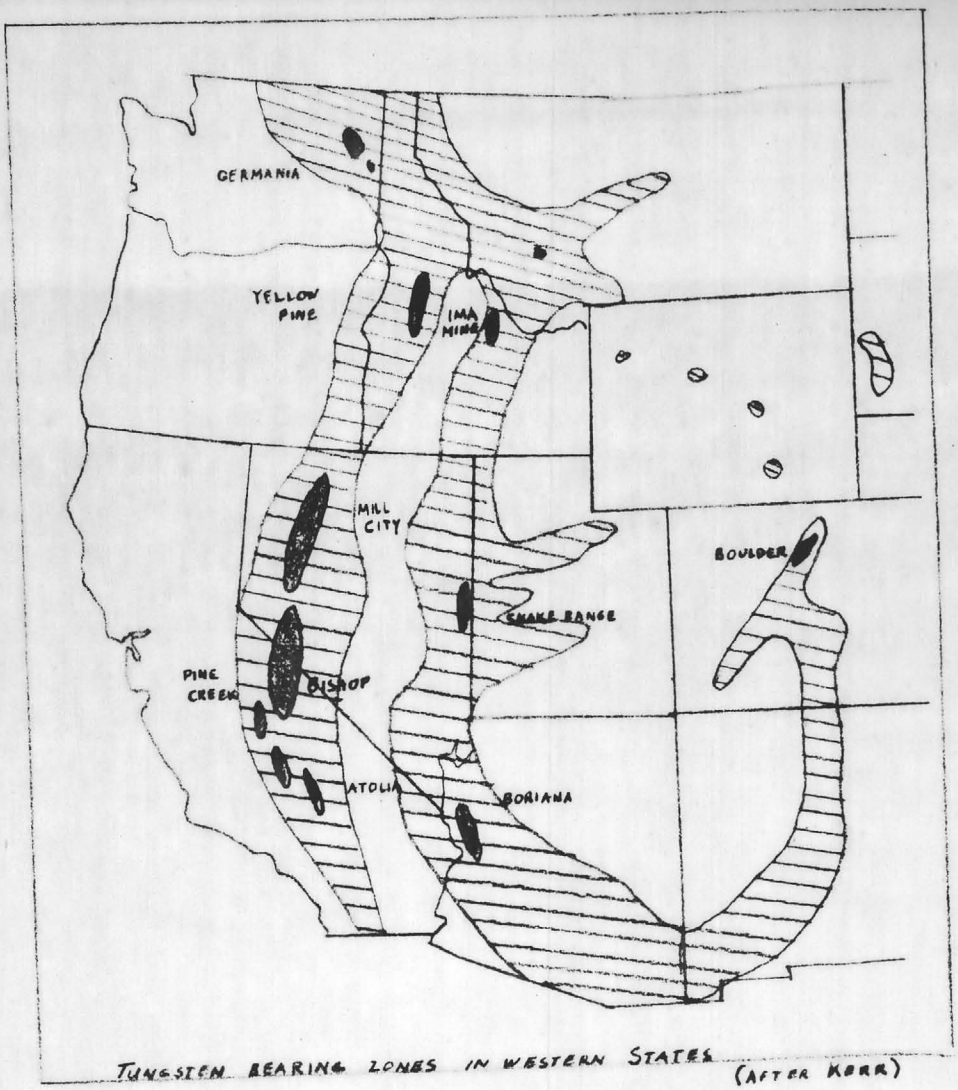
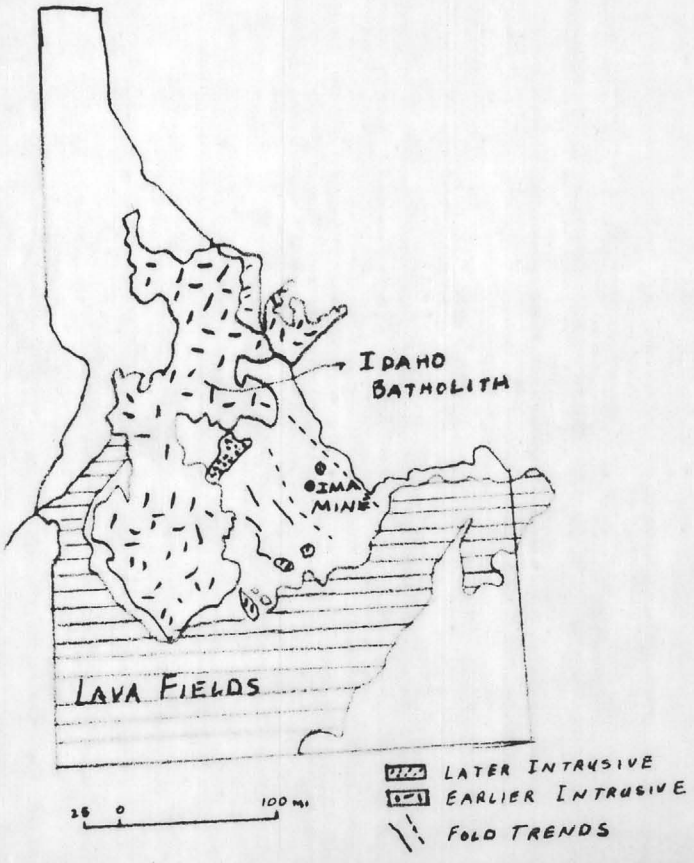


TUNGSTEN BEARING ZONES IN WESTERN STATES (AFTER KERR)

REGIONAL SETTING



(MODIFIED AFTER KERR)

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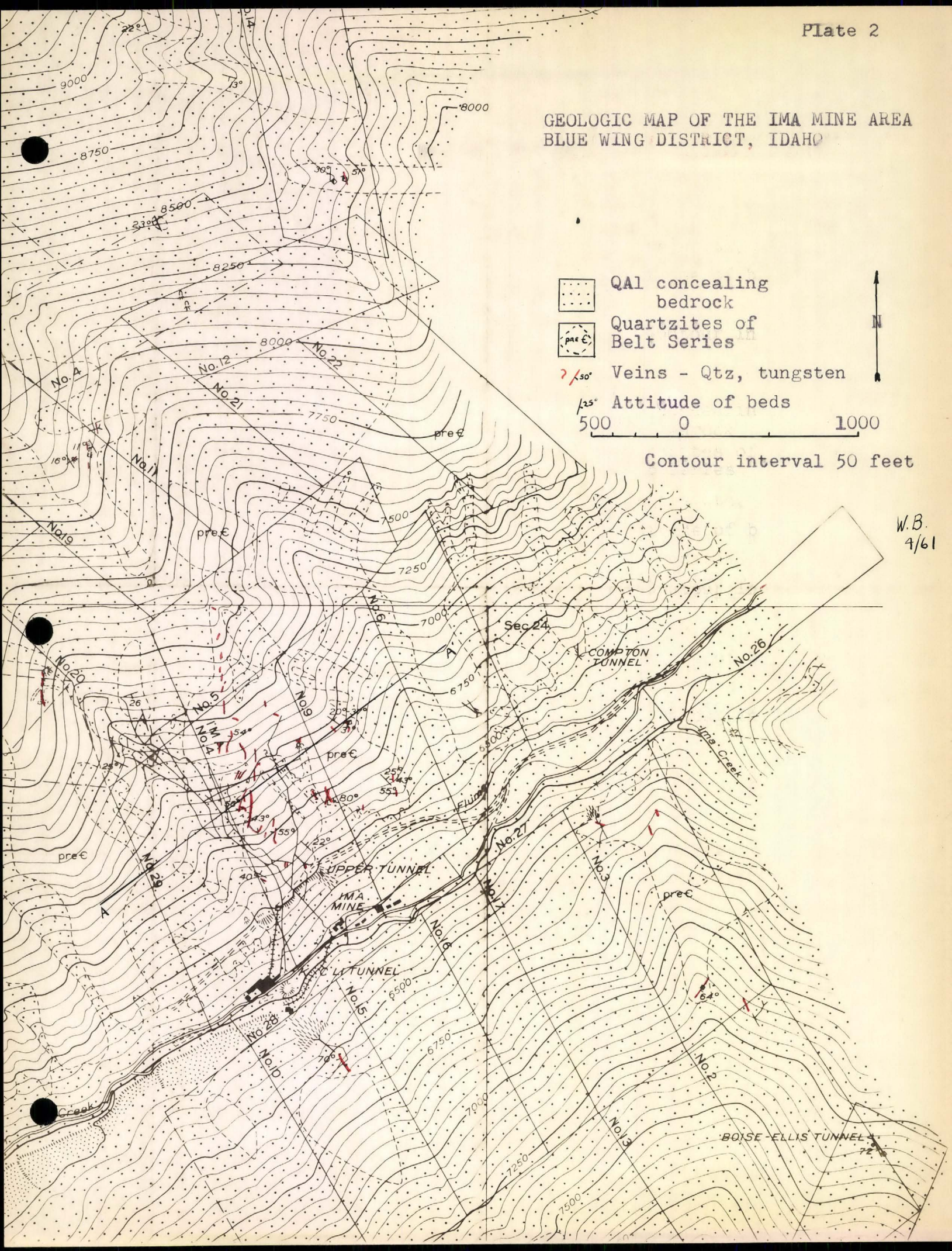
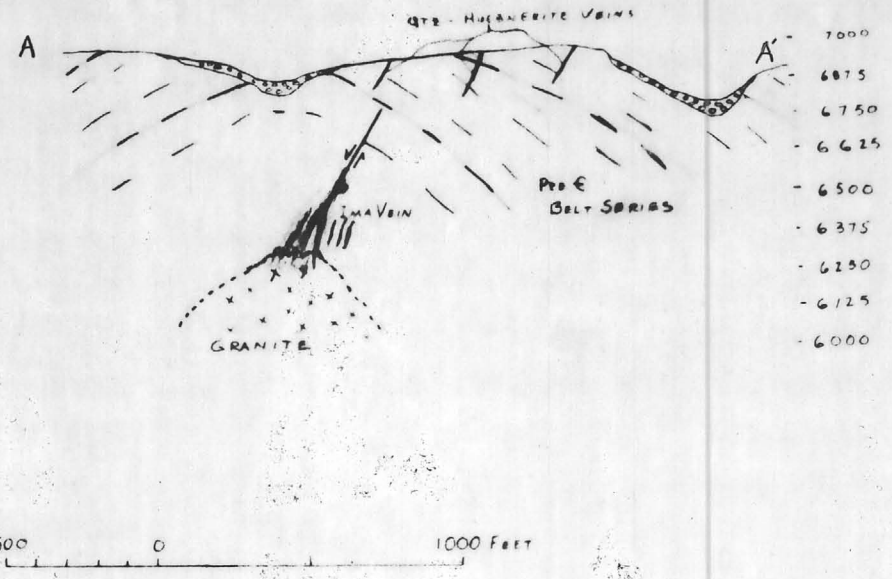
Plate 2

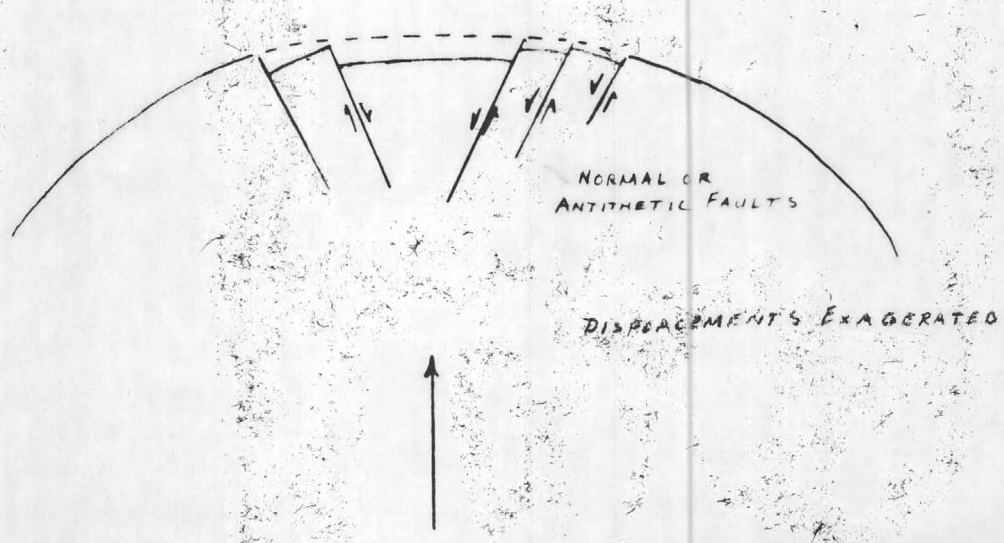
GEOLOGIC MAP OF THE IMA MINE AREA
BLUE WING DISTRICT, IDAHO



SECTION BLUE WING DISTRICT, IDAHO



LONGITUDINAL FRACTURE PATTERN - CLAY EXPERIMENT
(AFTER H. CLOOS)



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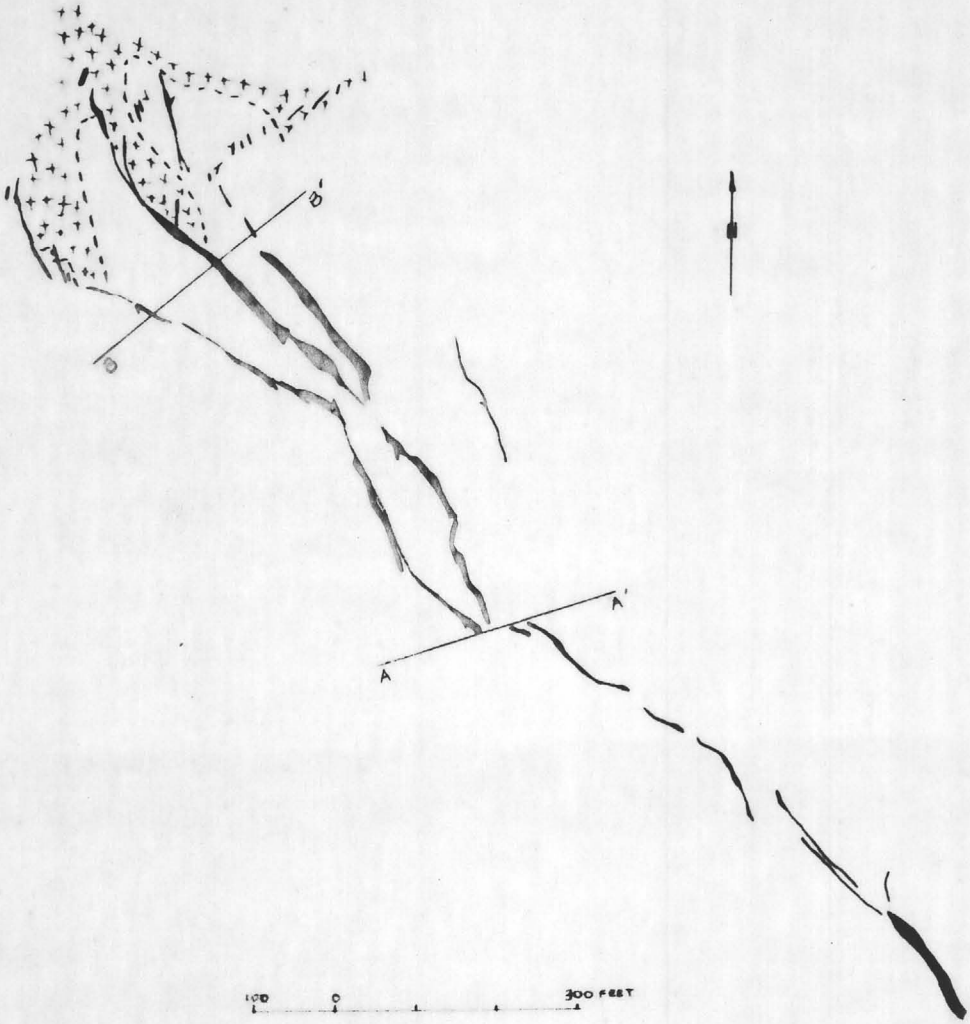

PLAN SHOWING VEINS & GRANITE ON THE LOWER LEVEL OF THE IMA MINE.
(ADAPTED FROM CALLAGAN & LEMMON)

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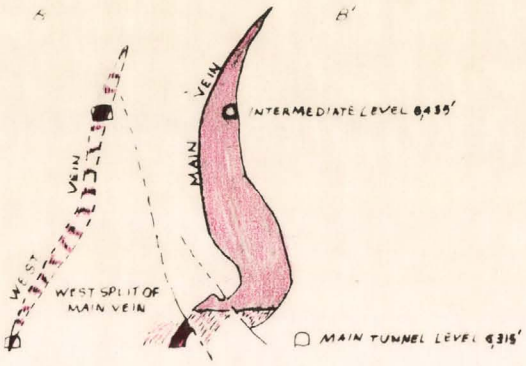
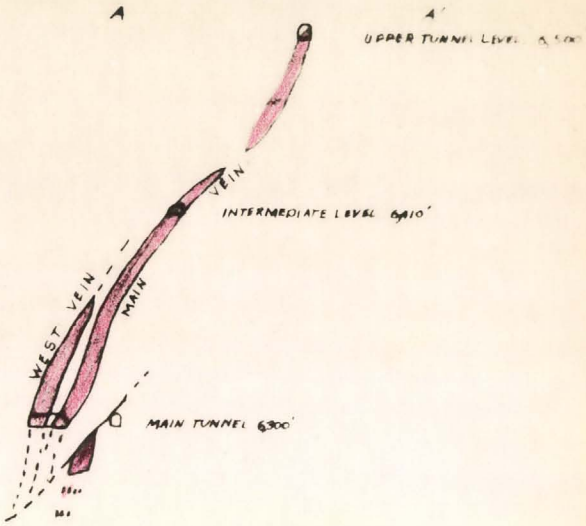
SECTIONS OF THE IMA MINE



SECTION ALONG LINE B-B'

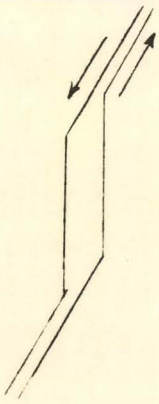


" SECTION ALONG LINE A-A'

100 0 100

(AFTER CALLAGAN & LEMMON)

MOVEMENT ALONG A FAULT PLANE



IN NORMAL FAULTS OPENINGS WILL TEND TO BE FORMED AND CONSEQUENTLY ORE SHOOTS WHERE THE DIP STEEPENS UP OR DOWN THE DIP OF THE FAULT.

(AFTER NEWHOUSE)

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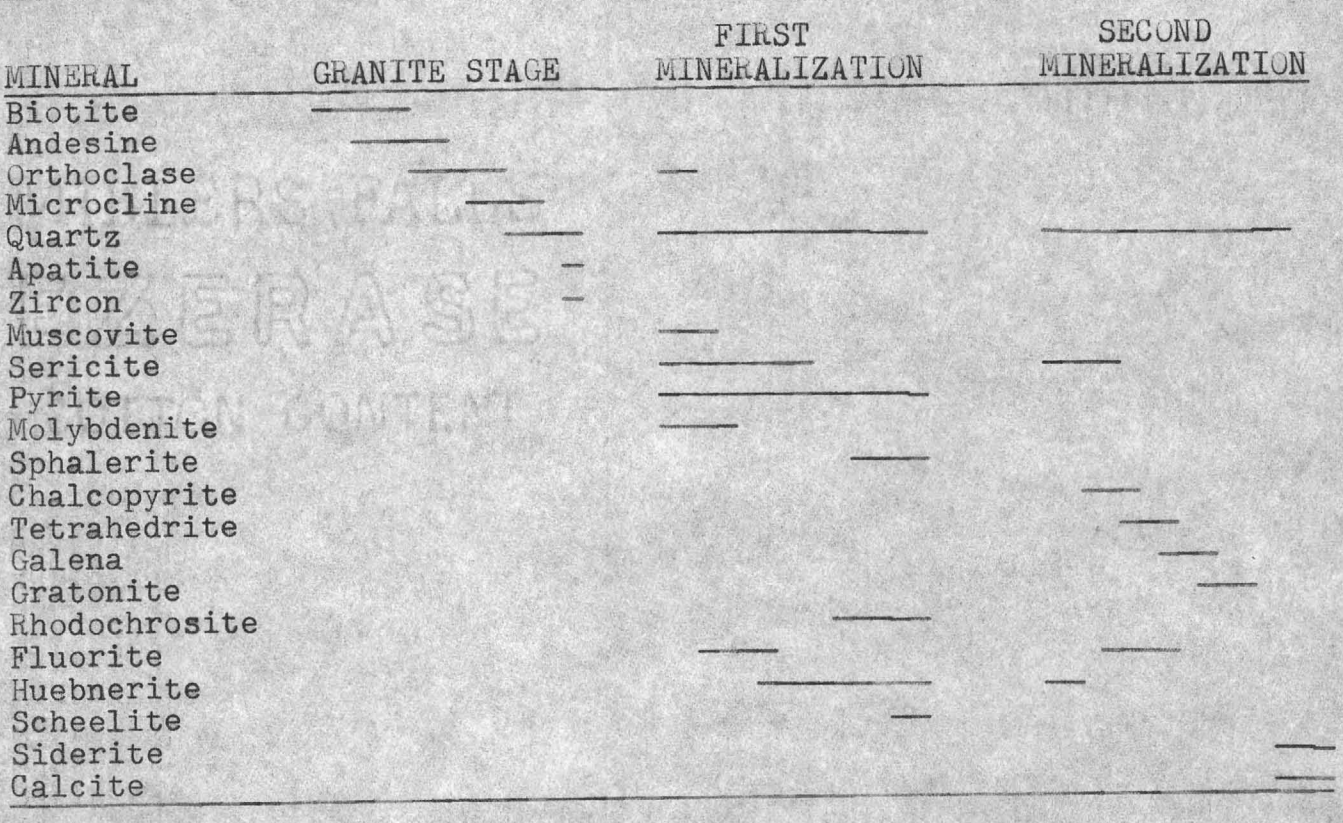
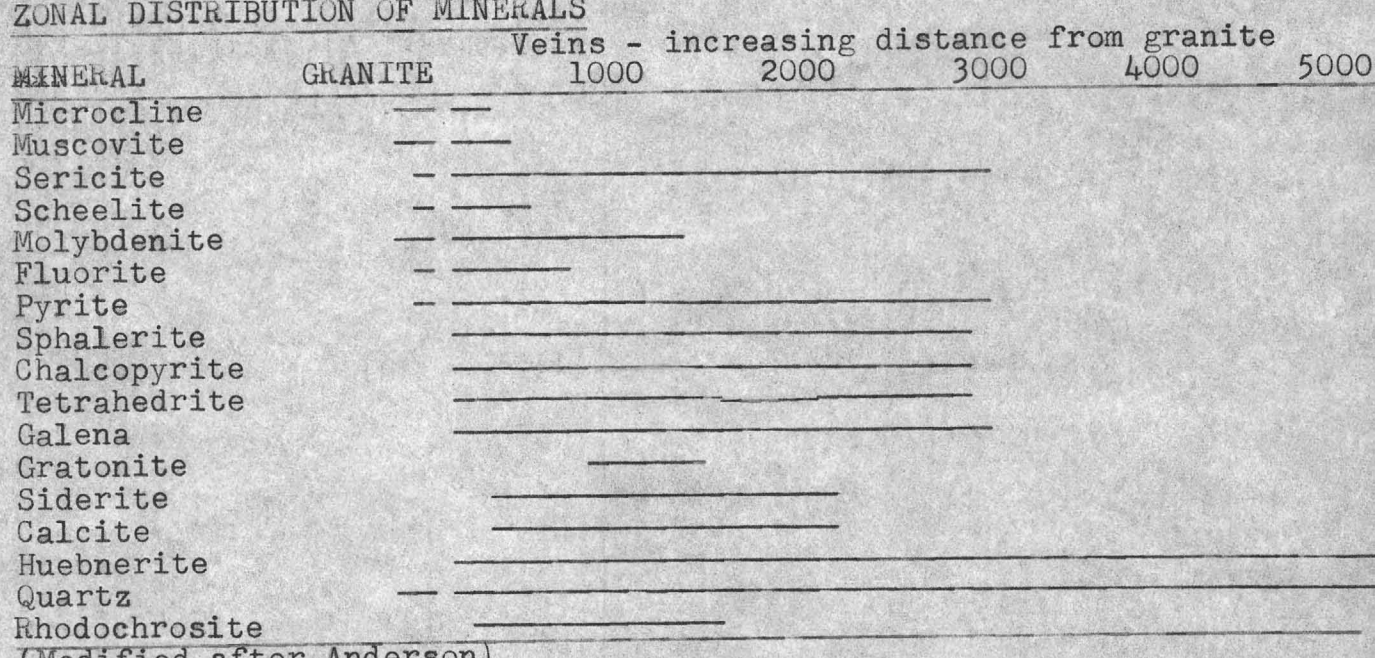
PARAGENESIS



ZONAL DISTRIBUTION OF MINERALS



(Modified after Anderson)