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Rabbit Creek
Gold Deposit

DISCOVERY, GEOLOGY AND MINERALIZATION OF THE RABBIT CREEK GOLD DEPOSIT HUMBOLDT COUNTY, NEVADA

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LOCATION

The Rabbit Creek deposit is located approximately 45 miles northeast of Winnemucca in Humboldt County, Nevada (Fig. 1). The deposit is within the Getchell Trend on the eastern flank of the Osgood Mountains and is in proximity to the Preble, Pinson, Mag, Getchell and Chimney Creek gold deposits. More specifically, the Rabbit Creek deposit is located within Section 19, Township 39 North, Range 43 East, Mount Diablo Base and Meridian.

DISCOVERY HISTORY

Santa Fe geologists first reviewed the Rabbit Creek area in late 1985 after the discovery of the Chimney Creek deposit by Gold Fields Mining Corp. That review proved discouraging, because our property position was a small group of railroad grant sections about a mile or more from the nearest outcrop and appeared to be covered by deep valley fill.

In early 1986, Santa Fe formed a joint venture with the Cordex Syndicate to explore on the pediment north of the old Marigold mine near Battle Mountain. The impact of the Cordex success in discovering the buried South Section Eight ore body caused us to strengthen our own ongoing program in pediment reconnaissance and to re-evaluate the gold potential of company land on trend from known gold deposits, especially south of the Chimney Creek deposit.

In May of 1986, Wayne Bruce, Wade Hodges and Charles Tapper, while conducting helicopter reconnaissance, flew over the Chimney-Rabbit Creek area. Gold Fields was drilling south of the Chimney Creek gold deposit in the valley toward, but still some distance from, our property. Gold Fields' drilling appeared widely-spaced and condemnation oriented, however, reddish piles of waste cuttings indicated that bedrock might be shallow and possibly altered.

With this possibility in mind, a photogeological evaluation of the district searching for lineaments, color anomalies and structural control of mineralization was conducted. Lineaments were found to trend near north-south, northwest and northeast. A strong north-south linear from Chimney to Rabbit Creek was of particular interest, especially where it intersected the northwest and northeast linears.

In July of 1986, using this information as a targeting concept, a reconnaissance drilling program was conducted by Charles Tapper. Ten (10) widely spaced holes were drilled to investigate depth of bedrock, to determine subcrop lithology and to gather information on bedrock geochemistry. The depth to bedrock intersected at that time varied from 40 to greater than 500 feet. Although bedrock was altered, none of the holes contained an ore grade gold intercept, but one hole did intercept 30' of 0.01 opt between 435' and 465'. In addition, trace element data for most of the holes were quite anomalous. Arsenic values of hundreds of ppm and ppm level mercury were common. In view of these results and proximity to a known gold deposit, further drilling was unquestionably necessary.

In October of 1986, a second phase of drilling was conducted consisting of ten (10) more holes. Similar trace element geochemistry was obtained, and the gold values were somewhat better but generally low, although a five (5) foot interval of 0.15 opt in reduced rock was encountered at 500' in one hole. Gold and trace element values generally increased toward the bottom of many holes, but unfortunately most holes bottomed in unoxidized, carbonaceous rock.

In January of 1987, a deeper series of holes with target depths of 800' to 1000', was commenced. The second hole encountered 155' of 0.033 opt Au oxide ore with about 50' of similar grade unoxidized primary mineralization. This was the first ore hole and eventually became part of the low grade oxide reserves of the North Central Area. The fifth hole proved of even greater importance by discovering 145' of .18 opt Au at 630'. This was the discovery hole for the main sulfide orebody which ultimately was found to contain about 1 million ounces of gold.

Drilling activity through 1987 focused on delineation of both the oxide and the sulfide mineralization of the North Central Area. Further exploration of Section 19 was conducted by reverse-circulation holes spaced 800' apart and drilled to a depth of 1000'. The discovery of the reduced mineralization of the West Central and the East Central areas were the result of this program. The West Central Area is relatively shallow and contains excellent grade but has not been sufficiently evaluated. The East Central Area is deeper, is of lower grade and is currently not considered in the reserves.

In late 1987, a hole on the south side of the North Central area found high grade oxide mineralization. In early 1988, we decided to switch from sulfide delineation to pursue this oxide mineralization. This effort identified the largest part, in terms of ounces, of the high grade mineralization now planned for milling.

In mid-1988, the 268 area of oxide mineralization was discovered (Fig. 13). During the last months of 1988, another area of mineralization, the 122 Area, was discovered in the southernmost part of the section. Drilling in 1989 established this area as a significant resource and further evaluation is continuing.

DEVELOPMENT PLANS

From the initial discovery to the completion of feasibility was about 22 months and in March 1989, prestripping commenced. In August 1989, construction began on a 1500 TPD conventional carbon-in-leach mill and heap leach facility. Initial production is planned for September, 1990 at an annual rate of production of 100,000 ounces per year. A second circuit to treat unoxidized ores is being planned.

GEOLOGY OF THE POTOSI (GETCHELL) MINING DISTRICT

The Rabbit Creek gold deposit lies in the Potosi (Getchell) mining district which occupies the eastern flank of the Osgood Mountains (Fig. 2). Although it has only recently emerged as a world-class gold district, the discovery of the Getchell deposit was in 1934. Currently, the annual production is about 435,000 ounces, and at this rate, reserves are sufficient through the year 2000. The Rabbit Creek discovery is six miles east of the old Getchell Mine (FirstMiss Corp.) which has undergone modernization and now produces about 150,000 ounces of gold a year. A newly developed extension to the south of Getchell, Summer Camp Creek, is reported. The recently opened Chimney Creek mine, (Gold Fields Operating Company), produces 200,000 ounces per year. Gold Fields' new South Pit orebody, bordering the Rabbit Creek mine from the north, is reported to have inferred oxide geological reserves of 14,000,000 st of 0.044 opt containing 690,000 ounces (EMJ, 1988a). Gold Fields has also announced the discovery of 2.1 million ounces of sulfide resources below this oxide mineralization (EMJ, 1988b). The Pinson, Mag and Preble mines of the Cordex syndicate are located 10, 9, and 20 miles respectively to the southwest of Rabbit Creek. Combined, these mines produce 85,000 ounces of gold per year, (Kretschmer, 1984; Madrid & Bagby, 1988). The potential for expansion of the Potosi district through the discovery of other covered gold deposits is believed to be very good.

Principal elements of the district's geology include an Early and Late Paleozoic basinal sedimentary sequence intruded by a large Cretaceous (85 - 90 m.y.) granodiorite stock (Holtz and Wilden, 1964; Berger and Taylor, 1980). The stock generated a two mile wide contact-metamorphic aureole that hosts small tungsten skarn deposits. A twenty five mile long structural zone known as the Getchell high-angle fault system bounds the eastern flank of the Osgood Mountains. Several gold deposits, notably Getchell, are associated with this fault system. Gold deposits in this district, except for Chimney Creek, are hosted by the Middle Cambrian Preble Formation and Early Ordovician Comus Formation. In the Getchell area, the unmetamorphosed Preble Formation consists of thin intercalated limestone and carbonaceous shale (Rowell, Rees and Suzcek,1979). The Comus Formation is composed of dolomitic siltstone and carbon-bearing calcareous shale interbedded with basic volcanic rocks (Berger & Taylor, 1980). Both depositional and tectonic contacts of Comus with the underlying Preble are common. Another member of the Lower Paleozoic sequence, the Middle Ordovician Valmy Formation, is present in the district only as small isolated quartzite and greenstone outcrops. The Valmy outside of the area consists of sandstone, micaceous siltstone, cherty argillite and greenstone (Madrid, 1988). These sedimentary and volcanic rocks host gold deposits and represent a broad depositional spectrum across the Lower Paleozoic continental margin. Rocks outcropping in the Osgood Mountains represent some of the westernmost exposures of Paleozoic rocks in Nevada. They broadly coincide with a Precambrian-age boundary between the oceanic crust to the west and continental crust to the east (Solomon & Taylor, 1989). Features of gold mineralization in the district can be characterized as typical for Carlin-type sedimentary-hosted gold deposits (Tooker, 1985; Percival et al., 1988).

The main Chimney Creek gold deposit is hosted by limestones of the Etchart Formation of Pennsylvanian-Permian age. These rocks belong to a younger structural assemblage, the Antler sequence, formed by thrusting over the Lower Paleozoic rocks (Roberts, 1966).

GEOLOGY OF THE RABBIT CREEK GOLD DEPOSIT

STRATIGRAPHY

Quaternary Alluvial Fan

The Rabbit Creek gold deposit is concealed under a large series of coalescing alluvial fans forming a piedmont from the southern end of the Osgood Mountains to the northern end of the Dry Hills. The alluvial fan stratigraphy consists of three main components, loess (10-20′), limestone-dominated alluvium (20-300′) and volcanic-dominated alluvium (300-500′).

Loess occurs across the mine area in a layer from two to six feet in thickness. In many areas, the loess has been fluvially reworked and is mixed with coarse alluvium.

The provenance for the limestone-dominated portion of the Rabbit Creek alluvial fan is the Permian-Pennsylvanian Etchart and Adam Peak limestones of the Dry Hills. The derivation of the volcanic component is the Miocene volcanic rocks of the Snowstorm Mountains, located to the east.

Ordovician Comus Formation

Siliciclastic, volcanic and pelagic carbonate rocks of Lower Paleozoic age are exposed in the Osgood Mountains near the Rabbit Creek Mine. The rocks of the area hosting the Rabbit Creek Mine, are ascribed to the Comus Formation of Early Ordovician age (Fig. 3). Locally the rocks are divided into a lower and upper member. The terminology is informal and does not designate a regional-scale division of the Comus Formation. The Comus assignment is based on two facts. First, Conodont fauna are found about midway within the lower member and Cariocaris crab fossils and Radiolarians are found in upper member. Second, the dolomitic character of the calcareous rocks and the absence of sandstone and quartzite is typical of the Comus Formation.

Madrid (1987) implied that the Comus and Valmy Formations are transitional into each other and represent facies of time-equivalent rocks. The differentiation of these formations as described by previous workers is summarized by Holtz and Willden (1964). Concerning the Comus Formation they state that "sandstone and quartzite are conspicuously absent." Therefore, we accept the lithologic distinction between the Valmy and Comus; the Valmy contains sandstone and quartzite and the Comus does not.

Age

A conodont fauna, consisting mostly of Codilovus proavus, defines the age as Early Ordovician (J. Repetski, 1988, written communication). A similar fauna was identified previously near the Pinson mine in Lower Comus rocks. Another type of fossil, fragments of the phyllocarid crustacean Caryocaris, was found in the Upper member (described by J. Berdan, 1989, written communication). Caryocaris is a Lower Ordovician fauna that is found in abundance in the Goodwin Limestone in Eureka County. The upper member rocks contain a number of radiolarian-bearing chert and siliceous mudstone beds which are also rich in sponge spicules. Radiolarians and spicules of the upper member are characteristic of a pre-Mississippian, Paleozoic assemblage (D. Jones, 1989, written communication). The preservation of the fossils was poor and an unequivocal identification was not possible. Jones's interpretation is based in part on the absence of large, bladed, well-preserved radiolarian spines that are suggestive of a post Devonian age. The Rabbit Creek radiolarians are very different from those contained in cherts of the Mississippian Gough Canyon Formation. The Gough Canyon Formation is reported to host the lower part of the Chimney Creek gold deposit (Osterberg and Gilbert, 1988).

Local Stratigraphic Division

The differentiation of the upper and lower members is based on the following criteria: 1) the percentage of sedimentary rocks to basaltic volcanic rocks, 2) the presence or absence of coarse volcaniclastic rocks, and 3) the content of TiO_2, CaO and organic carbon. The volume of sedimentary rocks in the lower member is about twice that of basalts. In the upper member, basalts are almost one-half of the total rock volume. Beds of coarse volcaniclastic rocks are present only in the upper member and can represent as much as 20% of the section. Sedimentary rocks of the lower member are more calcareous, more dolomitic and contain more organic carbon.

The rocks of the upper and lower members were further classified as shown by a triangular diagram of $CaO-MgO-SiO_2$ (Fig. 5). According to this diagram the upper member's protolith composition is a calcareous silicic mudstone whereas those of the lower member are a calcareous mudstone. The chemical analyses of these rocks are given in Table 1. Note that the upper member rocks are still quite calcareous (average of 5.30% CaO) and magnesian (average of 2.3%).

The ratio TiO_2/Al_2O_3 was used to detect the presence of basaltic material in shales and mudstone. As Figure 6 shows, the composition of black shales of the lower member was not influenced significantly by volcanic activity. Conversely, shales and siltstones of the upper member have a high average content of 2.67 wt. % TiO_2 and the TiO_2/Al_2O_3 ratio of 0.24 which is similar to the ratio of 0.22 of the source basaltic rocks.

Lithologies

On the basis of grain size, the host rocks for Rabbit Creek gold mineralization are classified as claystones and siltstones given the predominance of clay-size (less than 4 microns) and silt size grains (from 4 to 60 microns). Sandstones are rare or absent. Using field oriented descriptive features, the claystones are further classified into fissile and laminated shales and more massive mudstones. Both shale and mudstone rocks are calcareous, however true limestones at Rabbit Creek (>75% calcite) are uncommon, in fact, rocks with more than 50% calcite are rare. Also present at Rabbit Creek are microcrystalline bedded siliceous sediments such as chert and siliceous mudstone. These rocks, in places, contain relatively abundant skeletons of radiolarians and sponge spicules. The chert-mudstone boundary is defined as 30% silt-sized detrital component. Due to widespread hydrothermal silicification, the distinction between primary cherts and completely silicified mudstones is difficult.

The total thickness of the stratigraphic section known by core and rotary drilling is about 1200 feet. The thickness of the lower member is about 560 feet in the North Central Area and is comparable to a similar section of about 780 feet in the south. The thickness of the upper member is as much as 570 feet.

LOWER MEMBER - BLACK SHALE, CHERT, MUDSTONE AND SILTSTONE

The lower member contains, by volume abundance, twice the percentage of sedimentary rocks than igneous. Most of the sedimentary rocks of the lower member are shales and mudstones. They are more calcareous, dolomitic and organic-rich than those of the upper member.

The shales of the lower member are thinly laminated and typically fissile. The laminated character decreases as calcareousness or siliceousness increases. Unoxidized shales and mudstones are dark-gray to black and become grayish orange where oxidized.

The shales can have non-planar and disturbed bedding. Where present the beds are deformed by plastic deformation indicating a prelithification disturbance. These contortions are much like load features or microfolding common to slump blocks.

Rocks composed of shale clasts can be either shale breccias or conglomerates. The distinction of the two varieties is based on the angularity of the clasts, the sharpness of contacts and the presence or absence of grading. Shale breccias, that appear to be tectonic and post-depositional, contain fragments, both rounded and angular, of similar lithology to the enclosing shales. The contacts of these breccias are indistinct and transitional. Conversely, shale-fragment conglomerates are composed of rounded rip-up clasts and have a distinct lower contact. The beds of conglomerate are generally graded and have a gradational upper contact.

Interbeds of light-gray to yellowish-gray siltstones are present in places. The rock volume abundance of the siltstones varies. Each siltstone bed is finely graded with a sharp, conformable base. The siltstone beds (or laminae) are poorly sorted and have submature texture. In areas, compaction has separated the thinner beds into a boudinage texture.

By microscopic 'nalysis the shales and mudstones composition can be described by six constituent minerals and radiolarians. The constituent minerals are calcite, dolomite, illitic clay, pyrite, organic carbon and quartz.

Calcite

Calcite occurs in two morphologies, micro-lenses and clastic fragments (intraclasts ?). The calcite micro-lenses were probably originally micrite or calcareous ooze. The micrite was diagenetically recrystallized into a coarser mozaic. Based on modal analysis of thin sections the average amount of calcite is 16%. The size of carbonate grains within lenses ranges from 20 micron to 8 mm. Intraclasts of carbonate are less common (3%) and occur in layers with detrital silt and sand grains and cubic grains of pyrite. The fragments range in size from 30 micron to 5mm.

Dolomite

Dolomite, evidenced by rhombic morphology and confirmed by staining of thin sections and by SEM analysis, is present in amounts ranging from 1% to 3%. Dolomite occurs in clusters of small (about 10 micron) anhedral crystals that were probably formed as a product of the original deep-water sedimentation rather than secondarily in open voids. In unaltered organic-rich shale the dolomite is iron-poor.

Illitic Clay

Clays are diagenetic illite of dioctahedral type (2 M). It occurs as random flakes in mudstone. The average amount of illite is 17%. In laminated shales and especially tectonically deformed folded shales, illite has a strong preferred orientation that defines a foliation parallel to bedding but in some cases at an angle to it. Such shales may even be considered phyllites, however, they lack any evidence of high temperature metamorphic minerals and are believed to be formed by highly directed stress.

Pyrite (Iron Oxide)

The pyrite (iron oxide in oxidized shale) occurs in three morphological groups: framboidal, disseminated and cubic. Framboidal pyrite (iron oxide) occurs in round clumps. The size of individual grains within these clumps ranges from 4 to 30 micron. The amount of framboidal pyrite varies from 5 to 15%. Often the original pyrite grain is so extensively oxidized that the surrounding matrix is iron-stained. This pyrite is interpreted to be diagenetic.

Pyrite that has no definite morphology has been classified as disseminated or "amorphous". It ranges in size from 2 to 20 microns. Often it is concentrated in stringers, selveges of veinlets or acts as a cement. This variety is common, averaging about 5%, and has been shown to contain gold and arsenic.

Cubic pyrite (1%) is represented by square grains ranging in size from 2 microns to 2 mm. Often they occur in layers with detrital quartz and sometimes are surrounded by quartz fringes. The quartz fringes are generated when quartz mobilized by pressure solution is redeposited in the pressure shadows of the pyrite.

Organic Carbon

Black shales of the lower member contain from 0.6 wt. % to 1.5% total organic matter and, therefore, may be considered as source rocks, albeit poor, for liquid hydrocarbons. The organic matter has a marine derivation and was deposited under reducing conditions. This interpretation is based on the ROCK-EVAL and gas chromatography results and on large concentrations of such biomarkers as tricyclic terpanes and high proportions of C27 and C28 steranes.

Organic matter occurs in shales as microlenticular concentrations parallel to bedding. Megascopically organic matter is observed as opaque clots in organic-rich bands and as translucent coatings in organic-rich veinlets. About 90% of the organic matter is represented by thermally mature kerogen, a high molecular weight polymeric residue. In polished sections the kerogen observed is almost entirely black, amorphous and grainy. Oval and round particles in kerogen, sometimes with a boxwork texture, resemble algae remnants. The organic petrography and reflectance data show that the kerogen has undergone very strong heating and thermal maturation, from 4 to 5 Ro. Such highly matured kerogen has been converted to meta-anthracite.

Organic matter also contains highly reflective white fragments of solid pyrobitumen, that is considered to be a remobilized organic matter. Pyrobitumen occurs in stylolites and in "gash" microfractures in calcareous shales. The microfractures are very abundant in the axial part of the Conelea Anticline and apparently developed during folding. Flooding of pyrobitumen veinlets in calcareous shale makes the rock sooty, soft and very black. The shales also contain visible translucent veinlets of pyrobitumen. Carbon enrichment and bitumen remobilization are considered a pre-gold mineralization event.

In addition to the described types of organic carbon, the lower member shales contain bitumens or saturated hydrocarbons, extractable by the use of methanol chloride organic solvent. The total amounts of bitumen extracts ranged from 30 to 80 ppm. The gas chromatography results shows that the "light" and "heavy" n-alkanes are present, and could be interpreted as indigenous and remobilized hydrocarbons.

Not all of the dark coloration is attributable to carbon, in places it is a very fine-grained powder of sulfides, principally pyrite. In parts of the ore body the rock has a very strong odor resulting from the combination of hydrocarbons and sulfur.

Quartz

Silica occurs as detrital quartz and in a microcrystalline form. Detrital quartz represents an original clastic component, while the microcrystalline form reflects either a chert or a hydrothermal silicification event. Rounded detrital grains range in size from silt (4-60 micron) to sand (60-500 micron). The detrital quartz grains are commonly concentrated in layers. The amount of detrital quartz reaches 12% and averages 8%.

Radiolarians

Some cherts and mudstones contain ovals or balls identified as silicified or pyritized radiolarians. The poorly preserved radiolarians had simple, spherical and elliptical spines. The rocks also contain numerous elongate and cylindrical sponge spicules (D. Jones, written communication).

UPPER MEMBER

The upper member contains the following lithologies: basaltic rocks (50%), basaltic hydroclastic tuffs and coarse volcaniclastic rocks (20%) and fine-grained siltstones, cherts and shales (30%).

Basalts

Basalts are stratigraphically significant at Rabbit Creek. First, the basalts are concordant with the sedimentary bedding which allows them to be used as stratigraphic marker beds. Second, their chemical and mineral compositions and textures often vary. Most of the basalt rocks are believed to be flows because of the extreme concordance with bedding, the presence of vesicles, pillow structures and load-features of the underlying sediments The differentiation between flows and sills is difficult and, in the past, some of the rocks that are now thought to be flows were named as "sills". In the interests of continuity of nomenclature the names are still used.

Six principal basaltic flows/sills are recognized in the Rabbit Creek section. Three of them occur in the upper member. These beds are the Upper Sill/341 Porphyry, (thickness 20-30 meters), Top Sill/311 Porphyry (thickness 20 meters), Northern Sill/316 Porphyry (thickness 30 meters). The lower member hosts the Main Sill (thickness 10-30 meters), the HGO Flow/Jack Rabbit Flows (thickness varies from 1 to 10 meters) and the Mafic Porphyry, a sill near the base of the known stratigraphic section. The thickness of Mafic Porphyry varies from 2-3 meters in the North-Central Area to 70 meters in 122 Area.

Basaltic rocks contain phenocrysts of clinopyroxene, plagioclase and olivine and have either porphyritic or aphyric texture. Phenocrysts constitute 20-30% of the rock volume. The texture of most basalts is doleritic or ophytic. In the doleritic text, small grains of monocline pyroxene occur between large plagioclase phenocrysts ranging in size from 0.25 mm to 5 mm. Olivine phenocrysts are rare but present.

Basaltic flows, such as the HGO and Jackrabbit, are massive lavas with pillow margins. Vesicles and amygdules may constitute as much as 10 to 15% of rock volume and are rather large in size (10-20 mm). A CO_2 gas phase during extrusions is shown by the existence of vesicles (Moore, 1979).

Perhaps the most distinctive of the basaltic rocks, the Mafic Porphyry, contains large, up to 1 cm, phenocrysts of Mg-rich olivine, Mg-rich hypersthene and Ca-poor pigeonite. The rock also contains 2 to 5 % of phlogopite mica with flakes up to 0.5 mm in size. Apatites constitute not less than 1%. This is an ultramafic rock that closely resembles a two-pyroxene peridotite or lherzolite. Chloritization and carbonatization are the principal alteration processes in these rocks. Carbonate veinlets cut through the phenocrysts and groundmass. The rock is structurally foliated in tight microfolds. The distinctive character of this porphyritic rock was instrumental in compiling the stratigraphic picture.

All basalts are altered, and contain two alteration assemblages. The "early" alteration assemblage, albitization and propylitization (chlorite, calcite and minor epidote) is caused by low-temperature zeolite-greenschist metamorphism and is rather typical for Ordovician basalts of the Robert Mountains Allochthon (Madrid, 1988). The "late" alteration assemblage, silicification and argillization, are related to the gold deposition and are described in the next chapter with the mineralization.

Although the major element chemistry of basalts has undergone some changes caused by low-temperature metamorphism and hydrothermal alteration (i.e., mobility of K_2O, Na_2O and MgO and the introduction of SiO_2, H_2O and CO_2), the trends on Figures 7 and 8 are believed to be valid. The sample base of these diagrams is more than one hundred analyses. Each whole-rock sample was verified by mineralogic and petrographic observations combined with the data for such alteration-resistant elements as Ti, Y, Zr. The data demonstrates that the Rabbit Creek igneous rock suite is composed mainly of tholeiitic basalts (i.e., Main Sill) and of a lesser amount of alkalic basalts (i.e., Upper Sill).

If further divided into two groups based on Ti content, the basalts of the Upper Sill and 341 Porphyry, the HGO Flow and the Mafic Porphyry constitute a "High-Ti" group whereas those from the Main, Top and Northern sills form a "low-Ti" group (Fig. 10). The high-Ti basalts vary in TiO_2 content from 2.60 to 5.53 wt. % with an average of 3.95 wt. %, while the "low" Ti basalts vary from 1.20 to 2.42 wt. % TiO2 with an average of 1.81 wt. %. Such high titanium contents are characteristic of alkalic basalts such as melilite and of some lamprophyres that contain titanium-rich olivine and augite along with abundant titanomagnetite, rutile and anatase.

Hydroclastic Tuffs and Associated Coarse Volcaniclastic Rocks

Hydroclastic tuffs and coarse volcaniclastic rocks comprise almost 20% of the upper member's thickness. As demonstrated by deep sea drilling and mapping, hyaloclastites, hydroclastic tuffs and their reworked products represent the most widespread submarine rocks (Bonatti, 1965). At Rabbit Creek, coarse-grained hydroclastic breccias are interbedded with fine-grained hydroclastic siltstones and pillow-lavas. Differences in brecciation, fragmentation and depositional mechanisms has generated a large variety of hydroclastic rock types. Similar hydroclastic tuffs and breccias have been recently described in the Valmy Formation in north-central Nevada (Watkins and Browne, 1989).

Pillow breccias, where angular clasts of amygdaloidal pillow basalts occur in a glassy matrix, are mostly matrix supported. The clasts are generally lapilli size and comprise 20-40% of the rock. Basalt pillows contain 15-25% vesicles which are arranged either in concentric or bedded fashion. The large amount and coarse size of vesicles is explained by a considerable mechanical intake of external water into a basaltic magma erupting on a sea floor.

Hydroclastic rocks of the upper member consists of a large percentage of angular, vesicular, glassy clasts which originated from pillow basalts. The hydroclastic breccias and tuffs are strongly altered. Volcanic glass is altered to clay and iron oxides. Pyroxene and olivine phenocrysts are completely altered to serpentine, while plagioclase phenocrysts are completely altered to clay and quartz. Vesicles are filled with clay, carbonate and zeolite. Veinlets of carbonate, minor pyrite with sericite and quartz veins developed diagenetically in the volcaniclastic rock after the hydroclastic disaggregation.

Reworked volcaniclastic rocks occur as beds ranging in thickness from several centimeters to 4 meters. Typically, they consist of several types of fragments that include vesicle-rich glass, clear vesicle-poor glass and siltstone. The clasts are cemented together by hematitic carbonate. Virtually all the vesicles within the clasts are filled with kaolinitic clay. Siltstone clasts are composed of rounded quartz grains in a clay matrix. The presence of siltstone lithic fragments highlights the epiclastic origin of these rocks.

Siltstones, Mudstones and Shales

The poorly-sorted siltstones of the upper member are typically composed of quartz silt approximately 60 micron in diameter and clasts of carbonate approximately 300 micron in diameter in a matrix of microcrystalline quartz, carbonate, clay and cubic pyrite. They are greenish-gray to orange-gray in color depending upon the oxidation state. The beds are typically 1/4 to 1/2 inch thick but can be several inches thick. They are calcareous and contain up to 1.5% organic carbon in places.

The thin siltstone beds have an indisputable association with the hydroclastic and volcaniclastic rocks with lapilli-size fragments. The fine-grained siltstone beds thicken and become more coarse-grained laterally. These rocks do not contain basaltic fragments, glass shards, broken crystals of plagioclase or mafic minerals. Silt-size detrital quartz and carbonate are the only significant clast types. The basaltic parentage of the siltstone and mudstone is apparent only from the high TiO_2 content (Figure 2) and the intimate association with volcanic and volcaniclastic beds.

Most of the titanium in the siltstone and mudstones is adsorbed on illitic clay flakes as tiny particles of rutile. The TiO_2/Al_2O_3 ratio of 0.025 is the maximum shown for the Ti structurally bound or adsorbed in clay minerals (Spears and Kanaris-Sotirou, 1976). Siltstones with higher ratios, would have the free titanium oxide minerals such as anatase, rutile and magnetite.

Cherts

Distinctly bedded primary or early diagenetic cherts are present but are difficult to distinguish from post-lithified, silicified rocks. Radiolarians have been identified in many of the samples. This fact together with the dense character and conchoidal fracture support a primary chert interpretation. In other silicified rocks, spongy, crustiform or honey-comb textures and open-space fillings with quartz indicate post-lithification hydrothermal silicification. In places, the silicified rocks are not diagnostically primary or secondary in origin. In these zones the silicifed rocks grade gradually into the surrounding lithology and are not distinctly bedded. The character of the silicification is microcrystalline and homogenous throughout.

Massive Sulfides

A 25-foot thick stratabound "lense" of silver-lead-zinc-rich "massive sulfides" is contained within the titanium-rich hydroclastic tuffs, calcareous shale and bedded cherts of the upper member. The rocks contain up to 75% total sulfide, mostly pyrite/marcasite occurring as subparallel large anhedral masses. Other ore minerals include sphalerite, galena, chalcopyrite, tetrahedrite and enargite. Most of them occur in discontinuous veinlets cross cutting the pyrite/marcasite masses. The hydroclastic tuffs are silicified and sericitized. Quartz-calcite veinlets are common. The maximal zinc grade is 9.3%, lead 4.35% and silver 6.65 opt. This mineralization resembles the Paleozoic submarine exhalative mineralization described elsewhere in north-central Nevada (Ketner, 1983).

INTERPRETATION OF DEPOSITIONAL ENVIRONMENT

During Ordovician time the Rabbit Creek area was located west or oceanward of the continental margin and slope on the abyssal plain. The area was underlain by oceanic crust and the beginning of extensional tectonics resulted in basaltic volcanic activity from rift-like fractures. The depositional setting of the lower member is interpreted to have been a relatively quiescent, deep- water, anoxic seafloor. Characteristics of the black shales that support this interpretation are the thin, monotonous laminae and the general lack of fossils or bioturbation. Additionally, Codilovus proavus is a deep-water form of conodont and they were buried in a "straight up" position that is indicative of anoxic conditions (J. Repetski, written communication).

The upper member is a facies of the slope and debris apron peripheral to a basaltic seamount (Fig. 9). The rocks represents a time-progressive progradation of the seamount and volcanic activity. Associated with each volcanic event, whether proximal or distal, was a disturbance of the normal low-energy common to the open seafloor. The volcanic activity was sporadic but increased in frequency with time. The lower member contains limited volcanic flows whereas the upper member is dominated by them. The sedimentary rocks that represent higher energies of deposition, i.e.- siltstones, debris-flows breccias and hydroclastic stone-streams, are interpreted to have been triggered by volcanic events or in response to modifications of seafloor topography caused by the growing seamount.

High-titanium, alkalic basalts such as those found at Rabbit Creek are common to midplate seamount volcanism within an extensional stress field (Bostrom, 1973). Titanium, zirconium and yittrium are relatively immobile during alteration processes, and have been used to characterize the magma series and the plate- tectonic setting of the basalts. A diagram of Zr/Y versus Zr (Pearce and Norry, 1979) show that the Rabbit Creek rocks fall into the field of intraplate basalts rather than the field of island arc basalts, supporting the Ordovician intraplate rift interpretation (Fig. 8).

Seamounts, that are Mesozoic and younger in the Pacific and Atlantic oceans, vary in size and shape. Typically, they are fracture related and have a significant length to width ratio (Natland, 1973). For example, Horizon Guyot, considered to be a slightly larger than average seamount, is 70 km wide and 175 km long. They grow from the ocean floor by the accumulation of lavas and swelling. Seamounts usually have flat tops that are attributed to the high fluidity of the lavas (Natland, 1973). The hydrostatic confining pressure does not allow the lavas to degas and accounts for the high fluidity. For alkalic basalts at water depths of approximately 1800 m.(5905 ft.) volatiles can escape and vesicles will form (Moore, 1970). Many of the basalts at Rabbit Creek are vesiculated, therefore, the water depth was probably shallower than 1800 m.(5905 ft.) or, alternatively, some amount of external water was mechanically jetted into the basaltic magma.

The internal composition of seamounts is poorly understood but it is believed to be composed of massively stacked pillow basalts. The flank slopes of seamounts are typically 20 to 30 degrees and are covered by hydroclastic stone streams and calcareous shale ooze (Natland, 1973). The slopes are unstable and slumping is common. Plastic deformation folding is prelithification and is interpreted to be the result of slumping.

Density currents within the seamount environment probably originate in a variety of ways. The generative processes or conditions include slope topography and instability, the dynamic effects of the flowing lavas, tectonics, and seawater convection resulting from volcanic heat and vent eruptions (Fisher and Schmincke, 1984). A variety of volcaniclastic rocks ranging from deposits of hydroclastic stone streams to silt dominated turbidites are generated. At Rabbit Creek all the fine- to coarse-grained clastic beds representing these depositional processes have elevated TiO_2 levels. In the Pacific and Indian oceans, high TiO_2/Al_2O_3 ratios are characteristic of ocean floor sediments in close proximity to seamount chains (Bostrom, et. al., 1973).

Above the volatile fragmentation depth, the reduction of lava to clasts can be explosive and the generated clasts are therefore pyroclasts (Fisher and Schminke, 1984). This depth for alkalic basalts typical of seamounts is generally shallower than 500m (1640 ft.). Below the volatile fragmentation depth the lava is reduced to clasts by spalling, granulation, cracking and quenching. Clasts generated by these processes are hydroclastic. At Rabbit Creek the sparcity of fossils or bioturbation and the anoxic, deep-water shales and cherts interbedded with the volcaniclastic rocks suggests that the area was not shallow enough to be above the volatile fragmentation depth during deposition.

The presence of an ultramafic lherzolite sill combined with an abundance of tholeiitic-to-alkalic basalts and radiolarian cherts closely resembles an ophiolitic assemblage of Cordilleran type (Moore, 1982). Ophiolites are products of seafloor spreading both at mid-oceanic ridges and in marginal basins, their compositions representing either oceanic crust or upper mantle. Ophiolites could have been emplaced ("obducted") along the continental margin in the Osgood Mountains during the "accretion" process.

STRUCTURAL GEOLOGY - DESCRIPTIVE ANALYSIS

An antiform fold, the Conelea Anticline, is traceable in a generally North-South direction the length of Section 19 and dominates the structural picture of the Rabbit Creek Mine area (Fig. 4). The Conelea Anticline is named to honor Radu Conelea, who was the first geologist to recognize this fold. The fold is generally asymmetric. The limb architecture varies from open to isoclinal. The fold axis generally strikes N20-30W and dips southwest at twenty (20) to thirty (30) degrees. The plunge of the fold is slight and variable, but is generally northwest at about five (5) degrees. To the south in the central part of Section 19, the fold becomes isoclinal and the axis has ripped, thrusting the upper limb as much as six hundred (600) feet over the lower limb.

The geometry of the fold is that of a box or conjugate variety. The fold's limbs are planar and connected at the nose by a narrow, sharp, subangular hinge zone. The beds of the lower limb strike generally N30W and dip southwest at about sixty (60) degrees. The upper limb has beds with dips as much as thirty (30) degrees, but the dips are commonly about ten (10) degrees. The strike of the beds of the upper limb varies greatly as the result of broad warp- folds, typically of a scale of hundreds of feet wide. The axial trend of these broad warp-folds, the Tapper and Owen anticlines, is northwest to north-northwest. This axial trend is similar to that of the Conelea Anticline and suggests that these folds share a similar origin with the Conelea Anticline. The Tapper Anticline was identified very early in the project by Charles Tapper. Roy Owen directed the exploration effort responsible for drilling the area of the Owen Anticline.

A synclinal fold that bears a similar trend and roughly parallels the Conelea Anticline is located approximately 1000' east of the anticline. The synclines' axial plane strikes N15W and dips to the southwest at about 50 degrees. Within the level of drilling the beds of the western limb all dip steeply southwest. The eastern limb, however is not uniform. Beds in the lower part of the eastern limb dip steeply southwest at about 70-80 degrees. Beds in the upper part of the eastern limb also dip southwest but at a much shallower angle, about 10-15 degrees.

Smaller folds, from a few inches to several tens of feet in scale, are abundant. Because the drill hole spacing is generally not less than fifty feet these folds can not be traced with accuracy from hole to hole. The orientation and geometry is known only from single core examinations. Folds of this scale are highly variable in shape, but in general they have parallel to semiparallel limbs and curved, not sharp, noses.

At the scale of core, plastic and brittle fold deformation is present. In some folds, beds that typically would deform in a brittle fashion such as chert, are folded without breaking, suggesting a prelithification deformational event. Some bedding has been squeezed into sausage- or ovoid-shaped "boudins" by either sediment loading or folding. Conversely, other folds show marked brittle deformation. Thin chert beds have been broken into equidimensional blocks that have all been rotated in tandem to generate a discontinuous bed. Shearing has occurred between beds of different lithologies probably as the result of folding. Locally, there are bedding plane breccias.

A microstructural dynamic metamorphism, expressed by foliatiation and crenulation of illitic clays, was seen in thin-sections. In places these layers contain abundant mica with a strongly preferred orientation. However, because high temperature minerals are lacking, these laminae are interpreted to have been formed by processes of highly directed stress. Sometimes two generations of crenulation cleavage are of slightly different orientations are superimposed. Crushing and granulation that is parallel with bedding is observable even at the thin-section scale.

Microfaulting, with both reverse and normal sense of motion, is present and in places abundant in the core. The microfaulting is most abundant in areas of brittle deformation and the sense of motion is commonly reverse. Many of the microfaults or microfractures have not been sites of mineral accumulation, however microveins or veinlets are common.

Within the barren and marginally mineralized rocks three types of veinlets occur: calcite, quartz and Fe-oxide. They have been formed in several different stages as evidenced by "crack/seal" textures. Quartz veinlets are very common and may contain pyrite and matrix fragments. Where the paragenetic relationship is evident, the quartz-pyrite veinlets crosscut the calcite veinlets.

The Conelea Anticline has been offset by three northeast trending faults. The northernmost of the three, the DZ Fault, has about two thousand (2000) feet of dextral offset (Fig. 4). The fault is actually a zone of many left-stepping shears that dip northwest at about fifty (50) degrees. Beds caught in the zone have a northeast strike, nearly parallel to the fault's strike. Many brecciated shears, each with a N40E strike, are present within the fault zone. The line of bearing of the shear set is N25E. The fault zone is the widest, approximately 200', and most obvious where nearly flat beds of the upper limb of the fold are juxtaposed with the steeply dipping beds of the lower limb. In general, this occurs between two north-trending restraining bends. The southernmost of the restraining bends coincides with the intersection of the Conelea Anticline's fold axis and the DZ Fault. The northernmost of the restraining bends is coincident with the intersection of the eastern synclinal fold.

The southernmost of the three faults is Bill's Fault, named for Bill Matlack. The fault strikes about N55E and dips northwest at about fifty (50) degrees. The apparent offset of Bill's Fault is about 200' with a dextral, strike-slip motion.

Between Bill's Fault and the DZ Fault is the Wry Tail Fault. It strikes about N45E. The offset is dextral, but only about two hundred (200) feet. The dip is about fifty (50) degrees to the northwest.

A north to north-northwest trending, normal fault is present in the western part of the North Central Area. The fault dips west at 40 to 60 degrees. The displacement is not great and the fault apparently dies toward the south.

STRUCTURE-INTERPRETATION

Three major and independent stress fields can be interpreted from the rocks and structural deformation at Rabbit Creek. The first of these stress fields is an intraplate, extensional, fracture related stress field during Ordovician time. Alkalic basaltic volcanism indicative of this setting comprises a large percentage of the rocks at Rabbit Creek. Folding and deformation of soft sediments/prelithified rock occurred during slumping of sediment blocks from a growing, unstable seamount margin in response to gravity and is not the result of compressional tectonics.

The development of the Conelea Anticline and other associated folding was post-Ordovician but pre-Tertiary. Because the only rocks involved in the folding at Rabbit Creek are Ordovician a more precise dating is not possible. However, the Late Devonian and Early Mississippian Antler Orogeny is probably responsible for the Conelea Anticline. A major thrust fault, such as the Roberts Mountain Thrust Fault, is not evidenced by the rocks at Rabbit Creek.

A compressional stress field with the axis of maximum compression oriented ENE produced the Conelea Anticline. Since none of the above referenced compressional periods have a similarly oriented stress field, tilting and/or rotation of the rocks after folding is possible. Alternatively, the orientation of the stress field based on the fold at Rabbit Creek may be only a local variation within a much broader stress field compatible with those of the major orogenies.

The third stress field is a Miocene extensional tectonic event. In addition to simple extension, dextral or clockwise rotation of the crust of the Basin and Range/Great Basin provinces occurred during extension (Zoback, et. al., 1981; Best, 1988). The axial direction of maximum extension has rotated from WSW to ENE since about fifty (50) million years before present.

The apparent motion, orientation and character of the DZ Fault is interpretable as a synthetic shear (Riedel "R" Shear) associated with a major north-south basement suture with right-lateral offset. The line of bearing shown on a tracing of clay cake deformation (Wilcox, et. al. ,1973) is shown to represent a basement boundary between two rock masses that have moved with right lateral motion (Fig. 11). The principal fractures seen in the clay cake are Riedel "R", left stepping, right lateral shears. If positioned on a major north-south oriented basement structure, the line of bearing of the DZ Fault is compatible with a shear of similar orientation and offset to the Riedel "R" shears of the clay cake experiment (Fig. 12).

A major basement structure, the "Rabbit Suture", is an inferred metallogenic and tectonic north-south boundary that passes through the Chimney Creek and Rabbit Creek deposits (Figure 2). This suture is expressed locally as a 1.5 mile long belt of gold-arsenic-mercury mineralization. The boundary is marked by ophiolitic peridotite rocks which elsewhere are recognized as important suture indicators. A strong north-south lineament of considerable length was also identified by remote sensing data (edge enhanced linear stretched image, band 5

Thematic Mapper). The Rabbit Suture is probably a Precambrian deep-seated flaw which has been rejuvenated several times by the extensional tectonic episodes in Ordovician, Permian and mid-Tertiary. It served as a passageway for the emplacement of basic igneous rocks and gold-bearing hydrothermal solutions.

GOLD MINERALIZATION

The Rabbit Creek gold deposit is located within a north-south oriented belt of gold mineralization that is at least 1.5 miles long and 1000 to 1500 feet wide. This trend is considered the first order ore control at Rabbit Creek. Published geological resources within the belt, to date, exceed 5 million ounces gold. The Rabbit Creek deposit consists of three extensively drilled areas of mineralization, the North Central Area, 268 Area and 122 Area, that are contiguous and comprise a continuous zone of ore grade mineralization throughout Section 19 (Fig. 13). Gold Fields has discovered both oxide and sulfide resources on adjacent land to the north of Rabbit Creek deposit. Two additional areas of gold mineralization at Rabbit Creek, the West Central Area and East Central Area, are located outside this main trend and contain primarily sulfide ore. Drilling in both these areas has been limited. Demonstrated geological resources at the Rabbit Creek property total 53,800,000 at an average grade of 0.067 opt, or 3,610,000 ounces.

The North Central Area

Both the upper member and lower member rocks are mineralized in the North Central Area. Six different mineralization zones have been identified based on their stratigraphic and structural setting, HGO, DZ, LGO, Upper Sill, SWS, and Main Chert (Figs. 14, 16,17 & 18). Total geological reserves in the North Central area are 2,105,000 ounces. Oxide reserves total 16,400,000 st of material averaging 0.052 opt, or 843,000 ounces and sulfide reserves total 5,860,000 st of material averaging 0.215 opt, or 1,262,000 ounces.

Oxidation, as is the mineralization, is strongly influenced by the structural and stratigraphic setting of the rocks. The primary control is the structural setting. The oxidation-reduction boundary is relatively uniform and shallow when in flat-lying beds, but occurs in tongues and can be quite deep when steeply dipping beds subcrop (Figs. 14 & 15). Alteration, especially decalcification, brecciation and a relatively high inherent permeability are all important controlling factors that promote more extensive oxidation. Preferential oxidation of such mineralized zones as the HGO or Jackrabbit demonstrates this conclusively.

HGO ZONE: The HGO is the most significant orebody of the Rabbit Creek Mine in terms of reserves (Figs. 14 & 18). The mineralization, which is hosted by calcareous shales and mudstones of the lower member, is stratiform and dips 15 degrees to the northeast. The entire tabular orebody, most of which is oxidized, has northeast elongation and is approximately 1100 feet long, 600 feet wide and 20 to 120 feet thick. The HGO subcrops at approximately 400 feet below the surface in the south part of the North Central Area and becomes unoxidized down dip to the north. It is truncated by the DZ Fault to the east, by the roll of the Conelea anticlinal fold to the north, eroded at subcrop to the south and diminishes in grade to the west. Intercepts of about five feet in thickness which assay greater than 1.0 opt gold are common in the most altered rocks.

Host shales and mudstones of the HGO ore zone are fractured, brecciated and structurally deformed. Foliation and crenulation cleavages, stylolites and dissolution seams are present. Post-vein crack/seal textures in calcite and quartz veins developed as a result of deformation and multiple injections of mineralizing fluids. The HGO ore, where unoxidized, contains 5 to 20% orpiment (As_2S_3), 10% pyrite (or iron oxide) and minor getchellite ($AsSbS_3$), cinnabar and stibnite. Orpiment occurs in angular grains and anhedral masses, but mostly it together with quartz fills ragged, discontinuous and brittle fractures (Fig. 21) that crosscut the original carbonaceous bedding (Fig. 20). Orpiment contains gold and as much as 35% of antimony. Pyrite (or iron oxide) occurs in variable habits either as euhedra with curved faces or as disseminated irregular fluffy grains. There is also a small amount of natural coke or charcoal which was observed in the samples from this and SWS ore zones. This amorphous spongy material, apparently a final product of the kerogen thermal degradation, is similar in appearance to the charcoal used in cyanide mill circuits. Quartz, minor sericite and fine-grained euhedral pyrite also fill brittle fractures, reaching 8% of the rock volume. Decalcification and possible collapse of the host rock is probably the reason for increased permeability and oxidation. As a result of decalcification, the HGO ore contains 11% less carbonate than the host shale. Almost all massive calcite lenses (i.e. recrystallized original micrite) disappear. Also gone are intraclasts which often occurred in host rocks in distinct layers with detrital quartz and cubic pyrite.

The amount of introduced silica in the form of microcrystalline quartz ranges from 38% in low grade ore to 45% in high grade ore. The grains present are less than 20 micron. The introduction of silica occurred in several stages. Dolomitization accompanied one of the silicification stages. The dolomite content in the HGO ore can be as much as 10%. The SEM analysis showed that recrystallized dolomite occurred in ore in individual, distinct rhombohedrons of 20 to 100 micron in size.

Arsenic shows particular enrichment, the average content in HGO ore is 5,750 ppm but can be as high as 35,000 ppm in some samples. This average content is 12 to 25 times the typical background of a host shale. The average antimony content of the ore is 260 ppm reaching 2440 ppm in some samples. Antimony enrichment is 10 times that of the background of 20 ppm. The mercury data show very high average mercury content of 38.7 ppm in the HGO ore with occasional concentrations of 990 ppm. The local mercury background in carbonaceous calcareous shales of lower member is about 3,000 ppb. Silver content in the ore is low, about 1 ppm with maximal values of 7 ppm. The gold-to-silver ratio is very high. Base metal contents of the HGO ore are quite low averaging zinc 80 ppm, lead 10 ppm and copper 40 ppm.

DZ ZONE: The highest gold grade in the North Central Area, 7.6 opt, occurs in the fault breccia of the DZ Fault where it intersects the HGO ore zone (Figs. 14 & 16). The silver here has a maximum of 200 ppm, arsenic reaches 19%, antimony 781 ppm and mercury 346 ppm. The average values for trace metals are 1.8 ppm Ag, 7635 ppm As, 107 ppm Sb and 20 ppm Hg, and the average gold grade is 0.27 opt.

The ore-controlling significance of the DZ Fault is uncertain. The highest gold grades in the North Central Area are located in the DZ Fault breccia near its intersection with the HGO. This fact might suggest that the DZ Fault was acting as a feeder of hydrothermal solutions. Gold was deposited as fluids changed their path from an upward migration along the DZ Fault into the near-horizontal beds of the HGO of the Conelea Anticline.

Conversely, the DZ Fault has clearly separated the ore zones of the North Central Area from those of the 268 Area by about 2000′. Therefore, the DZ Fault zone seems to be an area of gold depletion and truncation of ore zones rather than one of enrichment. This fact suggests that the DZ Fault is a post-mineral fault and that areas of high-grade gold within the DZ are due to brecciation of the pre-existing gold-bearing rocks that have been reduced to rubble by the motion of the fault.

Additional oxide mineralization is hosted by basaltic volcaniclastic sediments of the upper member on the east side of the DZ Fault zone (Figs. 14 & 16). The beds there strike approximately N 30 W and dip approximately 60 degrees to the southwest. They represent the steeply dipping lower limb of the Conelea Anticline which is present east of the DZ Fault. Consequently, oxidation penetrates much deeper here than in the relatively flat lying beds to the west, especially along structurally prepared and permeable beds. There appears to be a definite top and bottom to this mineralization that is coincident with the presence of calcareous mudstone and siltstones that commonly contain calcite veins. This leads us to speculate that there may have been a strong horizontal movement of mineralizing fluids along the strike of the beds. The mineralization is truncated to the east by the 316 basaltic porphyry which probably acted as a barrier to the main mineralizing event. The overall mineralization zone, which consists of several mineralized volcaniclastic sediment beds and generally unmineralized basaltic flows, approaches 800 feet in length and 300 feet in width.

LGO ZONE: The LGO is the northernmost zone of low grade oxide mineralization and is hosted by basaltic hydroclastic tuffs, and siltstones and shales of the upper member which are associated with the upper limb of the Conelea Anticline (Figs. 14 & 16). The dimensions of this orebody are about 1500 feet in the east-west and 700 feet in the north-south directions, with the thickness reaching 250 feet at the extreme northern part of Section 19. The mineralization subcrops approximately 200 feet below the surface. The orebody is continuous with the Gold Fields' South Pit orebody that extends approximately 0.5 miles to the north. The orebody is eroded at subcrop to the south, truncated by the DZ fault on the east and truncated by the West Side fault on the west. The mineralization is generally stratiform with beds striking northwest and dipping approximately 20 degrees to the northeast. Supergene oxidation occurs to a depth of approximately 200 to 250 feet below subcrop. The average gold grade of 0.03 opt is low. Silver, arsenic and mercury are also low (1, 1230 and 2.5 ppm respectively) compared to other ore zones. However, the antimony average content is high, 228 ppm. Higher gold assays and maximal concentrations of antimony (0.7%) and mercury (100 ppm) reflect their enrichment, especially in north-trending enrichment zones and in the hanging wall of the DZ Fault. Veinlet fillings in this ore are represented by quartz, sericite and Sb-bearing limonite. Quartz occurs in sutured microcrystalline aggregates with gradational contacts to the host mudstone which suggests the replacement silicification. The disseminated low grade gold mineralization favored the hydroclastic rocks, siltstones and shales, versus the basaltic flows. Decalcification of the volcaniclastic siltstones with calcareous cement was an important alteration process that produced permeability for the gold-bearing fluids. Argillization and silicification are also important alteration processes.

UPPER SILL ZONE: Another zone of mineralization, the Upper Sill Mineralization, lies directly below the Upper Sill (Figs. 14 & 16). This orebody is different from the rest of the gold mineralization hosted by the upper member rocks in that it contains high-grade sulfide ore. The orebody is elongated to the northeast and is approximately 1100 feet long, 500 feet wide and 20 to 120 feet thick. The majority of the mineralized rocks are oxidized and low-grade, Au = 0.03 opt. The ore has been pervasively replaced by silica and is also fractured and full of quartz-goethite veinlets. Gold has been observed as 1-2 micron grains in a cryptocrystalline quartz along with cinnabar and pyrite. Limonite occurs both as a cavity filling in veinlets and microfractures and as oxidation pseudomorphs after original pyrite. From 0.1 to 0.5 % of arsenic and antimony are present in limonite. Along with limonite, some fractures contain abundant iron-antimony oxide, tripuhyite ($FeSbO_2$), which has also been found in the oxide ores of the Genesis and Candelaria deposits of Nevada. Blocky crystals of jarosite and barite were observed in strongly fractured rocks. The average trace metals contents are: silver - 0.4 ppm; arsenic - 3380 ppm; and mercury - 2.5 ppm and in the context of the Rabbit Creek deposit, these values, with the exception of arsenic, are low. The maximal values of trace metals in the oxide zone do not show significant enrichment, probably reflecting the absence of high-grade feeders.

The Upper Sill contains an approximately 400 feet by 300 feet unoxidized zone in the northeast, that is high grade. This high grade mineralization starts at approximately 600 feet below the surface. Twenty foot intercepts of +0.50 opt gold are common. The average gold grade is 0.28 opt. The trace element geochemistry is as follows: silver - 1.3 ppm; arsenic - 6140 ppm; antimony - 358 ppm and mercury - 7.2 ppm. The maximal contents are 5.8 ppm, 1%, 4160 ppm, and 57 ppm, respectively. The ore is carbonaceous and contains abundant orpiment, stibnite and minor realgar. Decalcification of the calcareous shale host is an important alteration process.

SWS ZONE: The SWS mineralization is associated with the lower limb of the Conelea anticlinal fold and is hosted by the calcareous shales and siltstones of the same stratigraphic horizon of the lower member as the HGO (Fig. 18). The SWS has been drilled to a depth of 1100 feet and is the deepest known high grade mineralization in the North Central Area. All of the mineralization is unoxidized and dips to the southwest at approximately 35 degrees. The mineralization zone is usually 20 to 80 feet thick and is up to 600 feet in length along strike and 500 feet in width. However, the zone is not fully tested at depth. The mineralization is strongly carbonaceous, contains abundant orpiment, pyrite (Fig. 19), minor arsenopyrite and is intensely brecciated.

The average gold grade of the SWS is 0.16 opt. Trace elements concentrations average silver - 3 ppm, arsenic - 1.7%, antimony -722 ppm, and mercury - 69 ppm. The maximum values for these metals show very high sulfide capacity of the hydrothermal system: arsenic - 38.5 %, antimony - 2.4%, mercury - 895 ppm, and silver - 22 ppm.

MAIN CHERT ZONE: The hydrothermally altered rocks called the "Main Chert" host the a large volume of the sulfide resources in the North Central Area and stratigraphically are a part of the lower member (Figs. 14 & 17). The name "chert" comes from the fact that siltstones hosting the ore are strongly and preferentially silicified over the surrounding rocks. The high grade mineralization is confined to the nose of the Conelea Anticline where the rocks are the most intensely brecciated and silicified. The northwest trend along the strike of the anticlinal fold is an important ore control in the Rabbit Creek gold deposit. The mineralization, as thick as 300 feet, is preferentially hosted by the upper limb and the nose of the anticline.

The high-grade orebody contains a complex network of replacement aggregates and fractures filled with 2 to 5 mm thick veinlets that constitute 25% of the rock volume. They cut across the bedding of the siltstones or shales and have sharp contacts with the host rocks. Corroded aggregates of matrix carbonate that have been replaced by microcrystalline silica and crossed by numerous quartz-orpiment-pyrite, quartz-stibnite and pyrite-sphalerite-barite veinlets are observed in thin section. The sulfides are particularly concentrated in the porous carbonate patches. Orpiment occurs as a late-stage mineral in vein fillings and as a central cavity filling in stibnite crystals and contains several percent Sb. The stibnite also contains a trace of arsenic. The presence of As in stibnite and Sb in orpiment suggests that these minerals formed as solid solutions at temperatures higher than in other parts of the orebody. A greater solid solution temperature in orpiment shows that it had formed earlier than the stibnite. Mercury-rich tennantite accompanies orpiment mostly in replacement aggregate. The pyrite is present in two forms, early framboidal in the matrix and late cubic pyrite in fracture fillings.

Decalcification and silicification with sulfide deposition is accompanied by dolomitization, carbon remobilization and a period of late quartz veining containing no sulfides. The dolomite in veinlets is Fe-rich. In addition to strongly silicified siltstones, the high-grade ore is locally hosted in moderately soft carbonaceous shale containing as much as 2% organic carbon and veinlets of remobilized bitumen. By analogy with the Getchell deposit, this rock is called "gumbo ore".

Gold occurs as micron-size grains adjacent to cubic pyrite surrounded by orpiment. The fineness of gold is Au 92% and Ag 8%. Gold grades range from 0.07 to 1.87 opt. The average silver content is 1.7 ppm but may be as high as 155 ppm in individual samples. The arsenic content is 8250 ppm, its maximum is 16.9%. The antimony average is 524 ppm, and it goes up to 2.2$ in some samples. The mercury content of the ore is 28 ppm, and it maximally reaches 297 ppm.

The host siltstones for this orebody are silicified and weakly mineralized over most of the west part of the Rabbit Creek deposit. Where the "Main Chert" subcrops in the southern part of the North Central Area, it usually contains low-grade oxide mineralization.

The 268 Area

The majority of the gold mineralization in the 268 Area is hosted by the Jackrabbit mineralization zone, and is considered to be the same stratigraphic unit of the lower member that hosts the HGO and SWS mineralization (Fig. 15). The zone is stratiform, strikes N 30° W and dips 60° to 65° to the SW. It is approximately 1800 feet long in the strike direction, up to 700 feet wide in the dip direction and 20 to 80 feet thick. The zone subcrops at a depth of 450 to 500 feet and is characterized by unusually deep oxidation, which in places exceeds 1200 feet, and occurs where the steeply dipping beds of calcareous shales and mudstones subcrop allowing oxidizing meteoric water into the beds. Decalcification, argillization and silicification are important alteration processes. Both mineralization and alteration decrease in intensity with depth. The average gold grade is 0.07 opt, but locally, as in the HGO and SWS, individual samples exceed 1.0 opt. The silver values in this zone have an average of 2.9 ppm and can be as high as 27 ppm. the average concentration of arsenic is 1143 ppm and the arsenic may reach 5450 ppm in individual samples. The antimony average is high (793 ppm) with a maximum of 0.8%. The mean value for mercury is 24 ppm and can be as high as 43 ppm. The upper limb of the fold, in particular the Main Chert, and lower limb contain abundant low-grade mineralization with minor high grade mineralization. There is also ore-grade mineralization hosted by volcaniclastic rocks of the upper member in the sparsely drilled eastern part of the 268 Area. Total preliminary demonstrated geological oxide resources in the 268 Area are 15,900,000 st of material averaging 0.033 opt, or 519,000 ounces of gold. Sulfide resources are 530,000 st of material averaging .110 opt, or 58,000 ounces.

The 122 Area

Two mineralized zones host the majority of the gold mineralization in the 122 Area. One, is a continuation of the "Jackrabbit" described above with the exception that the mineralization is slightly thicker. Including both the 122 and 268 areas, the Jackrabbit zone of mineralization is approximately 3000 feet long and is oxidized over most of its length. The average gold grade is 0.07 opt, but in some places is as high as 0.647 opt. The average concentrations of silver, arsenic, antimony and mercury are 2.5, 1360, 592 and 4.6 ppm respectively. The strongest enrichment (about 10 times) occurs in antimony.

The second mineralization zone, Snowshoe, is hosted primarily by upper member volcaniclastic shales and siltstones with calcareous cement. The hydroclastic tuffs and basaltic flows also host mineralization, but to a lesser degree and often the grade is lower. The "Snowshoe" strikes approxim'tely N 15° W and dips approximately 45° SW at subcrop and becomes steeper down dip. The zone has a known strike length of approximately 1200 feet and has been traced down dip for at least 800 feet. The true thickness usually varies from about 100 to 200 feet. The average gold grade is 0.11 opt, with some high-grade samples reaching 0.71 opt. The average values for silver, arsenic, antimony and mercury are 0.4, 112, 517 and 6.3 ppm, respectively. The antimony is enriched the most. Several kinds of pyrite grains are abundant. The subhedral pyrite and fine vein pyrite lack appreciable amounts of trace elements, while fluffy porous pyrite contains antimony and gold as minute impurities. The mineralization is divided nearly equally between oxide and sulfide. The sulfide mineralization is different from other zones of the Rabbit Creek gold deposit because it contains significantly less arsenic and no carbon. Decalcification and silicification are important alteration processes. Demonstrated geological oxide resources in the 122 area total 12,400,000 st of material averaging .048 opt, or 591,000 ounces. Sulfide resources total 2,760,000 st of material averaging .122 opt, or 337,000 ounces.

ORE GEOCHEMISTRY

The geochemistry of the Rabbit Creek gold system has been studied on the basis of a large number of core and rotary samples that have been systematically analyzed for Ag, As, Sb, Hg and other elements by fire assay, inductively coupled plasma spectroscopy and atomic-absorption analytical techniques.

The metal zoning and geochemical enrichment/depletion patterns are complex and are currently under study, and therefore, only the principal geochemical characteristics of the nine ore zones are presented in this paper.

Average and maximum concentration of gold and four closely related trace elements are summarized in Table 3.

The following conclusions can be reached from the analysis of the data.

1. The Rabbit Creek deposit is typical of Carlin-type deposits in the association of gold with anomalous arsenic, antimony and mercury values which are contrasted with the low silver (and base metals) contents. The high concentrations of the three metals in both oxide and primary ore at Rabbit Creek are much higher than in most of the sedimentary-hosted deposits being studied, i.e., Carlin (Radtke, 1985), Pinson (Kretchmer, 1984), Getchell (Joralemon, 1951b, R. Nanna, personal communication), Alligator Ridge, Gold Acres, Jerritt Canyon, Rain and Cortez (Ashton, 1989). Naturally, the Getchell and Pinson average values for As, Sb, and Hg are closer to Rabbit Creek ones than to any other deposit.

2. The silver, arsenic, and mercury abundances are dependent on the oxidation/reduction state of the ore. The trace metal content is two to three times higher in the unoxidized ore versus the oxidized ore.

3. The trace element concentrations are dependent on the composition of the host rock unit and on the prevalent alteration process. The primary unoxidized ores hosted by decalcified/silicified shales and mudstones of the lower member (i.e., the HGO, Jackrabbit, and SWS) have twice as much arsenic and eight times as much antimony than the primary ore hosted by the silicified and argillized basaltic volcaniclastic rocks of the upper member (i.e., the LGO, Upper Sill, DZ and Snowshoe). The oxidation process in both the calcareous and volcaniclastic rocks tends to reduce this substantial difference. As a result, the arsenic and

antimony concentrations in the oxide ores are nearly equal in the upper member and lower member rocks but the mercury values are still sharply different. In fact, the lower member-hosted oxide ore contains near three times more mercury (21320 ppb) than the upper member-hosted or (8,588 ppb).

Age of Mineralization

An alunite sample from oxide ore in the DZ Fault zone has been dated by the K-Ar method in the Geochron Laboratory (Cambridge, Massachusetts). The K-Ar age is 15.1 ± 0.6 m.y. The alunite contains 30 mol% sodium, and also probably contains some excess water based on an anomalously high "a" unit cell parameter. The alunite occurs in cubic crystals roughly 4 micron on a side (R. Stoffregen, written communication). The X-ray characteristics and the morphology both indicate its relatively low temperature of origin, probably at or below 100 degrees C. Alunite of these characteristics and morphology is thought to have formed during weathering of a sulfide ore deposit or in a low-temperature hydrothermal environment, such as a hot spring, or a marine or lacustrine environment (Slansky, 1975). Only coarse-grained alunite associated with relatively high-temperature volcanic gold deposits, such as Summitville, provide accurate K/Ar ages of mineralization (Menhaert, et. al., 1973).

The accuracy of K/Ar dates from fine-grained alunites, such as the DZ Fault zone sample, is unknown. Possible loss of argon, or addition of potassium from solution to the alunite grains by alkali exchange, would result in a K/Ar age lower than the actual age of formation of the alunite grain. In contrast, the K/Ar age of the alunite grain can not be plausibly increased. Thus the K/Ar age of 15.1 M.Y. can be viewed with a high level of confidence as a minimum age for the formation of this alunite, and also for the formation of the deposit. A similar age of 15 m.y. has been obtained by Madden-McGuire and others (1989) from $^{40}Ar/^{39}Ar$ dating of volcanic biotite in reworked rhyolitic tuff overlying the Rabbit Creek deposit.

SUMMARY

1. The Rabbit Creek gold deposit is controlled by a postulated north-trending regional scale deep-seated crustal suture. The suture zone also controls the location of the Chimney Creek deposit and may include the Getchell Fault system.

2. The discovery of the buried Rabbit Creek gold deposit emphasizes the high probability of similar discoveries on the trend and elsewhere in north-central Nevada. Methods such as the district-scale geologic studies and ore deposit modeling, photogeologic interpretation and exploration geochemistry will be important tools in discovering these deposits. Because of the 200 to 550 feet of overburden, all of the structural, stratigraphic and geochemical interpretations are based on core and rotary drilling.

3. The deposit contains five main areas of mineralization totaling 53.8 million tons of demonstrated geologic resources with an average gold grade of 0.067 opt. Gold is accompanied by a definite suite of anomalous arsenic, antimony and mercury which have gross average values in oxide ore 2020; 425 and 12 ppm respectively. In sulfide ore the values increase to 5240; 485 and 24 ppm.

4. The size and grade of the orebodies is a result of the superposition of favorable stratigraphy (i.e., porosity and permeability of host rocks) and structural controls (i.e., the confinement of principal ore reserves to the axial part of the Conelea anticline and to several other fault-fracture systems).

5. The Rabbit Creek deposit is a typical example of a Carlin-type sedimentary-hosted gold deposit displaying features such as the thin-bedded calcareous siltstone host rocks, sheet-like mineralized zones along permeable beds and pyrite-orpiment-stibnite-cinnabar mineral paragenesis.

6. Other significant characteristics of the Rabbit Creek deposit include the following features.

   a) At Rabbit Creek, there are hydroclastic basaltic tuffs and black calcareous shales and mudstones that were deposited on the pelagic ocean floor. In contrast, most Carlin-type host rocks were formed on a continental slope or shelf environment.

   b) A large amount of basaltic volcanism is present, and granites or any silicic magmatic rocks are absent.

   c) Organic matter in the lower member-hosted ore zones contains "light" and "heavy" n-alkanes, together with a mixture of overmature kerogen, pyrobitumen and natural coke.

d) Silver-lead-zinc "massive sulfide" mineralization of the submarine or exhalative character, is present and hosted by basaltic volcaniclastic rocks.

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We thank Santa Fe Pacific Mining, Inc. for their generous permission to release the information contained herein and for their support of the Rabbit Creek Project during the early years when men of lesser vision would have given up. Finally, we would like to acknowledge that in preparing this paper, our interpretations and conclusions were based on the careful and detailed geological logging and observations generated by numerous Santa Fe geologists and consultants. This data is the foundation which has led to our understanding of the geology of the Rabbit Creek deposit. It has been a pleasure for us to consolidate their collective observations and ideas into this paper, however, any errors or omissions remain the sole responsibility of the authors.

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FIGURE CAPTIONS

Fig. 1	Location map of the Rabbit Creek gold deposit, Humboldt County, Nevada.
Fig. 2	Geologic map of the Getchell mining district. Bar scale 1" = 200′.
Fig. 3	Generalized stratigraphic column of the North-Central, 268 and 122 areas of mineralization. A proposed correlation between units in three areas is shown.
Fig. 4	Geologic map of 4300′ elevation above sea level of the Rabbit Creek gold deposit.
Fig. 5	Compositions of lower and upper member of the Comus Formation rocks hosting the Rabbit Creek gold deposit projected on the triangular diagram CaO-MgO-SiO_2 (wt. %).
Fig. 6	Diagram TiO_2/Al_2O_3 versus the amount of detrital quartz, showing the separation of the upper and lower members.
Fig. 7	Total alkali-silica diagram for Rabbit Creek basalts. Rock types from Le Bas, et.al. (1986).
Fig. 8	Discrimination diagram Zr/Y versus Zr for representative Rabbit Creek basalts (squares) compared to Ordovician basalts of northern Nevada. Solid triangles - Independence Mountains basalts (Watkins and Browne, 1989), dots - pillow basalts (Wrucke, et.al., 1978).
Fig. 9	Block-diagram of the Ordovician ocean-floor sea-mount depositional environment showing future position of Rabbit Creek gold deposit, Section 19.
Fig. 10	Diagram TiO_2 (wt. %) versus Zr (ppm) for Rabbit Creek basalts. Compositional fields after Floyd and Winchester (1975).
Fig. 11	Experimental data on "clay cake" deformation of Wilcox, et al., (1973) with analog reference to faulting at Rabbit Creek.
Fig. 12	Subcrop geologic map of Rabbit Creek gold deposit, with strain elipsoid as reference for orientation of DZ fault.
Fig. 13	Areas of gold mineralization.

Fig. 14 Block diagram of the North-Central area showing individual zones of mineralization.

Fig. 15 Block diagram of the "Area 268" showing individual zones of mineralization.

Fig. 16 Upper member-hosted ore zones, North-Central area.

Fig. 17 Lower member-hosted ore zones, North-Central area.

Fig. 18 The HGO and SWS ore zones, North-Central area.

Fig. 19 Pyrite aggregate in the calcareous shale, unoxidized ore, SWS orebody. Back-scattered electron imaging reveals numerous enhedral micron-sized cubic crystallites. Sample 67-875. Screen magnification, 1000x.

Fig. 20 Three subparallel hydrocarbon veinlets in the silicified calcareous shale of the HGO unoxidized ore. Back-scattered electron image. Sample 61-698, screen magnification, 36x.

Fig. 21 SEM photomicrograph of the angular orpiment veinlet in the HGO oxide ore. Sample 79-694, screen magnification,350x.

TABLE 1.

AVERAGE CHEMICAL COMPOSITIONS OF LOWER AND UPPER MEMBERS OF COMUS FORMATION IN THE RABBIT CREEK AREA

	SiO_2	AL_2O_3	Fe_2O_3	MGO	CAO	NA_2O	K_2O	TiO_2	P_2O_5	MNO	LOI
Lower Member	63.07	8.42	4.70	2.61	7.05	0.33	1.70	0.86	0.36	0.07	11.80
Shale Unit L1 (Below mafic porphyry)	70.82	7.74	3.76	2.20	4.35	0.16	1.73	0.58	0.35	0.05	8.41
Shale Unit L2 (Between main sill and mafic porphyry)	68.23	6.55	3.78	2.21	6.67	0.15	1.51	0.52	0.41	0.04	9.88
Shale Unit L3 (Above main sill)	50.18	10.98	6.56	3.44	10.13	0.70	1.88	1.50	0.34	0.10	14.10
Upper Member	60.16	10.03	7.33	2.30	5.28	0.52	2.18	1.51	0.58	0.13	9.74

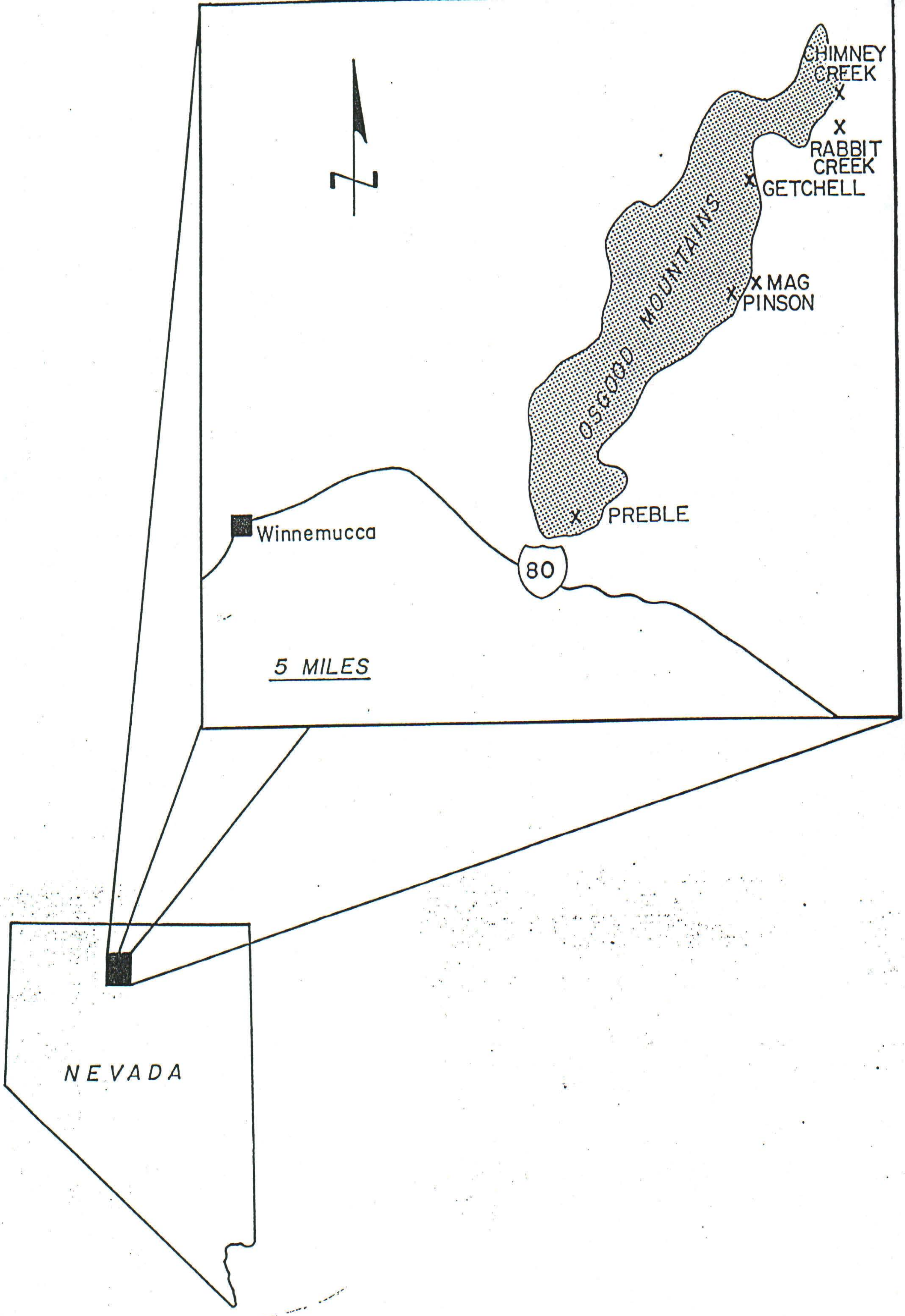
TABLE 2.
AVERAGE CHEMICAL COMPOSITION OF THE ORDOVICIAN BASALT SILLS AND FLOWS AT RABBIT CREEK

	Sill/ Flow	SiO_2	Al_2O_3	Fe_2O_3	MGO	CAO	Na_2O	K_2O	TiO_2	P2O5	MnO	LOI
Upper	Northern	44.42	15.79	9.33	4.77	7.31	1.69	2.44	2.80	0.63	0.14	10.19
	Top	47.40	14.92	12.00	1.20	3.14	0.33	4.49	2.81	0.88	0.04	5.91
	Upper	48.82	15.71	11.02	1.94	3.98	0.99	2.62	2.94	0.76	0.12	10.37
Lower	Main	45.49	16.36	7.97	2.90	7.78	1.21	2.61	2.16	0.40	0.11	11.75
	HGO	50.21	17.49	9.66	1.50	3.62	0.91	3.23	3.40	0.64	0.05	7.54
	Mafic Porphyry	45.37	15.14	7.82	4.80	7.25	1.18	2.39	3.27	0.54	0.13	2.38

TABLE 3.
AVERAGE CONCENTRATIONS OF GOLD AND ACCOMPANYING TRACE METALS IN OXIDE ORE AND UNOXIDIZED PRIMARY ORE OF THE RABBIT CREEK GOLD DEPOSIT

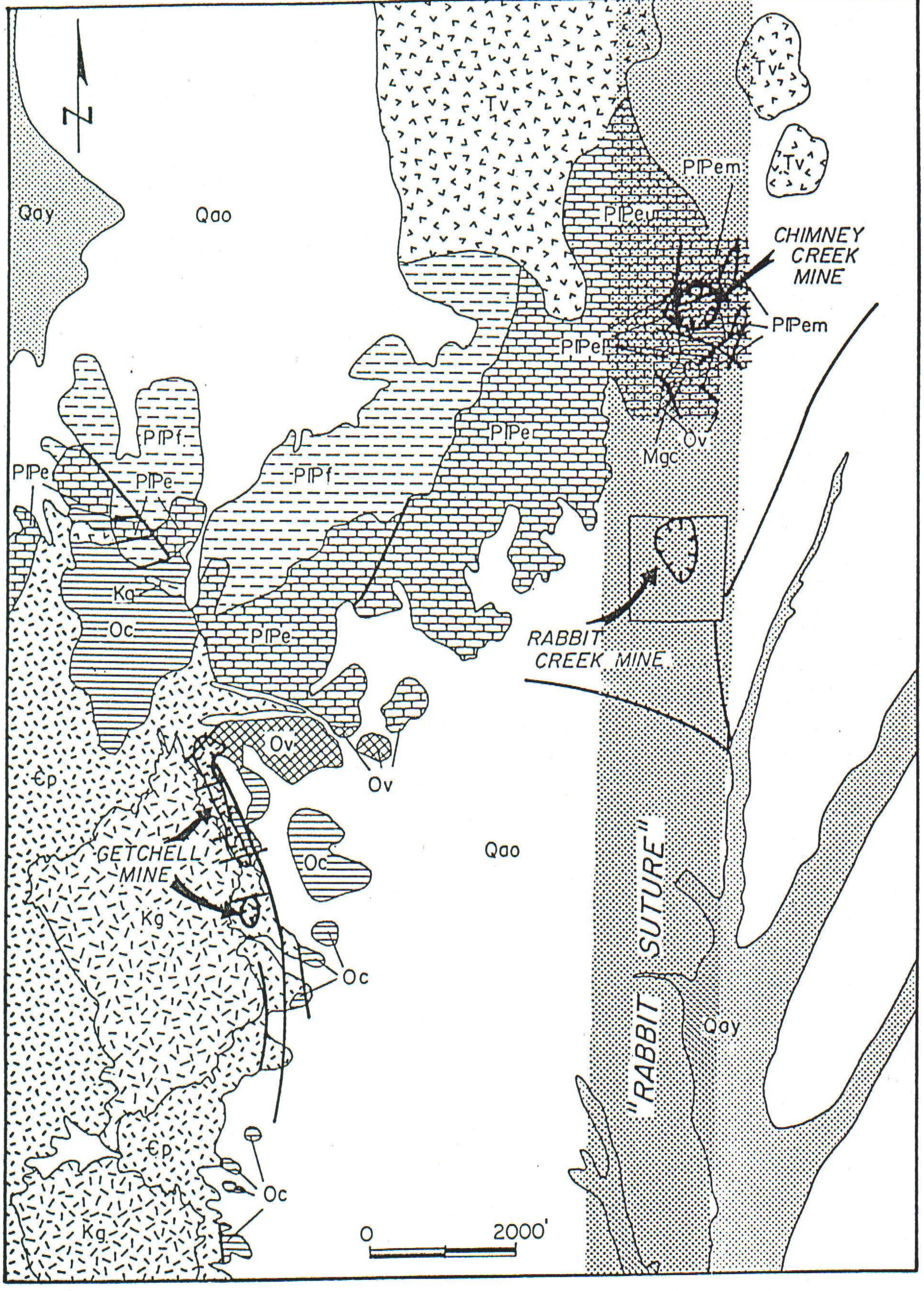
(ORE IS MORE THAN 0.02 OPT AU)

Area	Zone of mineralization	Stratigraphy of host rocks	Au (opt) Ave.	Au (opt) Max.	Ag (ppm) Ave.	Ag (ppm) Max.	As (ppm) Ave.	As (ppm) Max.	Sb (ppm) Ave.	Sb (ppm) Max.	Hg (ppm) Ave.	Hg (ppm) Max.
		Oxide Ore										
N.-Central	LGO	Upper member	0.05	0.52	1.02	11.6	1231	10,400	228	7100	2522	100,000
N.-Central	Upper sill	Upper member	0.06	0.43	0.43	1.5	3385	30,400	270	1022	2992	33,000
268	Snowshoe	Upper member	0.04	0.12	0.10	0.1	1646	4,680	275	940	2252	10,000
122	Snowshoe	Upper member	0.09	0.71	0.40	4.2	1112	4,670	517	4100	5694	121,683
N.-Central	HGO	Lower member	0.20	3.22	0.14	2.1	3365	35,800	204	1760	36736	<0.1%
268	Jackrabbit	Lower member	0.13	2.18	2.99	26.9	1143	5,450	793	8410	24684	430,000
122	Jackrabbit	Lower member	0.08	0.64	2.50	51.9	1361	6,100	592	6980	2540	8,200
		Unoxidized Primary Ore										
N.-Central	HGO	Lower member	0.13	1.08	0.71	7.2	6030	313,000	196	2440	35774	291,860
268	Jackrabbit	Lower member	0.20	3.01	9.05	27.5	505	1,010	280	871	12095	3,536
122	Jackrabbit	Lower member	0.12	0.41	11.56	35.0	486	12,000	2632	12200	11917	17,917
N.-Central	Main Chert	Lower member	0.07	1.87	1.76	155.2	8257	169,000	525	22500	28747	297,660
N.-Central	SWS	Lower member	0.16	2.44	3.14	22.2	17704	385,000	723	21500	69476	895,030
N.-Central	DZ	Upper member	0.16	2.46	2.70	200.0	7579	191,000	85	540	18734	346,070
268	Snowshoe	Upper member	0.07	0.45	0.15	0.6	3158	8,420	56	78	7682	3,570
122	Snowshoe	Upper member	0.13	0.96	1.42	13.6	917	8,290	1609	988	19175	157,900



N
CHIMNEY CREEK
RABBIT CREEK
GETCHELL
MAG
PINSON
OSGOOD MOUNTAINS
PREBLE
Winnemucca
80
5 MILES
NEVADA

FIG 1



Explanation

Qay	YOUNGER ALLUVIUM
Qao	OLDER ALLUVIUM
Tv	BASALTIC VOLCANICS
Kg	GRANODIORITE - Osgood Mtn. Pluton
PIPe	ETCHART FM. Sandy Limestone
PIPeu	UPPER MEMBER
PIPem	MIDDLE MEMBER
PIPel	LOWER MEMBER
PIPf	FARREL CANYON FM. Sandstone & Shale
Mgc	COUGH CANYON FM. Chert & Basalt
Ov	VALMY FM. Quartzite, Basalt & Siliceous Shale
Oc	COMUS FM. Calcareous Dolomitic Shale; Mudstone & Basalt
Єp	PREBLE FM. Phyllitic Calcareous

Fig 2

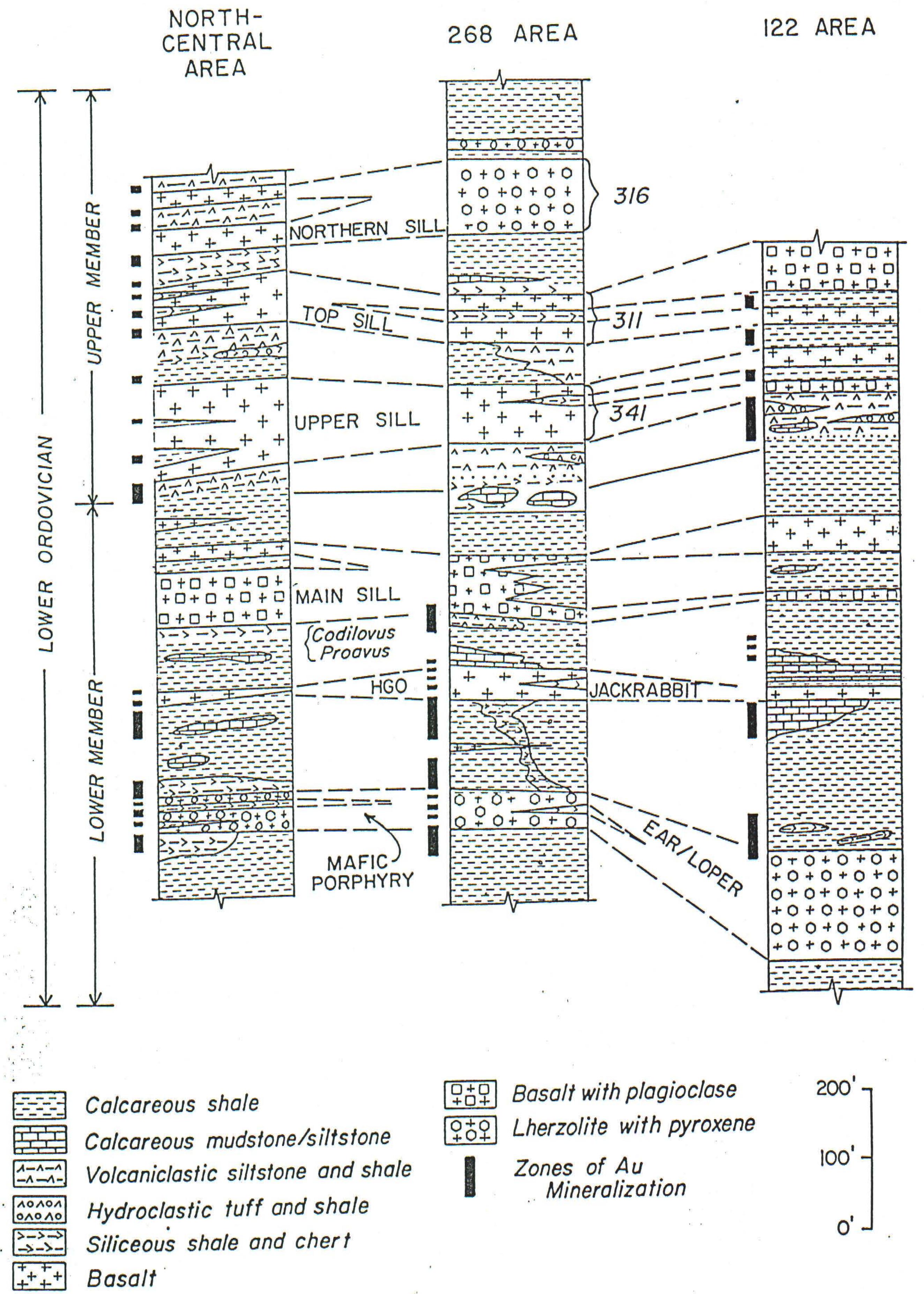
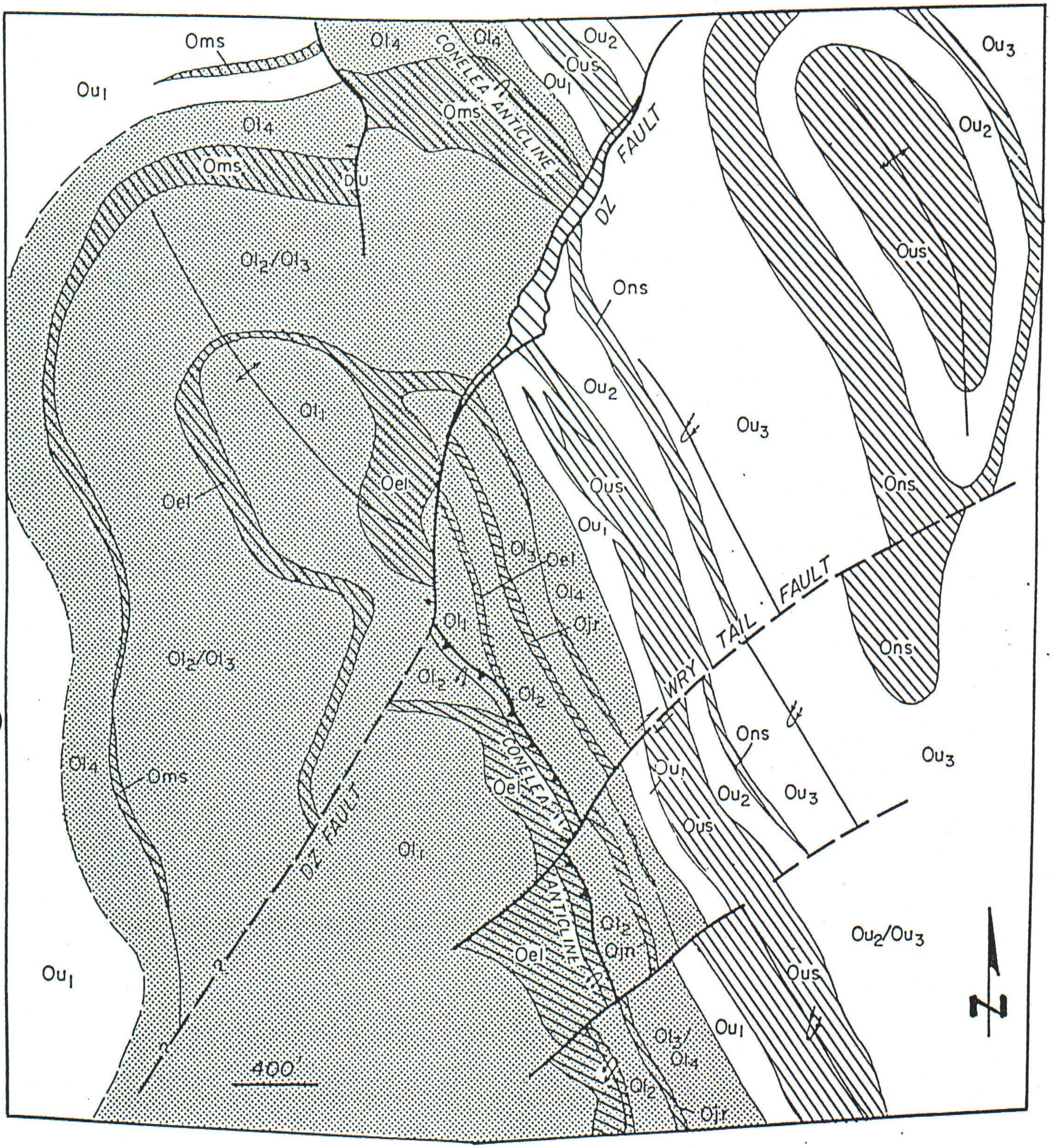

NORTH-CENTRAL AREA
268 AREA
122 AREA
LOWER ORDOVICIAN
UPPER MEMBER
LOWER MEMBER
NORTHERN SILL
TOP SILL
UPPER SILL
MAIN SILL
Codilovus Proavus
HGO
JACKRABBIT
MAFIC PORPHYRY
EAR/LOPER
316
311
341
Calcareous shale
Calcareous mudstone/siltstone
Volcaniclastic siltstone and shale
Hydroclastic tuff and shale
Siliceous shale and chert
Basalt
Basalt with plagioclase
Lherzolite with pyroxene
Zones of Au Mineralization
200'
100'
0'

Fig. 7



LOWER MEMBER

← ORDOVICIAN → ← COMUS FORMATION →

Ol4	*Shale, calcareous shale and chert*
Oms	*MAIN SILL - Basalt, phenocrysts of plagioclase*
Ol3	*Shale, calcareous shale and chert*
Ojr	*HGO and JACKRABBIT - Basalt, aphanitic and vesiculated*
Ol2	*Shale, calcareous shale and chert*
Oel	*EAR, LOPEAR and MAFIC PORPHYRY- Peridotite, phenocrysts of pyroxene and olivine*
Ol1	*Shale, calcareous shale, and chert*

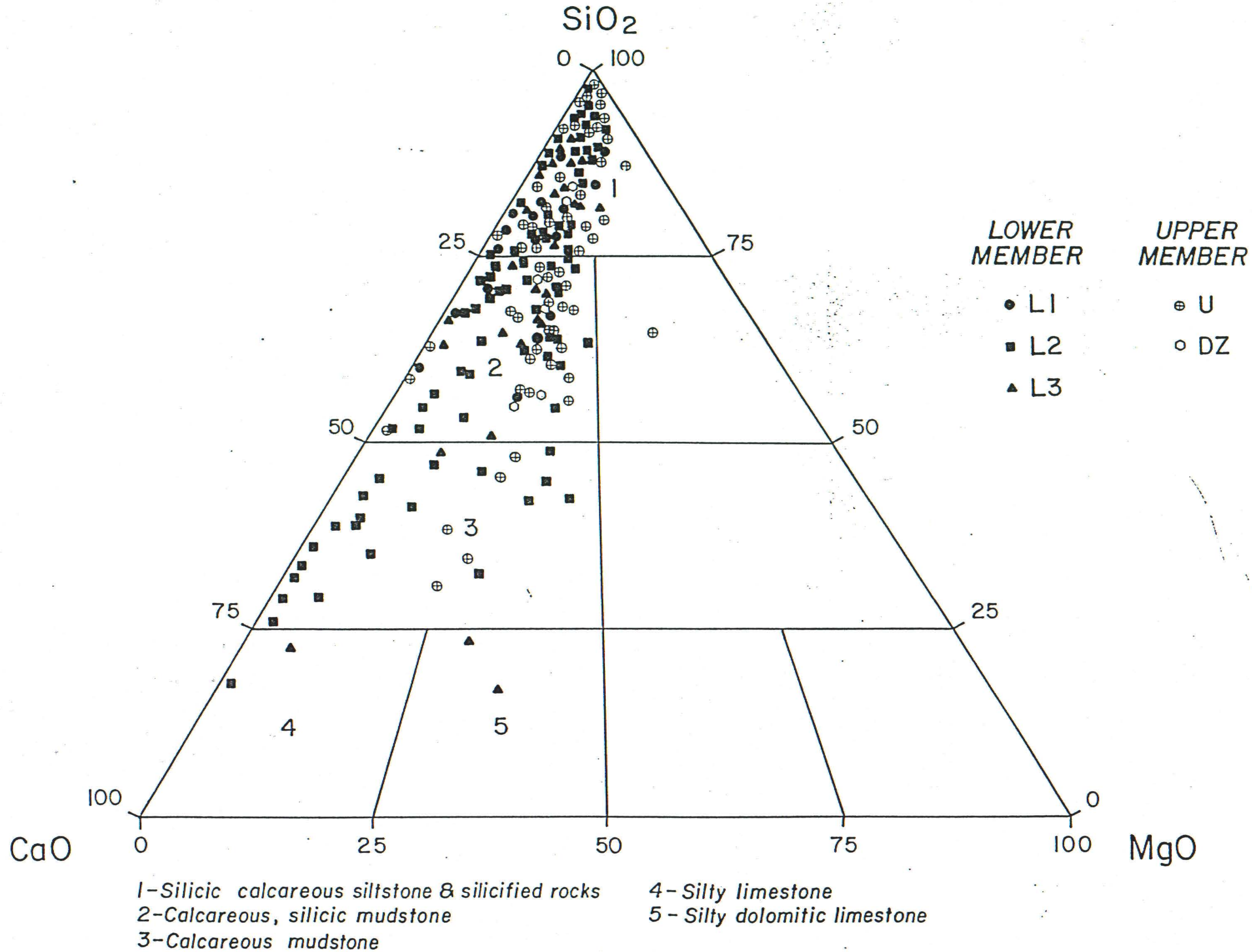
UPPER MEMBER

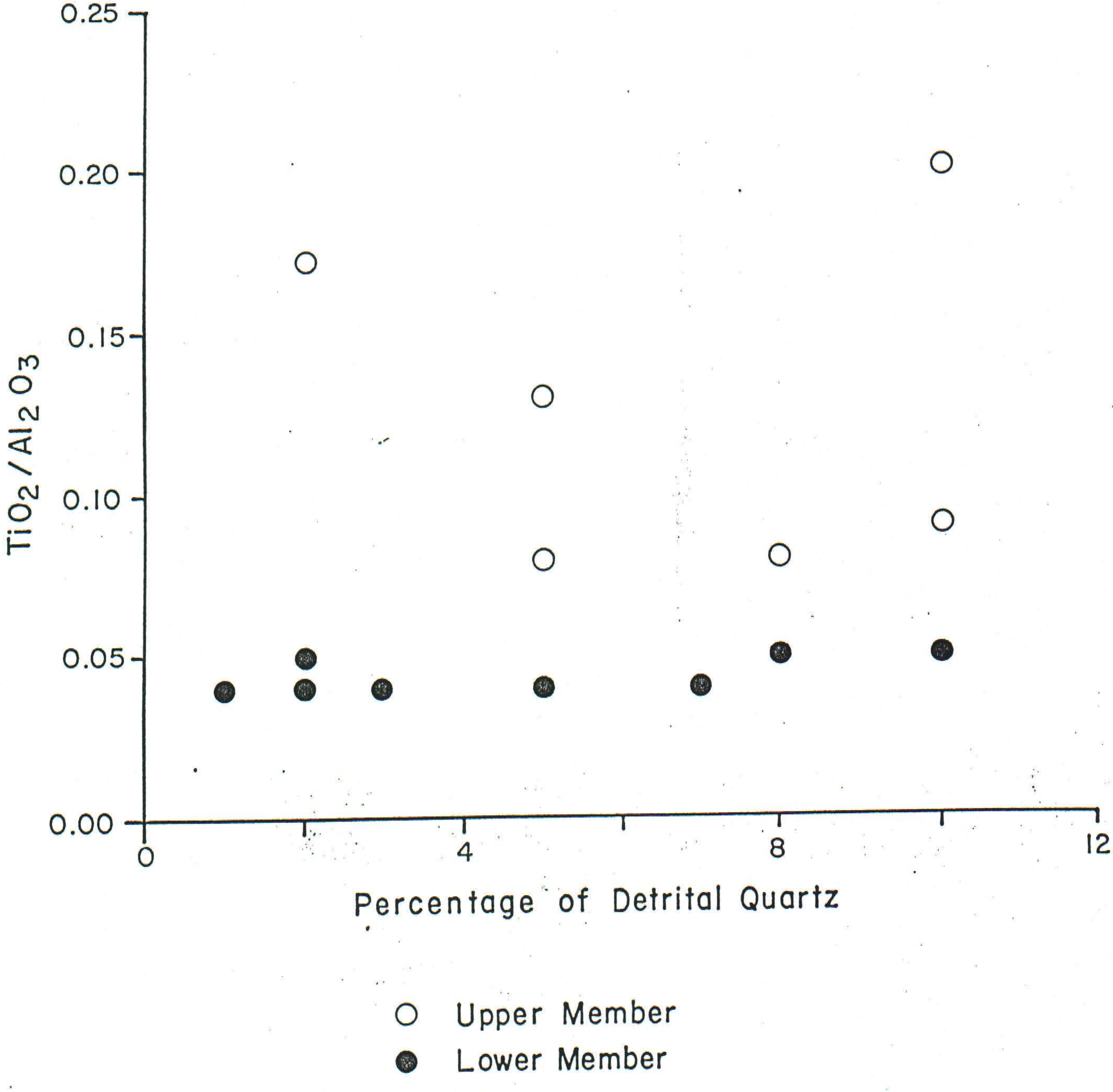
Ou3	*Hydroclastic tuffs and shale*
Ons	*MAIN SILL-Basalt, phenocrysts of plagioclase*
Ou2	*Hydroclastic tuffs, coarse volcaniclastic rocks, shales and chert*
Ous	*UPPER SILL, TOP SILL, 311, and 341 Basalt, generally aphanitic*
Ou1	*Hydroclastic tuffs, coarse volcaniclastic rocks, shales and chert*

Overturned anticline — *Overturned syncline*

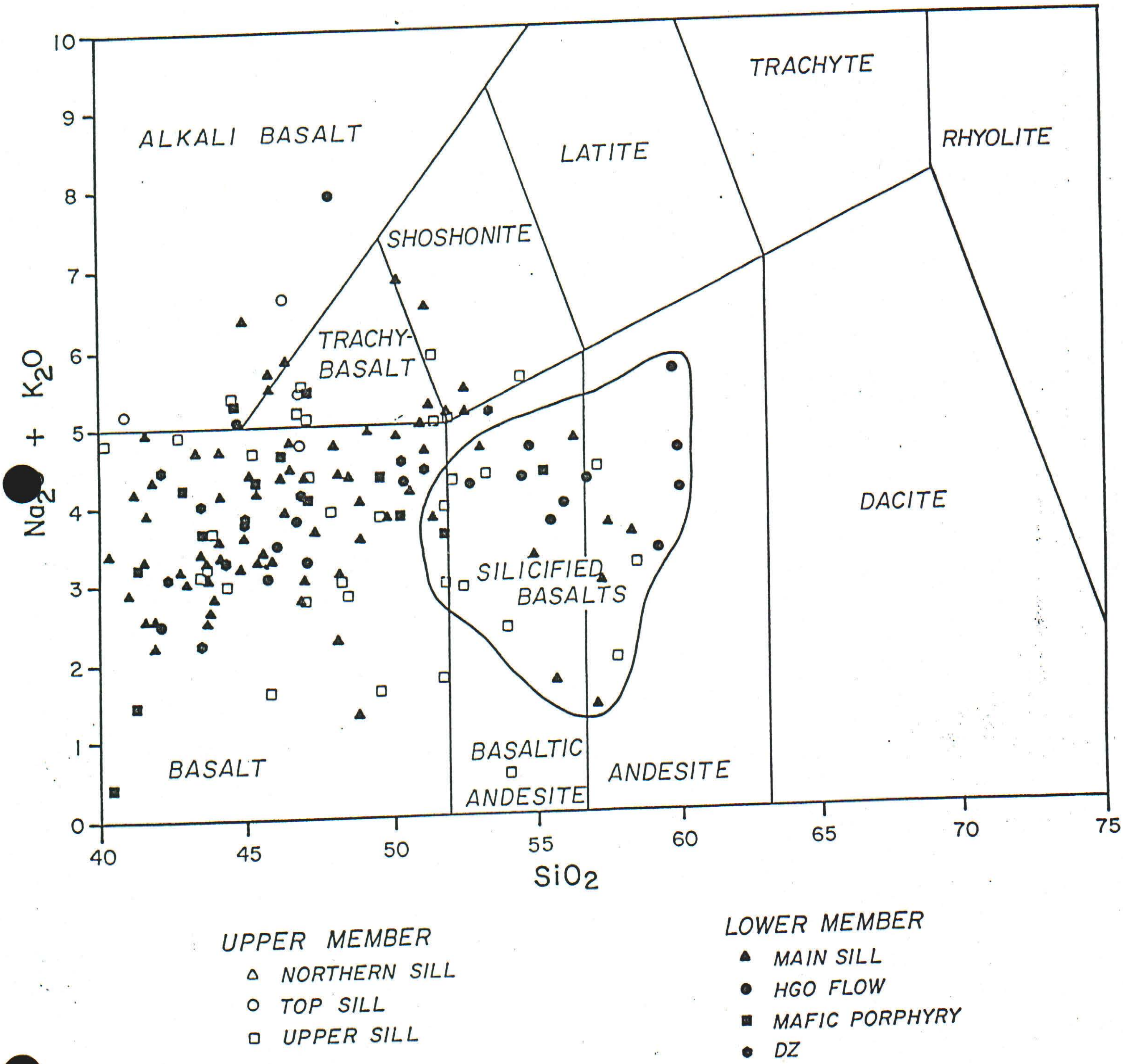
Anticline — *Low angle reverse*

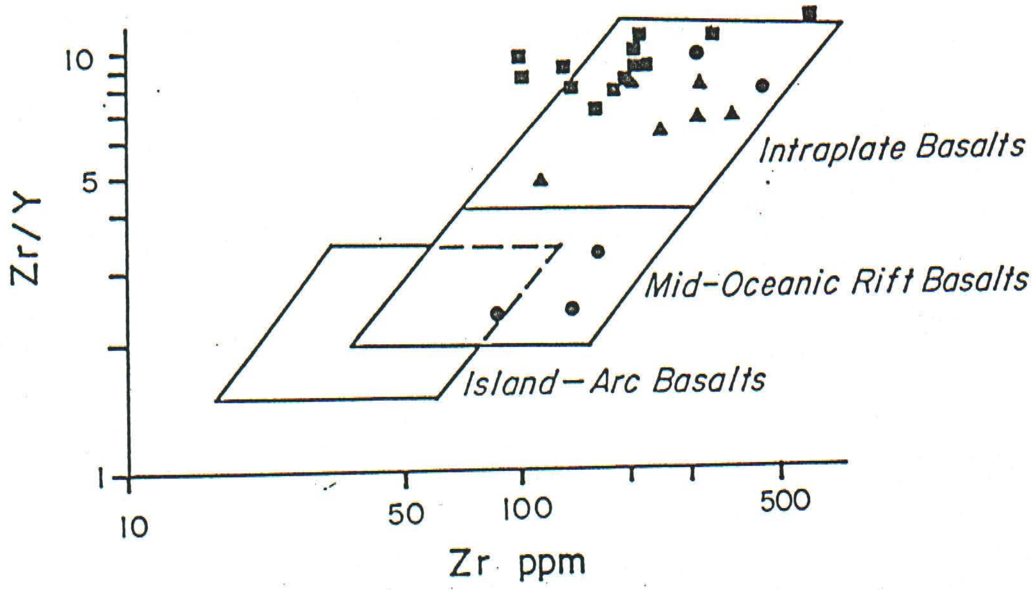
FIG 4


SiO2
0
100
25
75
50
50
75
25
100
0
CaO
0
25
50
75
100
MgO
1
2
3
4
5
LOWER MEMBER
L1
L2
L3
UPPER MEMBER
U
DZ
1-Silicic calcareous siltstone & silicified rocks
2-Calcareous, silicic mudstone
3-Calcareous mudstone
4-Silty limestone
5-Silty dolomitic limestone

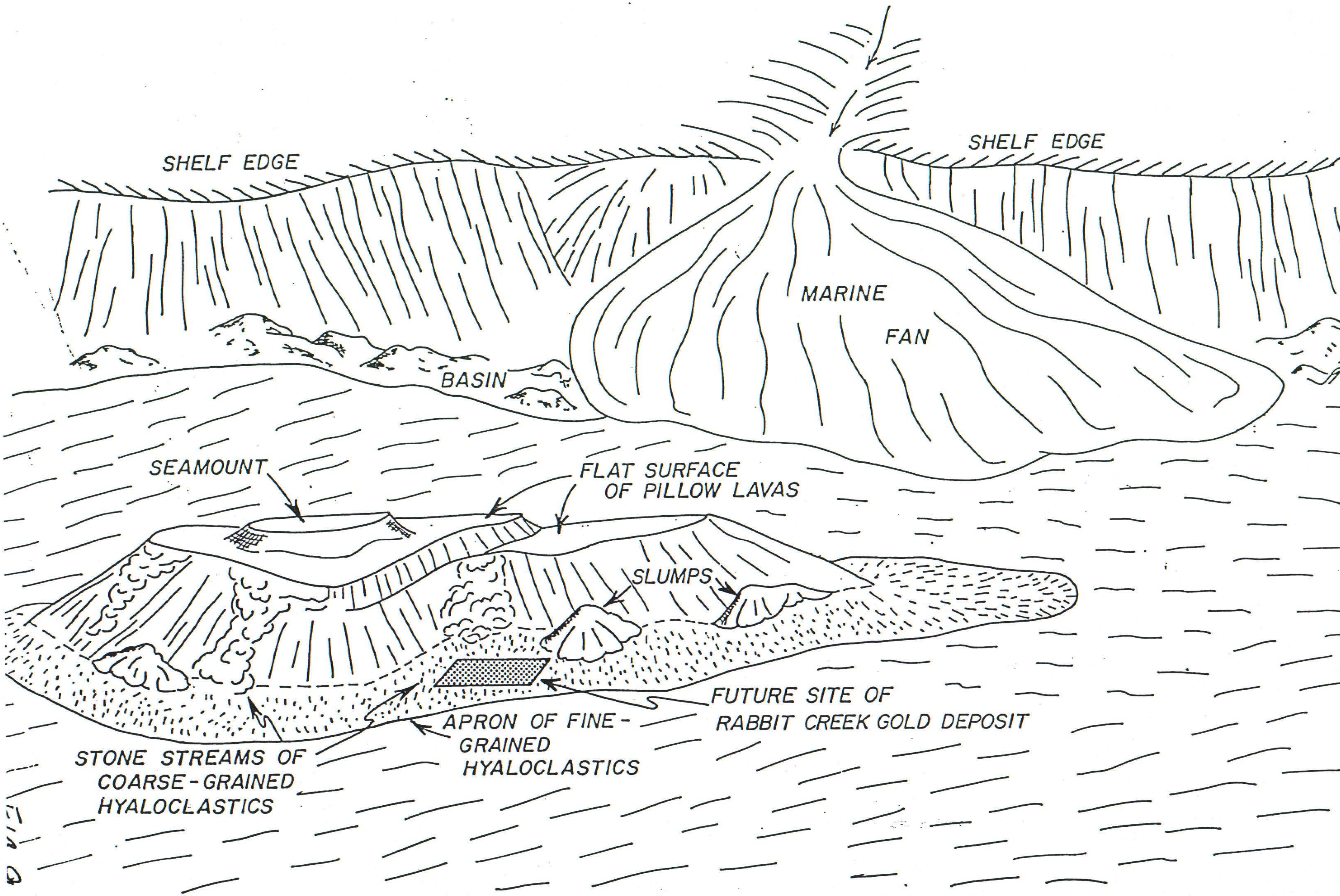

0.25
0.20
0.15
0.10
0.05
0.00
TiO_2/Al_2O_3
0
4
8
12
Percentage of Detrital Quartz
Upper Member
Lower Member

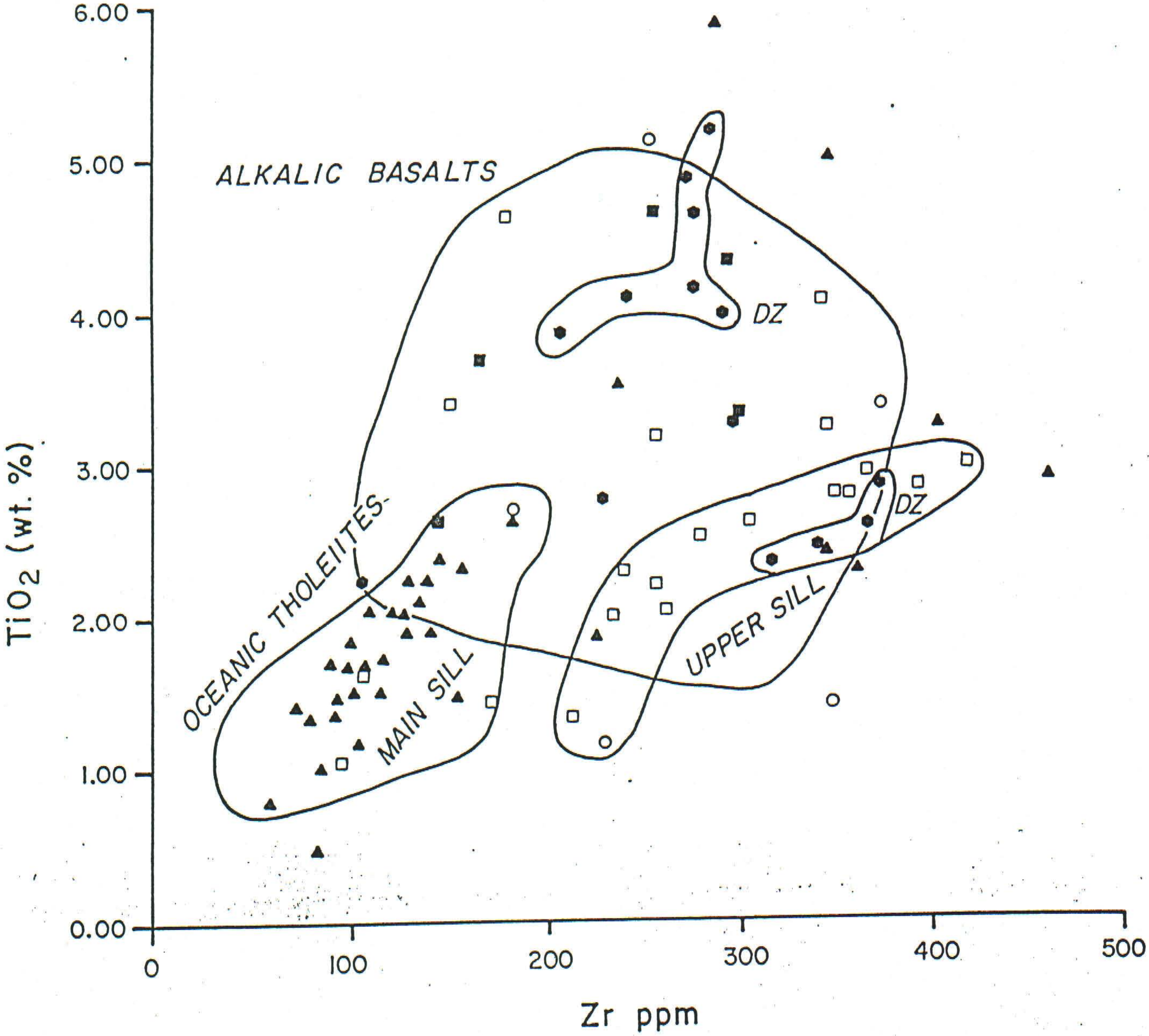
TOTAL ALKALI-SILICA DIAGRAM FOR RABBIT CREEK BASALTS





10
5
1
Zr/Y
Intraplate Basalts
Mid-Oceanic Rift Basalts
Island-Arc Basalts
10
50
100
500
Zr ppm


SHELF EDGE
SHELF EDGE
MARINE
FAN
BASIN
SEAMOUNT
FLAT SURFACE
OF PILLOW LAVAS
SLUMPS
FUTURE SITE OF
RABBIT CREEK GOLD DEPOSIT
APRON OF FINE-
GRAINED
HYALOCLASTICS
STONE STREAMS OF
COARSE-GRAINED
HYALOCLASTICS



ALKALIC BASALTS
DZ
OCEANIC THOLEIITES
MAIN SILL
UPPER SILL
DZ
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
100
200
300
400
500
TiO_2 (wt. %)
Zr ppm

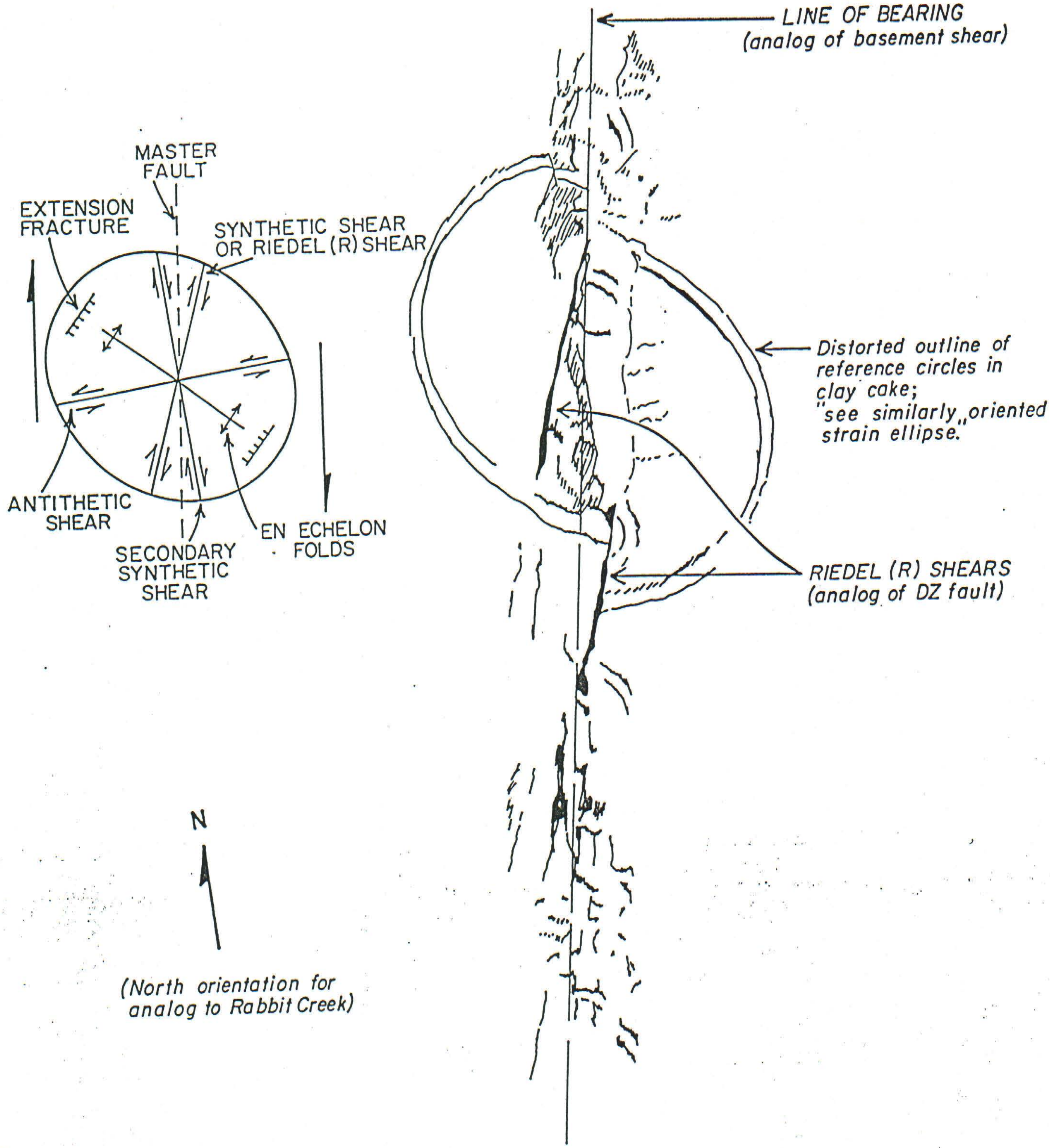

MASTER FAULT
EXTENSION FRACTURE
SYNTHETIC SHEAR OR RIEDEL (R) SHEAR
ANTITHETIC SHEAR
SECONDARY SYNTHETIC SHEAR
EN ECHELON FOLDS
N
(North orientation for analog to Rabbit Creek)
LINE OF BEARING (analog of basement shear)
Distorted outline of reference circles in clay cake; "see similarly oriented strain ellipse."
RIEDEL (R) SHEARS (analog of DZ fault)

FIG 11

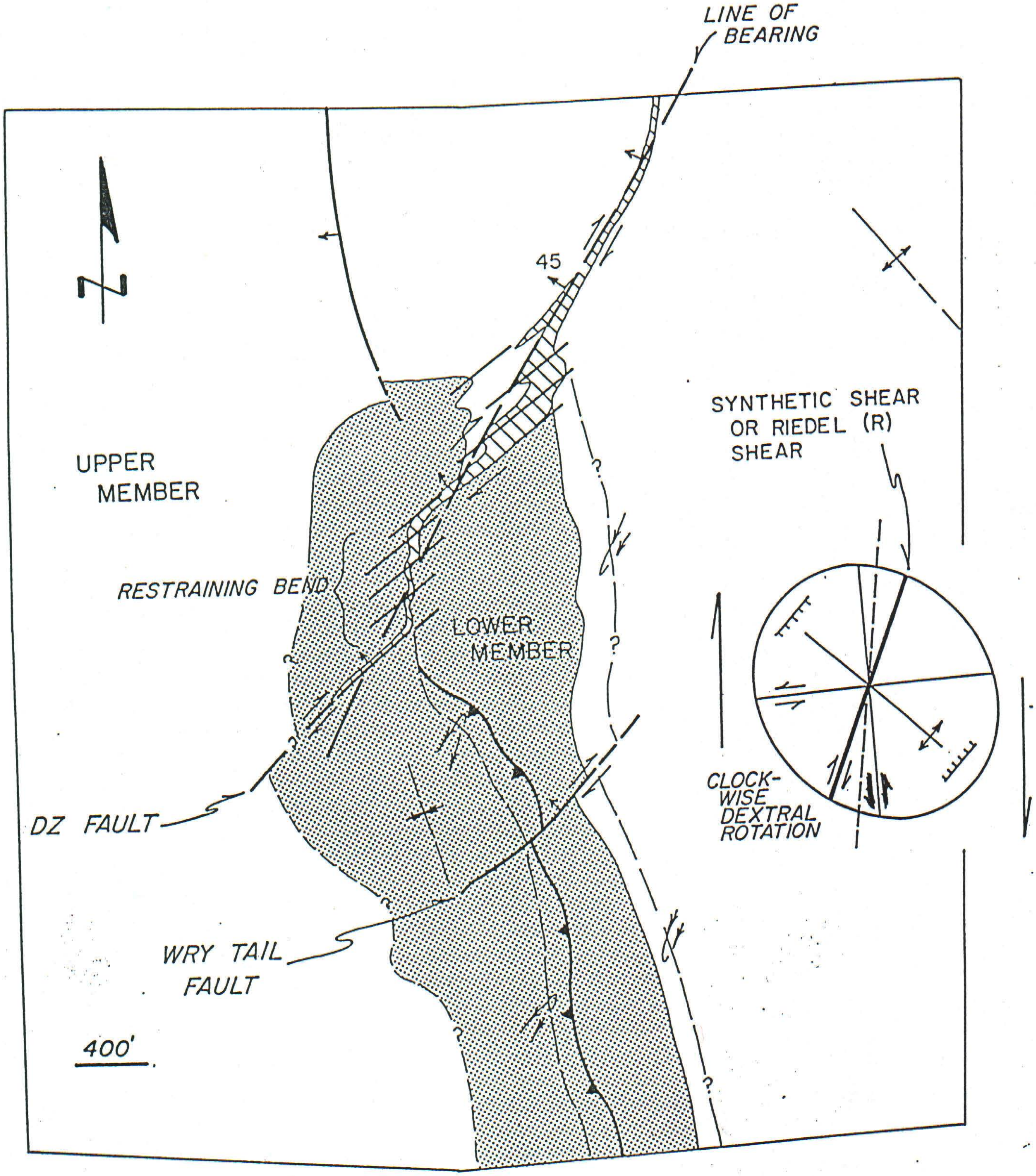
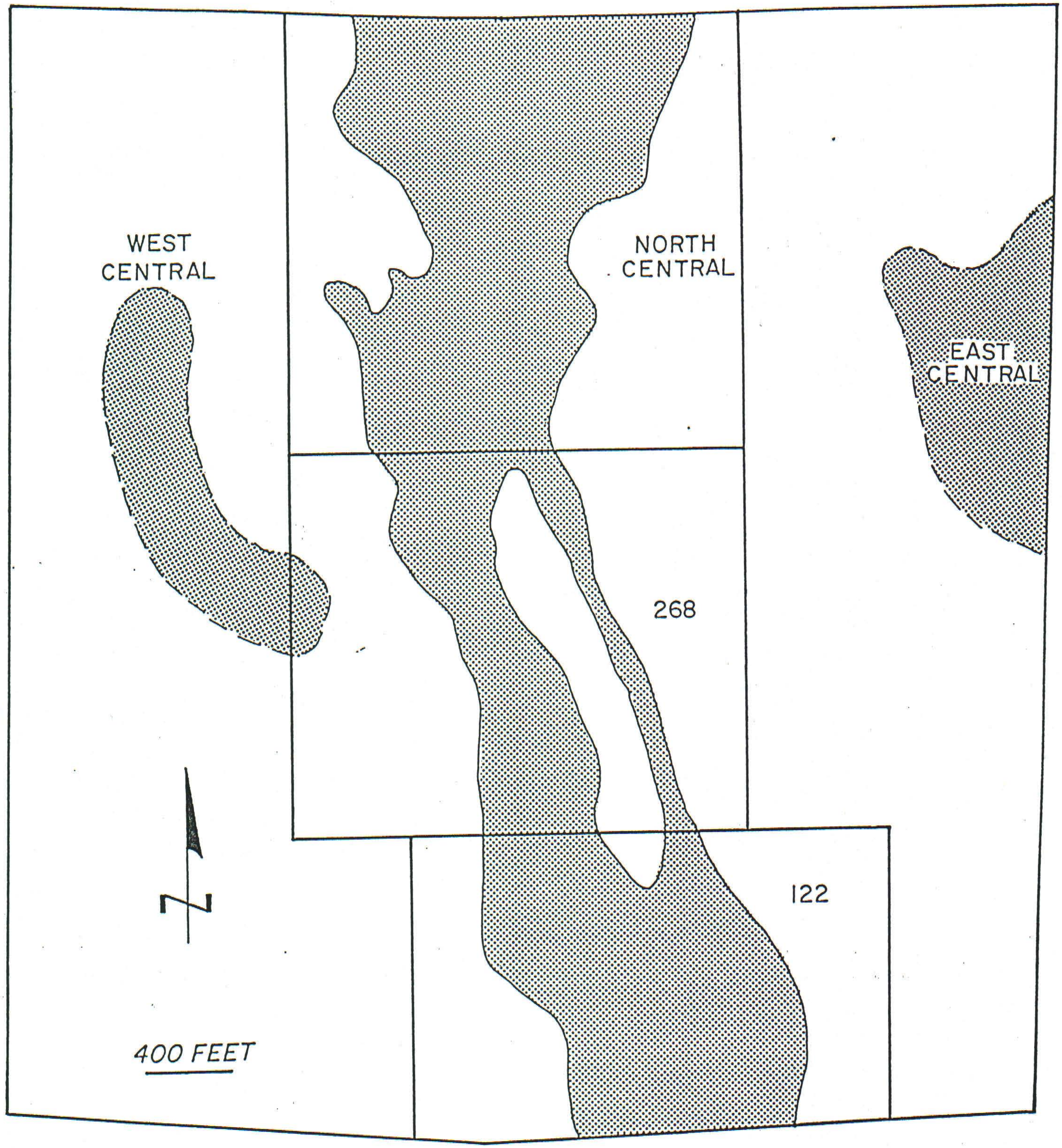
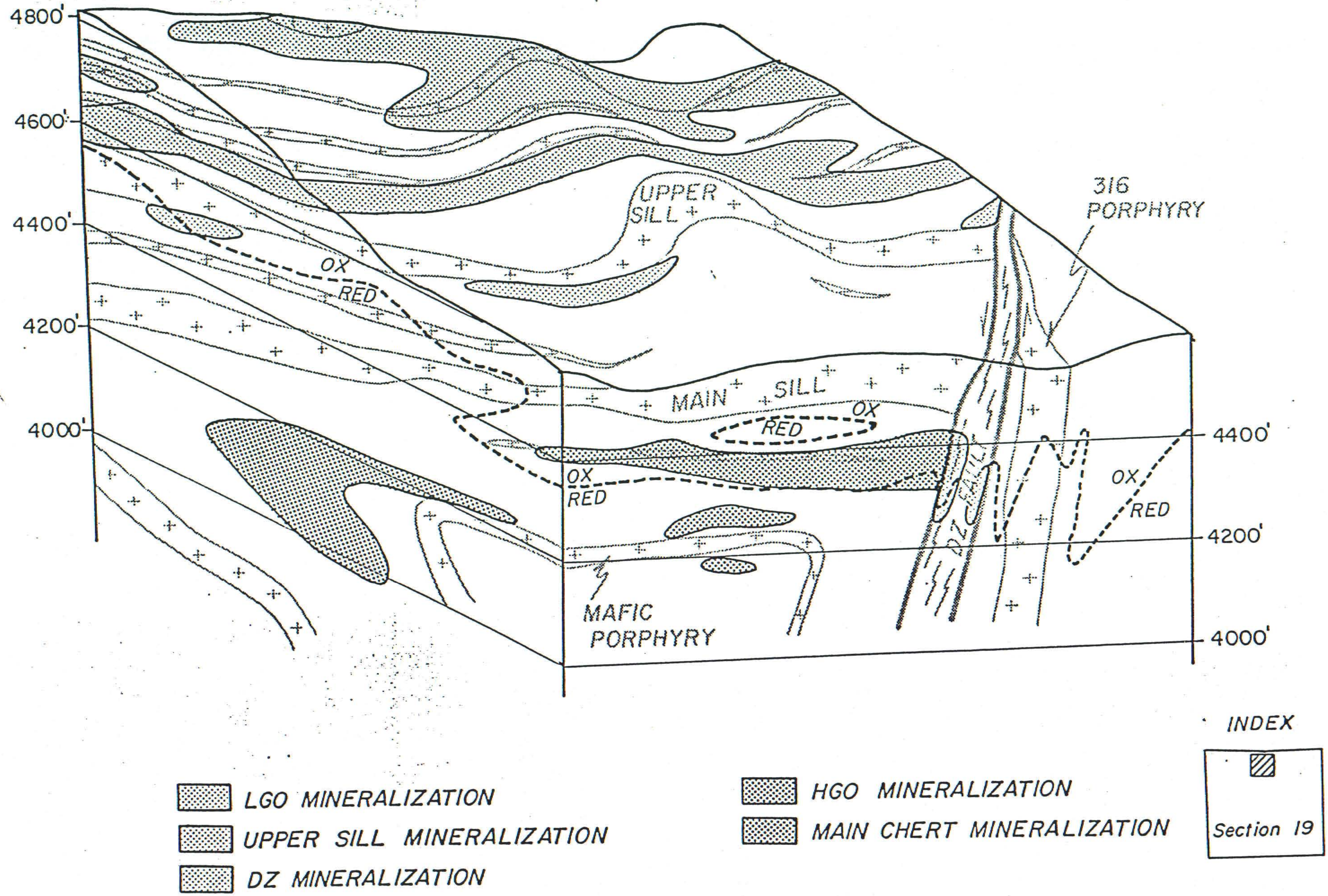
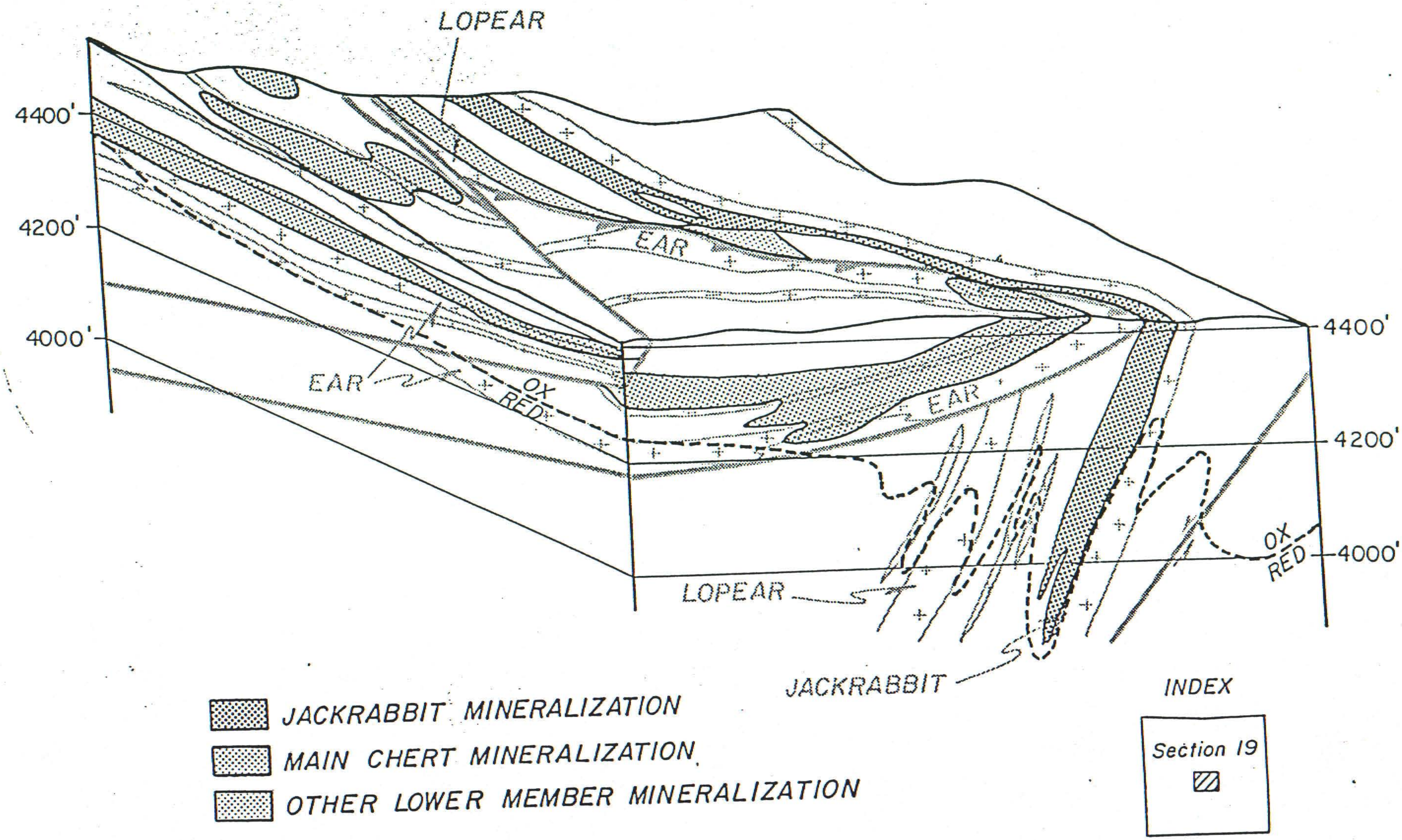
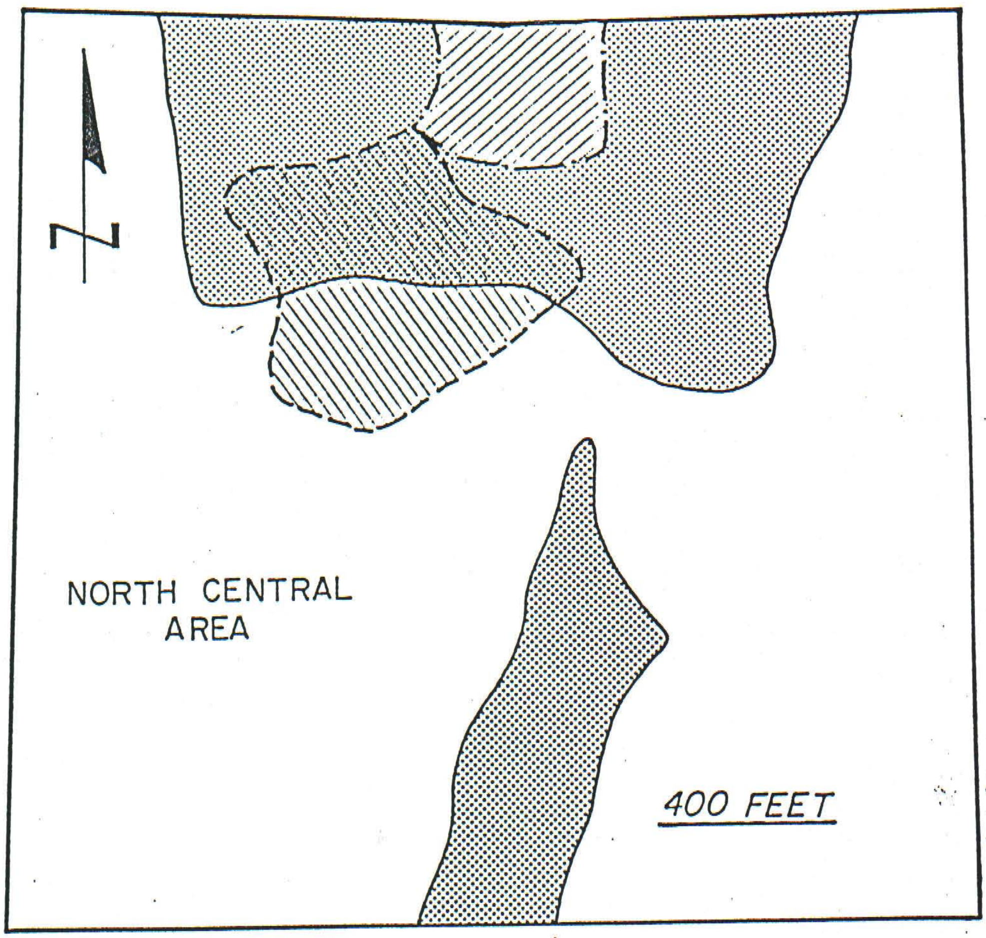

LINE OF BEARING
45
UPPER MEMBER
RESTRAINING BEND
LOWER MEMBER
SYNTHETIC SHEAR OR RIEDEL (R) SHEAR
CLOCK-WISE DEXTRAL ROTATION
DZ FAULT
WRY TAIL FAULT
400'

FIG 12

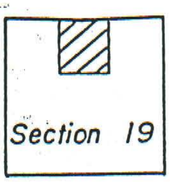

WEST CENTRAL
NORTH CENTRAL
EAST CENTRAL
268
122
N
400 FEET


4800'
4600'
4400'
4200'
4000'
UPPER SILL
316 PORPHYRY
OX
RED
MAIN SILL
OX
RED
OX
RED
DZ FAULT
OX
RED
4400'
4200'
4000'
MAFIC PORPHYRY
LGO MINERALIZATION
UPPER SILL MINERALIZATION
DZ MINERALIZATION
HGO MINERALIZATION
MAIN CHERT MINERALIZATION
INDEX
Section 19


LOPEAR
4400'
4200'
4000'
EAR
EAR
EAR
OX
RED
4400'
4200'
4000'
OX
RED
LOPEAR
JACKRABBIT
JACKRABBIT MINERALIZATION
MAIN CHERT MINERALIZATION
OTHER LOWER MEMBER MINERALIZATION
INDEX
Section 19

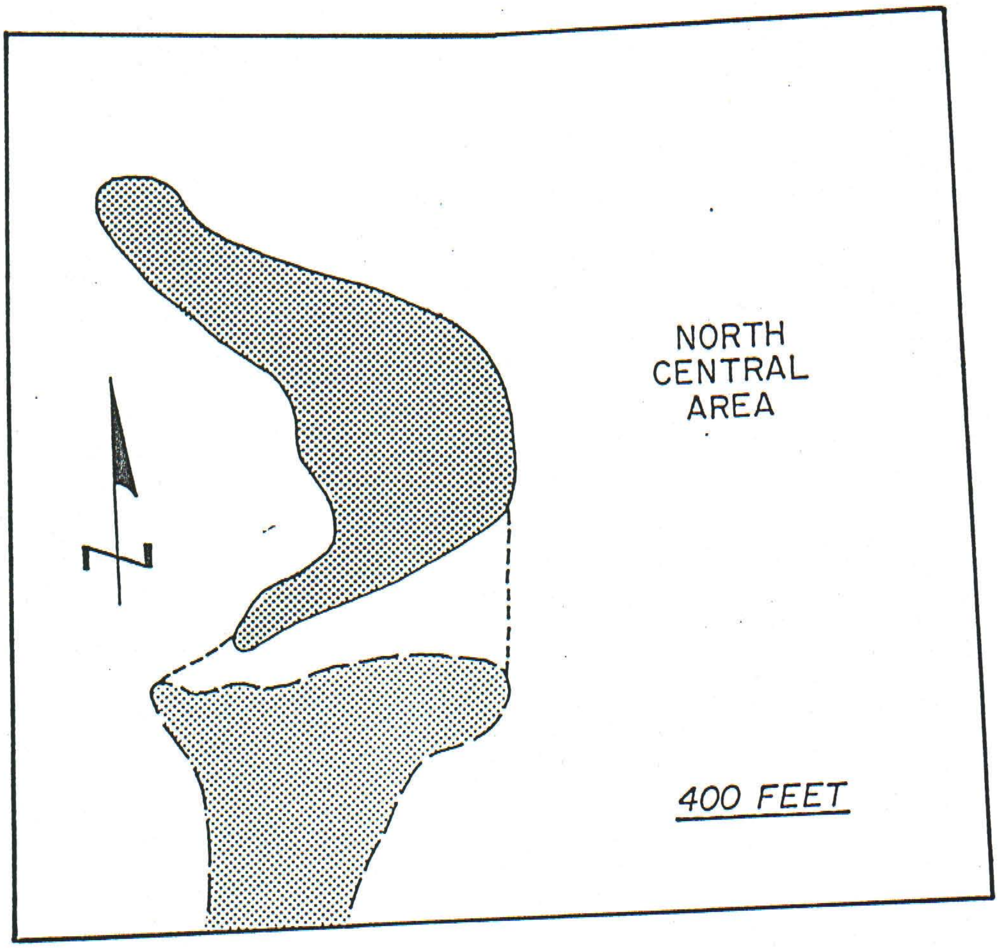


INDEX

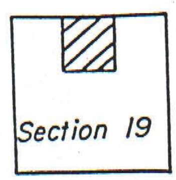


UPPER MEMBER ORE ZONES
NORTH CENTRAL AREA

- LGO oxide mineralization
- Upper Sill oxide mineralization
- Upper Sill sulfide mineralization
- DZ oxide mineralization



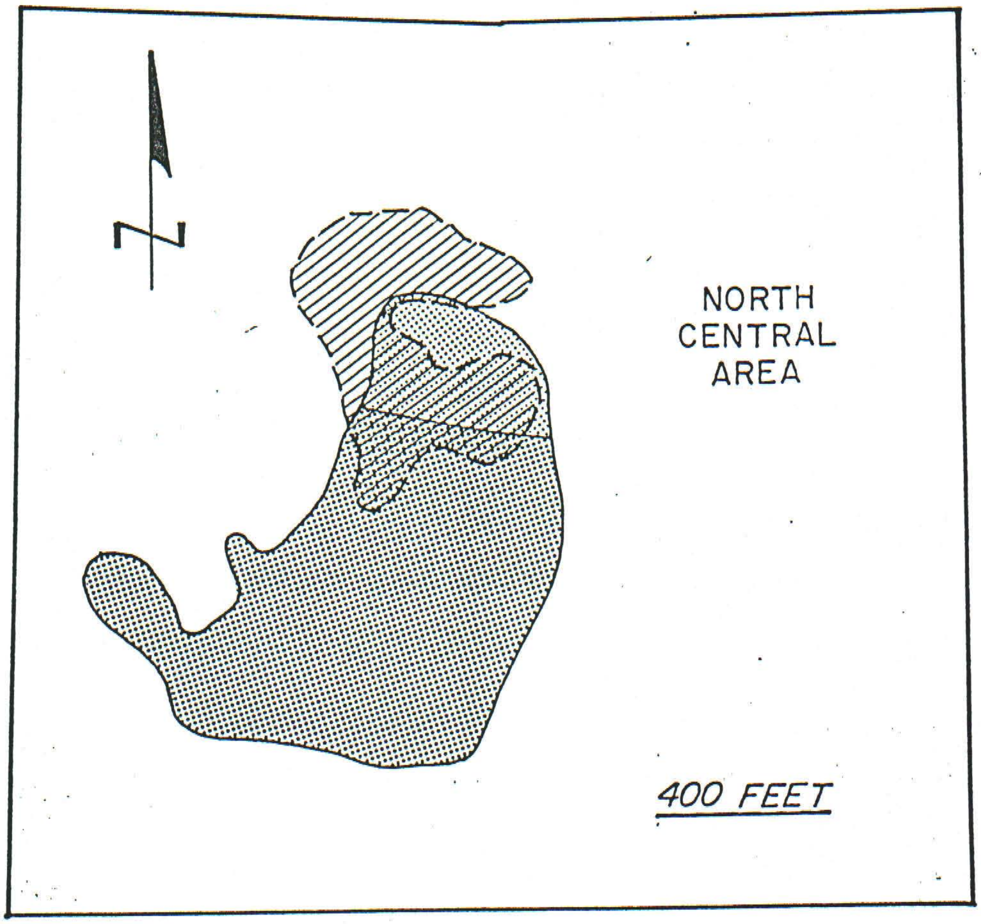
INDEX



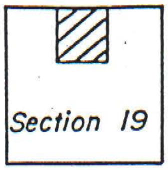
LOWER MEMBER ORE ZONES
NORTH CENTRAL AREA

- Main chert oxide ore
- Main chert unoxidized ore

FIG 17



INDEX



LOWER MEMBER MINERALIZATION

- HGO high grade oxide ore
- HGO unoxidized ore
- SWS unoxidized ore

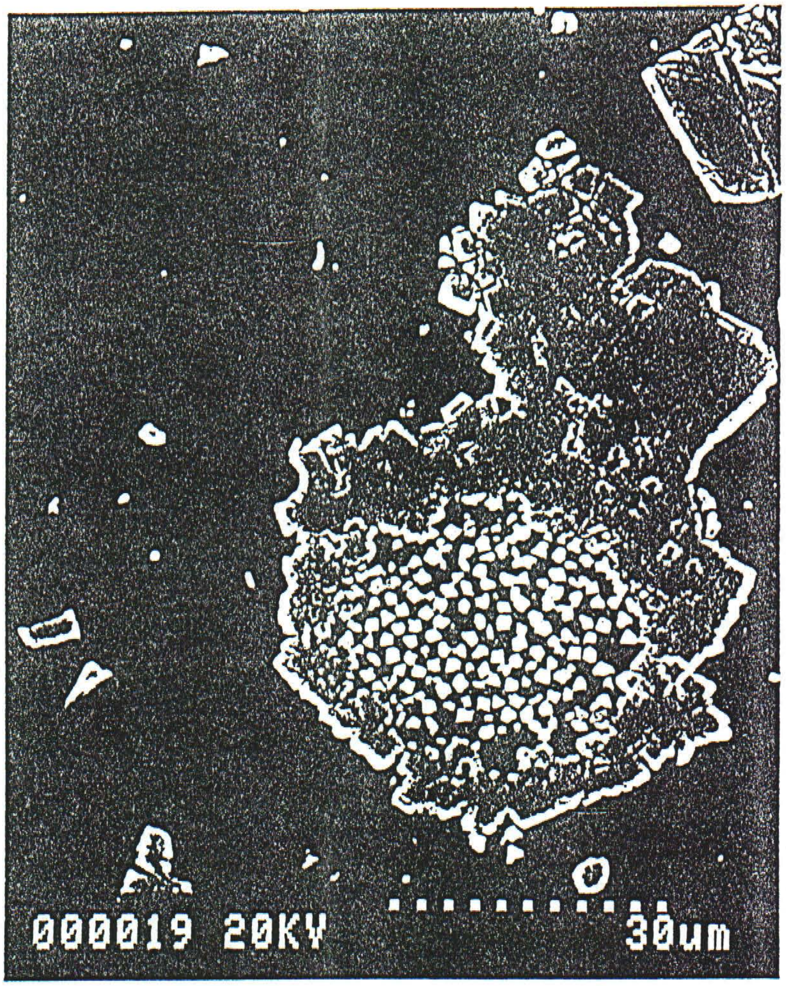


FIGURE 19.

PYRITE AGGREGATE IN THE CALCAREOUS SHALE, UNOXIDIZED ORE, SWS OREBODY. BACK-SCATTERED ELECTRON IMAGING REVEALS NUMEROUS ENHEDRAL MICRON-SIZED CUBIC CYRSTALLITES. SAMPLE 67-875. SCREEN MAGNIFICATION 1000X.

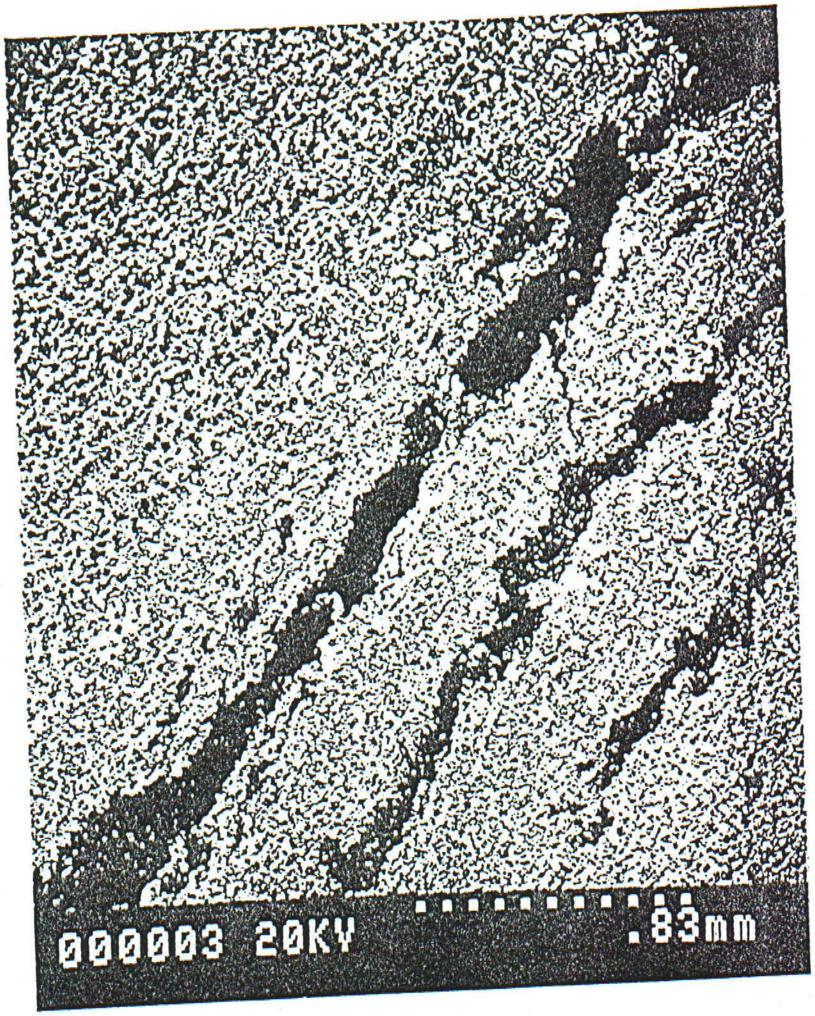


FIGURE 20.

THREE SUBPARALLEL HYDROCARBON VEINLETS IN THE SILICIFIED CALCAREOUS SHALE OF THE HGO UNOXIDIZED ORE. BACK-SCATTERED ELECTRON IMAGE. SAMPLE 61-698, SCREEN MAGNIFICATION 36X.

FIGURE 21.

SEM PHOTOMICROGRAPH OF THE ANGULAR ORPIMENT VEINLET IN THE HGO OXIDE ORE. SAMPLE 79-694, SCREEN MAGNIFICATION 350X.