106
Item 3

Paper #16

" The Tonkin Springs Gold Deposit"

Russell Hardisty

Geologist

Precambrian Exploration, Inc.

Wheat Ridge, Colorado

Presented at the 89th Annual
Northwest Mining Association Convention
Spokane, Washington
December 2, 1983

INTRODUCTION

The Tonkin Springs gold project is located in west-central Eureka County, Nevada, approximately 60 miles northwest of the village of Eureka (see Figure 1). The property is easily accessible by means of a 2-wheel drive vehicle from Eureka by traveling north on Nevada State Highway 20 approximately 40 miles, thence west-southwest 20 miles across a county maintained dirt road. The property was staked February, 1980 on the basis of several anomalous drainage sediment samples collected during the summer of 1979.

The topography of the Simpson Park range is typical of the Basin and Range province, with long narrow valleys and north trending mountain ranges. Vegetation covers varies from sagebrush covered hillsides to dense forest growths of pinon pine, juniper and mountain mahogany (see Figure 2). The climate is semi-arid with severe winters and mild to hot summers. The annual average precipitation is about 15 inches, the major portion of which is at higher elevations. Ideal field working conditions begin in early May and continue through late October.

REGIONAL GEOLOGY

The host rock for the gold mineralization at Tonkin Springs is a jasperoid within the lower to mid-Ordovician Vinini Formation (Merriam and Anderson, 1942). Merriam and Anderson divided the formation into two units; (1) the lower Vinini, represented by an interbedded sequence of sandy, dolomitic limestone, carbonaceous shale, calcarenite, siltstone, quartzite. The Vinini, as a whole, is included in the western siliceous assemblage, or upper plate rocks of the Roberts Mountain thrust fault (Roberts and Lehner, 1955). The thrust fault carried this siliceous assemblage east-southeast over the eastern carbonate assemblage, (see Figure 3), culminating the Antler Orogeny in late Devonian, early Mississippian (Roberts and others, 1958).

The thrust fault is not exposed in the immediate Tonkin Springs vicinity. Although Murphy and others (1978) mapped windows in the thrust plate near the gold deposit, no conclusive evidence of these windows has been found. The sole of the thrust zone is believed to be beneath the mineralization, within a few hundred feet. Anticlinal folding at the deposit is believed to be related to the thrust system, and may have produced fracturing that later became important during gold deposition.

The Tonkin Springs property is situated in the Eureka-Battle Mountain mineral belt (Roberts, 1966), approximately halfway between the two population centers (see Figure 3). The mineral belt is historically, one of great economic importance, especially in precious metal production.

To date, there are three mining companies producing gold in the belt: Duval's Copper Canyon and Copper Basin open-pit mines, porphyry copper deposits, now mined only for gold; Placer Amex's Horse Canyon deposit; and the Windfall mine near Eureka. Inactive deposits include: the original Cortez silver district; Placer Amex's Gold Acres and Cortez low-grade gold deposits; and the Keystone massive sulfide deposit, to name a few. Deposits in the belt with future production planned include Cominco's Buckhorn gold mine, Exxon's Mount Hope porphyry molybdenum deposit, and the Ruby Hill gold/silver mine near Eureka (see Figure 3).

The Eureka-Battle Mountain mineral belt has also been recognized as being tectonically active, and has been traced for approximately 700 km along a northwest trend from central Oregon (Stewart and others, 1975). This linement has been referred to as the Oregon-Nevada linement (Stewart and others, 1975), northern Nevada rift (Zoback and Thompson, 1978), and the Cortez rift (Barrash and Venkatakrishnan, 1982). The linement is characterized by a belt of closely spaced, NW trending en-echelon faults, dike swarms, and mid-Miocene volcanism thought to mark the inception of Basin and Range rifting in Nevada (Zoback and Thompson, 1978). The belt is also outlined by an aeromagnetic anomaly interpreted as being related to the deep-seated feeder system for the basaltic andesite flows and dike swarms in the Cortez and Roberts Creek Mountains (Stewart and others, 1975).

A parallel belt of low grade gold deposits occur in the Lynn-Railroad mineral belt (Roberts, 1966), made up of Newmont's Carlin, Maggie Creek, Boot Strap, Blue Star, Gold Quarry, and Rain deposits, and is located approximately 60 miles northeast of Tonkin Springs. In addition to Newmont's mines, two newly discovered low-grade gold mines along the trend include Dee Mining Company's Boulder Creek deposit and Western States' Gold Strike deposit.

STRATIGRAPHY

The Vinini Formation is the oldest exposed formation in the vicinity of the Tonkin Springs deposit. The formation has been subdivided into two units on the geologic map (see Figure 4), the lower and upper Vinini. The lower Vinini is represented by an interbedded sequence of sandy dolomitic limestone, calcarenite, and carbonaceous shale. This unit is inferred to represent a near-shelf facies, transitional to a true eugeosynclinal depositional environment, on the basis of the terriginous clastic fraction present in these sediments. Sandy, dolomitic limestone and calcarenite appear to be the most favorable lithologies for silica replacement or jasperoid development, and also for gold mineralization (see Figures 5, 6, 7). Overlying this lower sandy sequence, but still included within the lower Vinini, is an interbedded sequence of thin-bedded limestone, carbonaceous shale, quartzite, and minor greenstone. This sequence is inferred to represent a deeper water facies as compared with the sandy sequence. The large volume of carbonate material in the lower Vinini is suggestive of being more closely related to the transitional assemblage (Hotz and Wilden, 1955), than to the siliceous assemblage. The lower Vinini is in fault contact with the upper Vinini at all localities on the map where the contact is exposed. The contact is often concealed, but where exposed is always brecciated and silicified.

The upper Vinini is represented by quartzite, bedded chert, and black organic shale, lithologies more characteristic of the western siliceous assemblage. The base of the upper Vinini is represented by brecciated quartzite. Primary depositional bedding has been largely obliterated by brecciation and silicification. The quartzite is overlain by bedded chert that displays primary bedding that varies in thickness from 1 to 4 inches, with a few beds up to one foot or more, separated by thin-shaly partings.

The Devonian limestone, shown on the map (see Figure 4), as Dl, is represented by a gray fine-grained, crinoidal limestone, that also contains horn corals and brachiopods, and is in thrust contact with the Vinini Formation to the northwest of the Tonkin Springs deposit. The limestone was deposited in a miogeosynclinal environment and belongs to the eastern carbonate assemblage (Roberts and others, 1958). The limestone and jasperoid klippes are thought to be metagravity slides rather than tectonic thrust faults (Murphy and others, 1978). A cross-cutting, northeast trending high angle normal fault is responsible for silicification or jasperoid development within the limestone; fossils are preserved after silicification aiding in correlation.

TERTIARY IGNEOUS ROCKS

A clay-altered, biotite, hornblende, alkali feldspar intrusive is exposed on the surface, adjacent to the mineralized deposit on the west, and at several localities to the northwest. Feldspars are totally altered to clay, and biotite and hornblende are usually altered to chlorite or epidote, making identification and classification difficult. The rock has an abundance of cross-cutting calcite veins, and usually contains 2 to 3% disseminated pyrite.

The intrusive bodies appear to be sill-like in habit. Most are tabular and were emplaced parallel to bedding, possibly along thrust faults. However, intrusive bodies may occur as vertical dikes to the north of the mineralized body. The intrusives are important to the mineralization in as much as they appear to have influenced location of channel ways for the late mineralizing fluids. The intrusives themselves, however, are barren of gold. Age of the intrusion is uncertain, but field relationships show it to predate Tertiary volcanism and mineralization.

Tertiary volcanics, undifferentiated on the map, are made up of two units, a rhyolitic crystal-lithic tuff and a set of porphyritic andesite flows. The white to gray, crystal-lithic tuff contains phenocrysts of quartz and biotite, plus various lithic fragments set in a fine grained ground mass of ash and pumice. The reddish brown to purple, porphyritic andesite contains phenocrysts of alkali-feldspar and hornblende set in an aphanitic ground mass. K-Ar age dates on the rhyolite indicates ages of Eocene to Oligocene or 37.5 ± 0.4 m.y., and age dates on the andesite indicate an Oligocene age or 33.4± 2.6 m.y. (Murphy and others, 1978).

STRUCTURE

Two major sets of high angle normal faults have been recognized at Tonkin Springs, an older NW set that appears to have been the more important set during mineralization. The younger NE trending faults give rise to large soil and rock-chip anomalies, but as of yet have failed to prove to be economically important (see Figures 17, 18). The anomalies are thought to represent hydrothermal fluid leakages along these fractures in conjunction with jasperoid development and may have been sealed by silica prior to the main gold mineralizing event.

The NW trending fractures are thought to be Basin and Range faults, associated with the 17 to 14 m.y. rifting. Drill hole data within the main deposit defined to date, indicate three parallel fractures containing higher grade mineralization, up to 0.5 oz/ton Au, separated by zones of lower grade mineralization (see Figure 8). This would indicate that the age of the mineralization may be late miocene, or roughly contemporaneous with volcanism and plutonism in the Roberts Creek Mountains to the southeast and in the Cortez Mountains to the northwest.

The NE trending faults truncate the NW set at different localities on the map. The fractures have been interpreted as being tear faults, associated with Basin and Range oblique extension (Zoback and Thompson, 1978).

MINERALIZATION

Drilling to date has delineated a deposit that trends roughly northwest-southeast approximately 1500 feet, and laterally approximately 1000 feet. Reserve calculations indicate a deposit of approximately 2.5 m.t., with an overall average grade of 0.09 oz/ton Au. The stripping ratio has been calculated to be 2.4 tons of waste to one ton of ore. A deeper zone of mineralization has been determined to contain approximately 0.5 m.t. of 0.09 oz/ton Au material, but would have a stripping ratio of 14.7 to 1, making it uneconomical to extract at today's gold price (see Figures 9, 10). Chances for additional reserves along the trend appear to be excellent as indicated by the geology and geochemistry.

Mineralization occurs in both oxidized and unoxidized zones, with the bulk of the mineralization in the unoxidized zone. Microprobe work performed in conjunction with metallurgical studies carried out by Bacon, Donaldson, and Associates of Vancouver, B.C., has determined that approximately 75% of the gold mineralization in the unoxidized zone occurs as micron-sized particles in sulfide minerals, namely pyrite and arsenopyrite. Pyrite is found in two forms, as framboidal pyrite in silica veinlets and as normal cubic pyrite disseminated throughout the rock (see Figures 11, 12, 13). This type of mineralization has been documented at the Carlin gold deposit (Radtke and Rye, 1980), and at the Cortez gold deposit (Wells and Mullens, 1973). The remaining 25% probably occurs as micron-sized free gold particles in silica veinlets, although there have been no reports of visible gold. Other sulfide minerals associated with the deposit include realgar, orpiment, cinnabar, and stibnite (see Figures 14, 15).

Thin-section analyses indicated the following paragenesis: decalcification → silicification (jasperoid development) → silicification (silica veinlets with sulfide and Au mineralization ?) → calcification (calcite veinlets with realgar, → cinnabar, and barite fracture filling) → microfracturing → carbonization. There does not appear to be any significant gold mineralization associated with the late stage introduced hydrocarbon, which is found along microfractures and as a black oily film coating sulfide crystals.

Ore controls at Tonkin Springs include the following: Tertiary intrusive on the west, Tertiary volcanic capping on the east, northwest trending fractures, and a favorable host rock. The Tertiary intrusive is inferred to have intruded along a bedding plane thrust fault (see Figure 9). This conclusion is based on the following observations: geometry of the base of the intrusive; cross-sectional geometries of ore pods perpendicular to the intrusive's basal contact; and milled and fractured sedimentary inclusions within the intrusive. The sill-like intrusive body acted as a conduit as well as a dam for hydrothermal fluids. The Tertiary volcanics, namely the crystal-lithic tuff, also acted as an impermeable barrier, as there is ore-grade mineralization just below the silicified sedimentary contact with the volcanics, but only weak geochemical mineralization within them. The northwest trending high-angle fractures appear to be important conduits for the hydrothermal fluids, with subsequent lateral penetration into a favorable host.

Porosity and permeability appear to have been developed by different mechanisms: primary or intergranular porosity, developed as a result of deposition of terriginous clastic material; secondary intergranular porosity, developed after decalcification of sandy carbonates and calcarenites; tectonic fracturing produced by thrusting and associated folding; northwest trending fractures, associated with Basin and Range rifting and continental extension; and brecciation adjacent to intrusives.

GEOCHEMISTRY

Discovery of the main gold deposit at Tonkin Springs, is directly attributable to a well-designed geochemical survey and to quality geochemical analyses performed on approximately 4500 soil, rock-chip, and drainage sediment samples. The samples were analyzed by Mikron Geochemical Laboratory, Wheat Ridge, Colorado. In addition to geochemistry, detailed geological mapping and perserverance played an important role in the discovery. The Tonkin Springs vicinity has been an area of intense exploration over the past 16 years by seven major companies. All attributes combined, lead to targeting the first five drill holes where they intercepted ore grade mineralization and thickness.

The decision to stake the claims was taken after a gold anomaly was detected in drainage sediments during 1979. The samples defined an anomalous area of approximately 6 square miles (see Figure 16). Gold values ranged from 0.02 to 0.10 ppm. Drainages in the immediate vicinity of the Tonkin Springs deposit contained gold contents varying between 0.03 and 0.06 ppm.

Soil sampling, conducted on a 400 x 200 feet grid system revealed a number of large and intense gold anomalies within the gold bearing district defined by the drainage sediment geochemistry (see Figure 17). The soil gold anomalies are accompanied by elevated values for Hg, As, and Sb. The concentration ranges for these elements in the Tonkin soils were found to be:

Au	undetectable to 1.6 ppm
Hg	26 to 968 ppb
As	50 to 3000 ppm
Sb	1 to 52 ppm

Rock-chip samples collected over the Tonkin Springs deposit were analyzed for Au only. The gold contents varied from undetectable to 28 ppm. Figure 18 is a map showing rock samples collected by a competitive company that clearly defines the northeast trending fault shown on Figure 4, and also defined by soil geochemistry in Figure 17. The data in Figure 17 and 18 suggests a northeast trend for the mineralization, which drilling has since proven to be erroneous.

SUMMARY

Drilling at Tonkin Springs has delineated a mineralized deposit containing approximately 2.5 m.t. of 0.09 oz/ton Au. The stripping ratio has been calculated to be 2.4:1. A deeper zone of mineralization contains approximately 0.5 m.t. of 0.09 oz/ton Au material at a strip ratio of 14.7 to 1.

The mineralization occurs in the lower to mid-Ordovician Vinini formation, a near-shelf eugeosynclinal facies. Gold mineralization has been determined to occur as micron-sized particles in pyrite and arsenopyrite, and as micron-sized free gold in silica veinlets. The mineralization is controlled by Tertiary volcanic capping, Tertiary clay-altered sill-like intrusive bodies, northwest trending fractures, and a favorable host rock.

The property lies within the Eureka-Battle Mountain mineral belt (Roberts, 1966), a belt that has been tectonically active since at least 15 m.y. B.P. and was a locus for mid-Miocene volcanism and plutonism (Stewart and others, 1975). This is evidenced at Tonkin Springs by three northwest trending fractures containing higher grade mineralization. Fractures with this orientation have been interpreted as being related to Basin and Range rifting, suggesting a late-Miocene age for mineralization or roughly coincidental to volcanism and plutonism in the Roberts Creek Mountains to the southeast and the Cortez Mountains to the northwest.

Discovery of the mineralization is attributed to a well-designed geochemical survey and quality geochemical analyses. This in conjunction with detailed geological mapping over a three-year period, targeted the first five drill holes in ore-grade mineralization and thickness.

REFERENCES CITED

Barrash, W., and Venkatakrishnan, R., 1982, Timing of late Cenozoic volcanic and tectonic events along the Western margin of the North American plate: Geological Society of America Bulletin, v. 93, p. 977-989.

Hotz, P. E., and Willden, R., 1955, Lower Paleozoic sedimentary facies transitional between eastern and western types in the Osgood Mountains quadrangle, Humboldt County, Nevada: Geological Society of America Bulletin, v. 66, p. 1652.

Merriam, C. W., and Anderson, C. A., 1942, Reconnaissance survey of the Roberts Mountains, Nevada: Geological Society of America Bulletin, v. 53, p. 1675-1726.

Murphy, M. A., McKee, E. H. Winterer, E. L., and Matti, J. C., 1978, Preliminary geologic map of the Roberts Creek Mountain quadrangle, Eureka County, Nevada: U. S. Geological Survey Open-File Report 376, Scale 1:31,250.

Radtke, A. S., Rye, R. O., and Dickson, F. W., 1980, Geology and stable isotope studies of the Carlin Gold Deposit, Nevada: Econ. Geol., v. 75, p. 641-671.

Roberts, R. J., 1966, Metallogenic provinces and mineral belts in Nevada; Nevada Bureau of Mines Report 13A, p. 47-72.

___________________, Hotz, P. E., Gilluly, J., and Ferguson, H. G., 1958, Paleozoic rocks of north-central Nevada: Am. Assoc. Petroleum Geologists Bull., v. 42, no. 12, p. 2831-2857.

___________________, and Lehner, R. E., 1955, Additional data on the age and extent of the Roberts Mountains thrust fault, north-central Nevada: Geological Society of America Bulletin, v. 66, p. 1661.

Stewart, J. H., Walker, G. W., and Kleinhampl, F. J., 1975, Oregon-Nevada lineament: Geology, v.3, p. 265-268.

Wells, J. D., and Mullens, T. E., 1973, Gold-bearing arsenian pyrite determined by microprobe analysis, Cortez and Carlin gold mines: Econ. Geol., v. 68, p. 187-201.

Zoback, M. L., and Thompson, G. A., 1978, Basin and Range rifting in northern Nevada: Clues from a mid-Miocene rift and its subsequent offsets: Geology, v.6, p. 111-116.

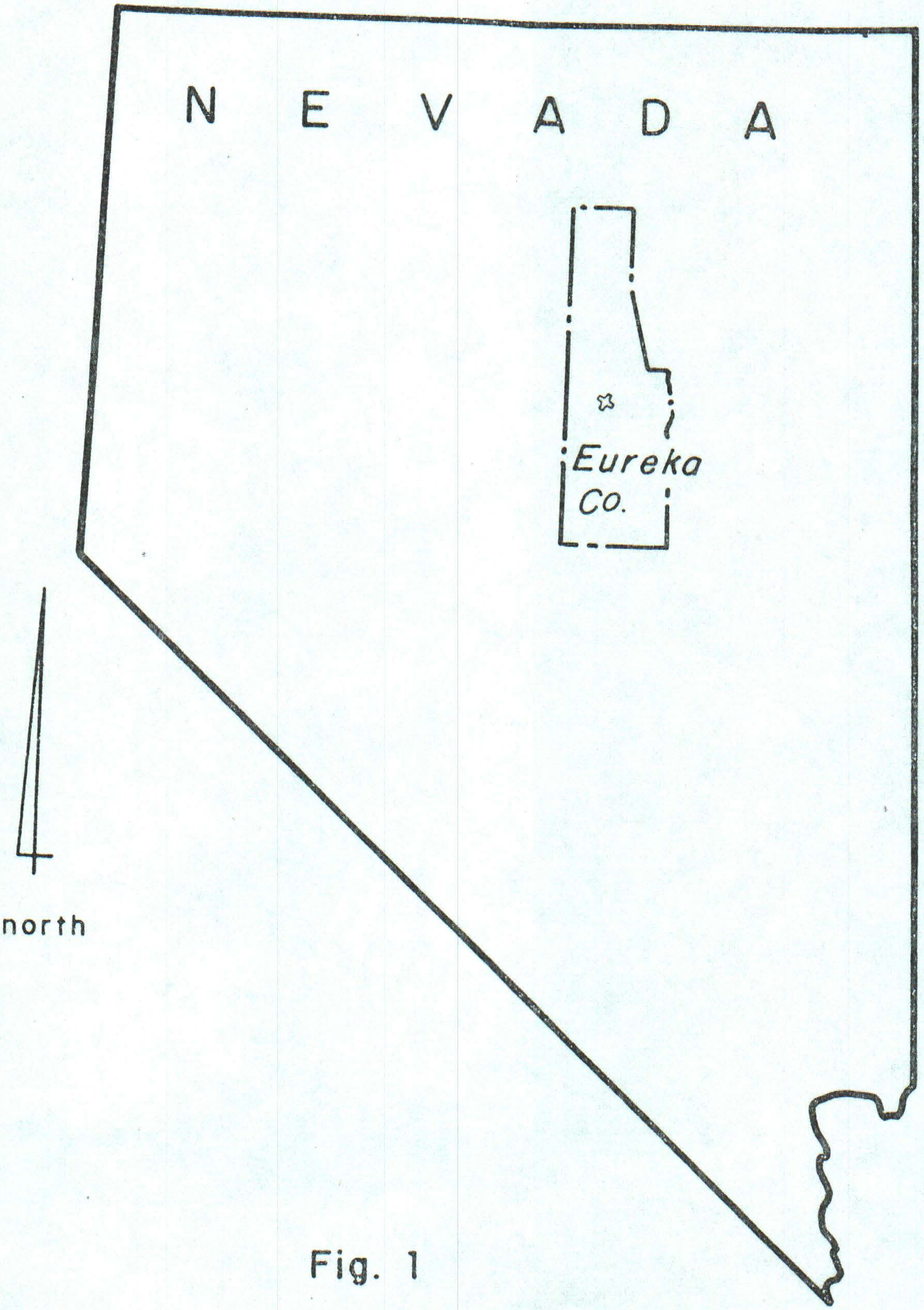

Fig. 1

LOCATION MAP, TONKIN SPRINGS.
Eureka County, Nevada

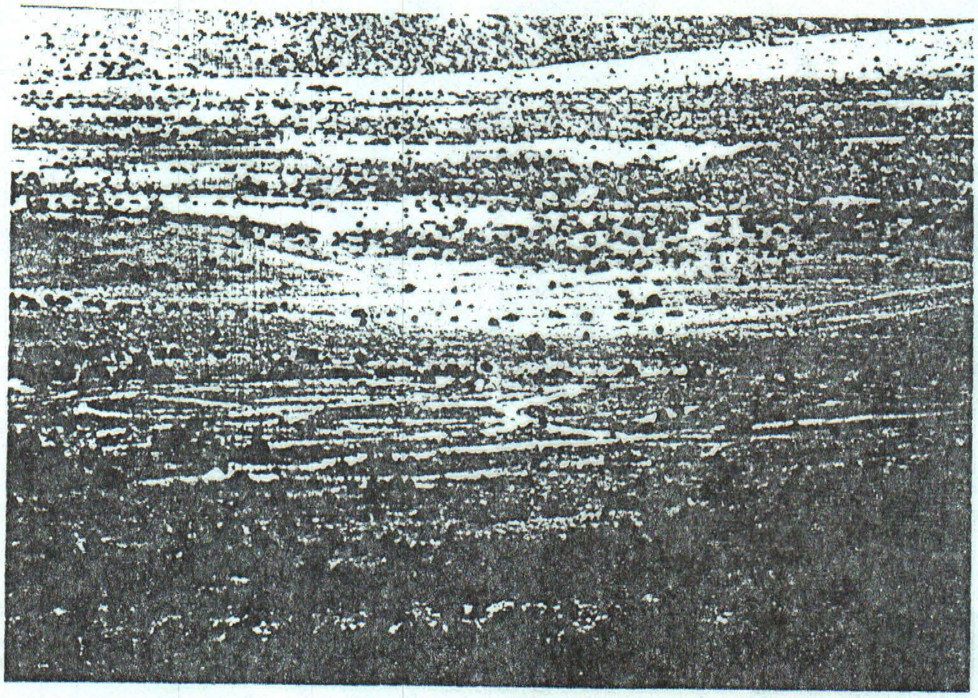

FIGURE 2 -- Photo of Tonkin Springs main deposit from above. Note drill rig in center of photo, and variation in vegetative growth.

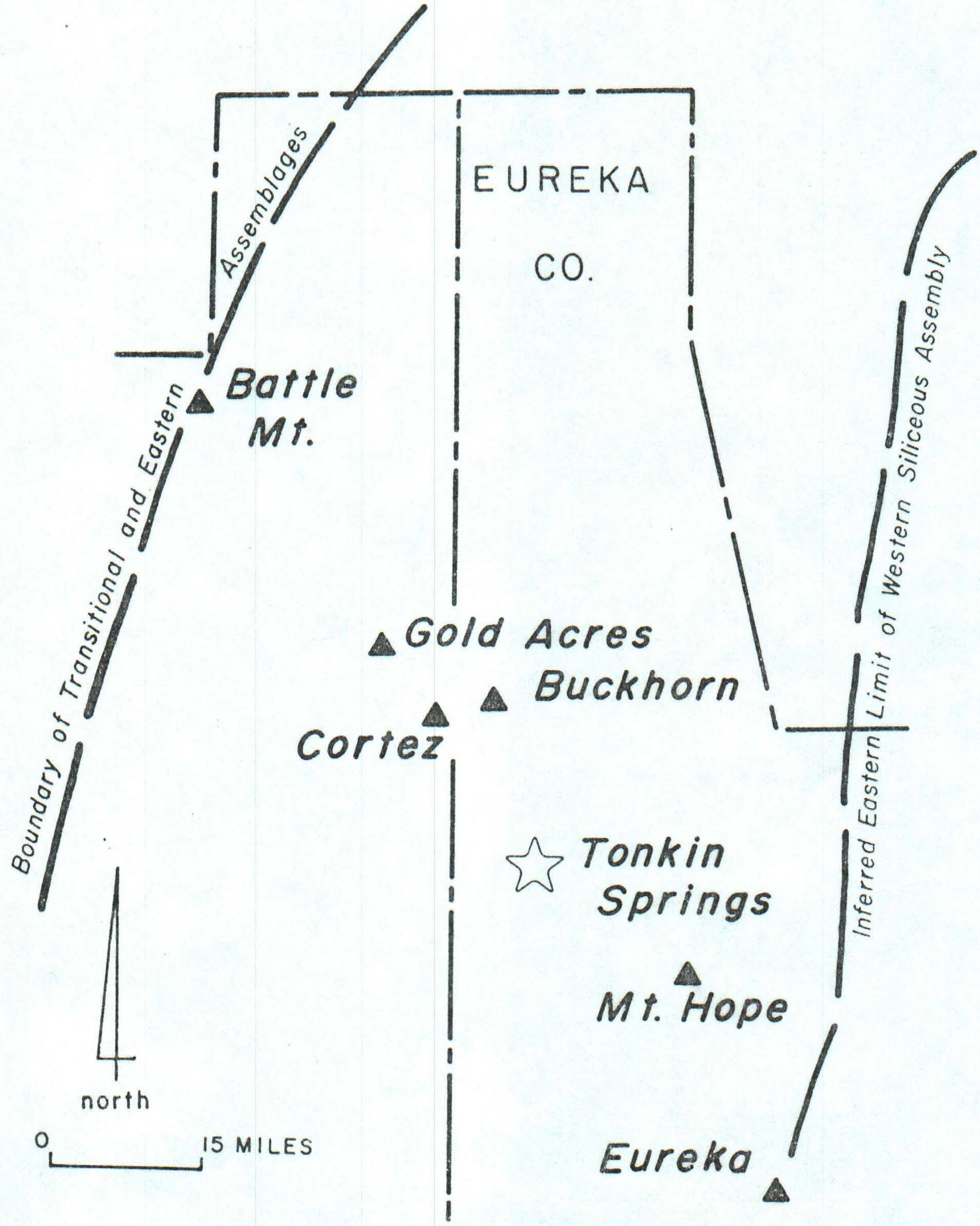

Fig. 3. REGIONAL MAP
Showing Tonkin Springs in relationship to Eureka - Battle Mtn. Mineral Belt, and Roberts Mtn. thrust.

After: Roberts and others, 1958;
Roberts, 1966.

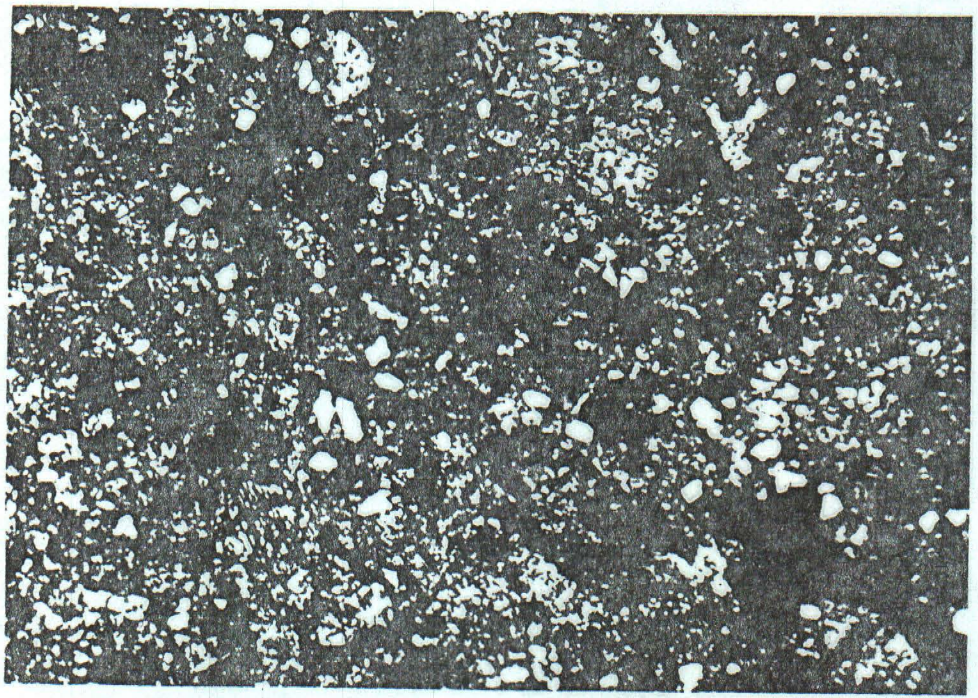

FIGURE 6 -- Photomicrograph, x-nichols, 4x, silty, dolomitic limestone. Fine grained to silt size quartz grains, embedded in calcite, dolomite matrix.

├──────────┤ represents 1 mm.

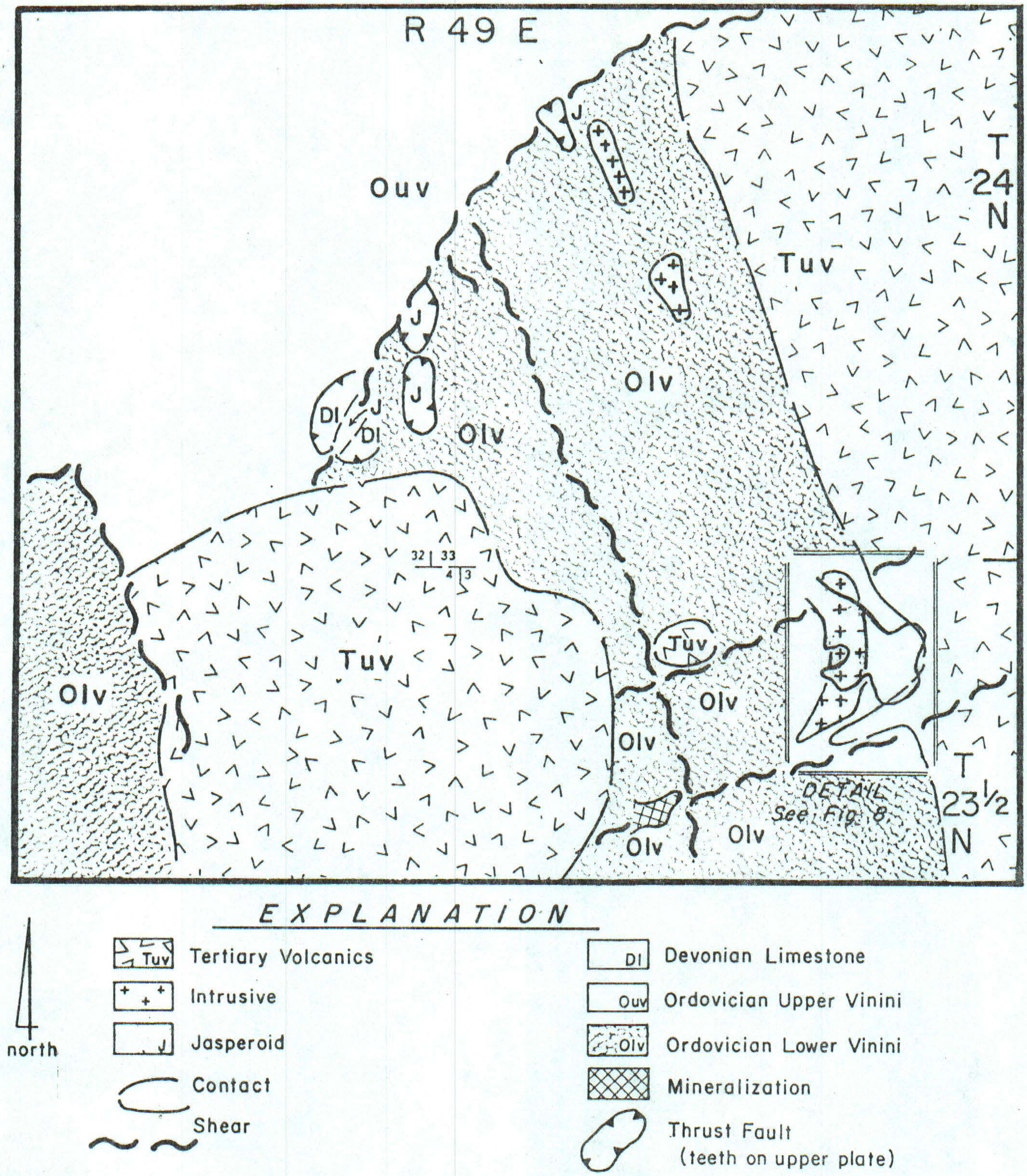

Fig. 4. GEOLOGIC MAP

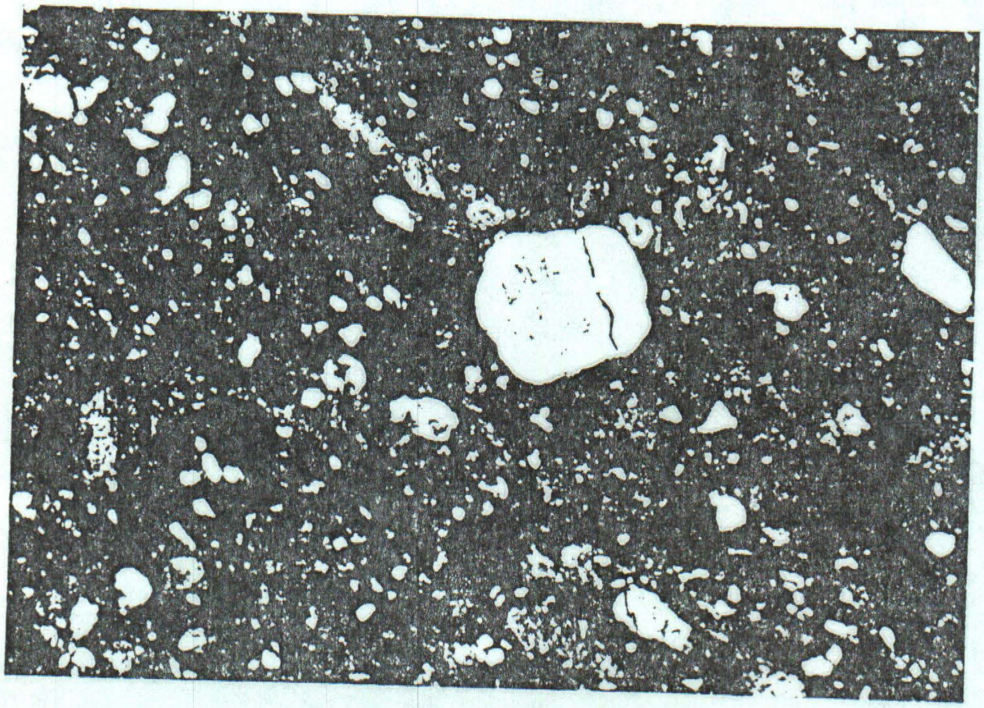

FIGURE 5 -- Photomicrograph, x-nichols, 4x, calcarenite, rounded quartz grain in center of photo is approximately 1 mm across. Quartz grains embedded in calcite matrix.

├──────────┤ represents 1 mm.

FIGURE 7 -- Photomicrograph, x-nichols, 4x, jasperoid, jig-saw texture, quartz grain bottom of photo, approximately 1 mm across, embedded in fine grained jasperoid matrix. Inferred to represent a silica replaced calcarenite.

├──────────┤ represents 1 mm.

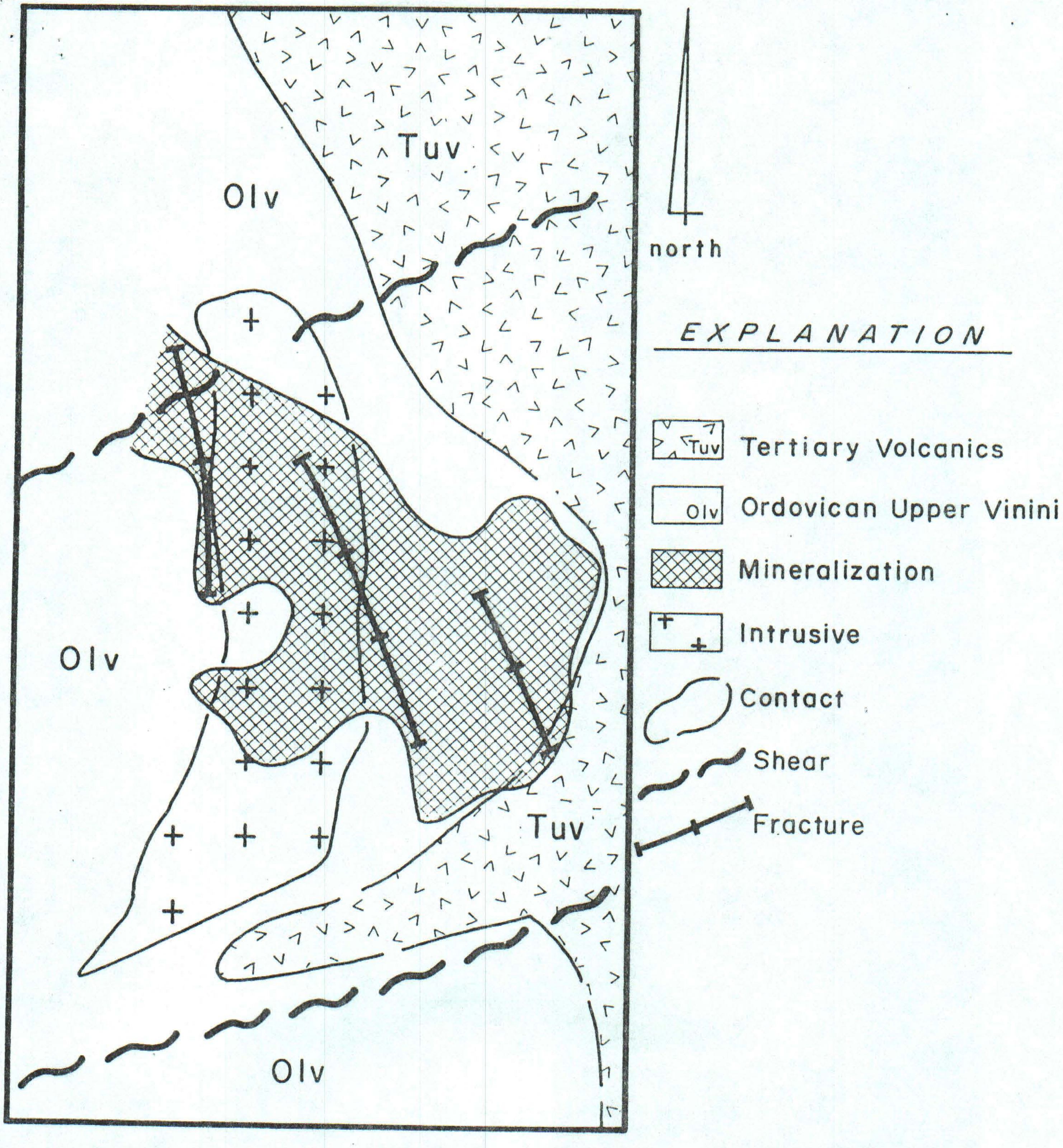

Fig. 8. DETAIL OF GEOLOGIC MAP

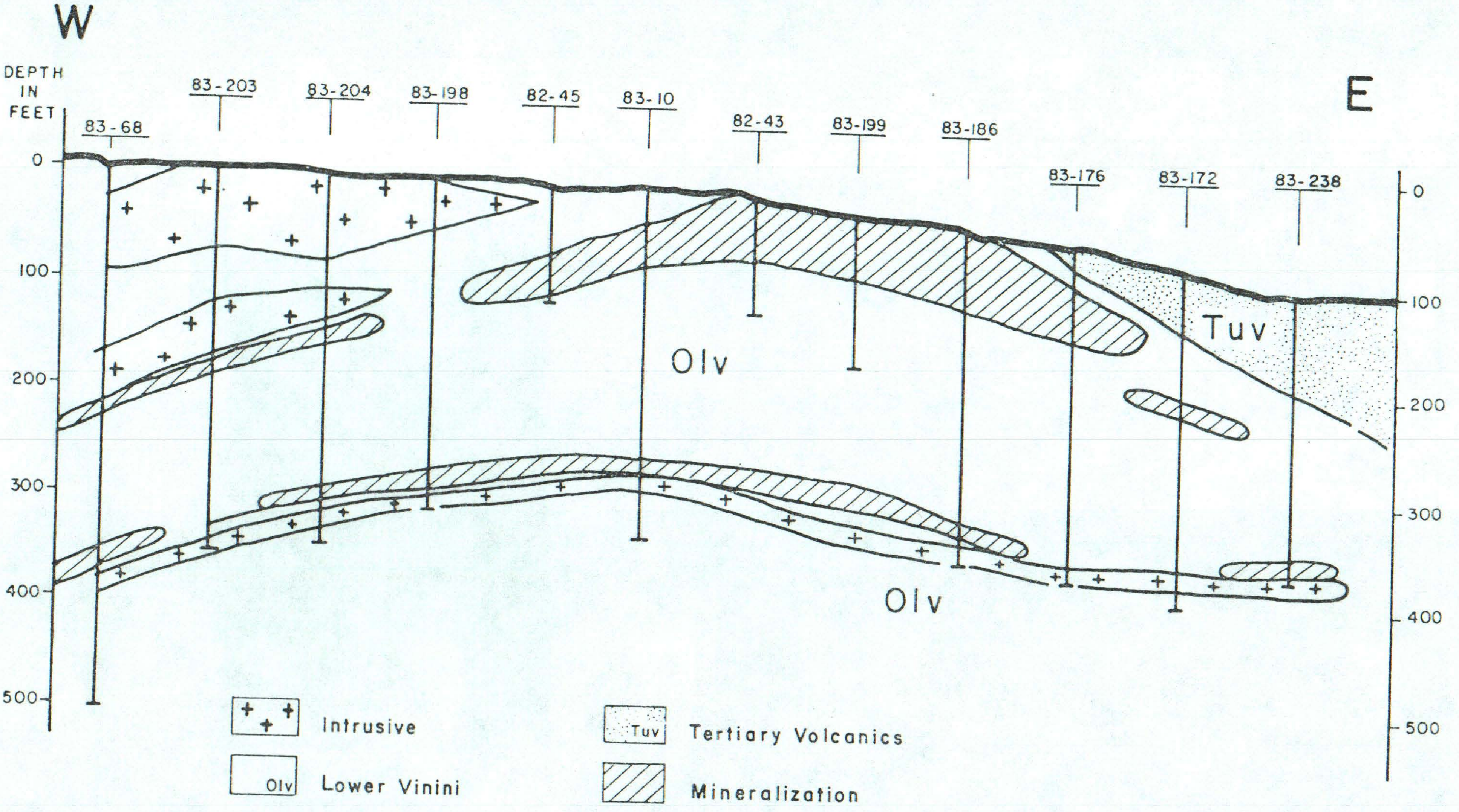

Fig. 9. EAST - WEST GEOLOGIC SECTION ACROSS TONKIN SPRINGS MAIN DEPOSIT

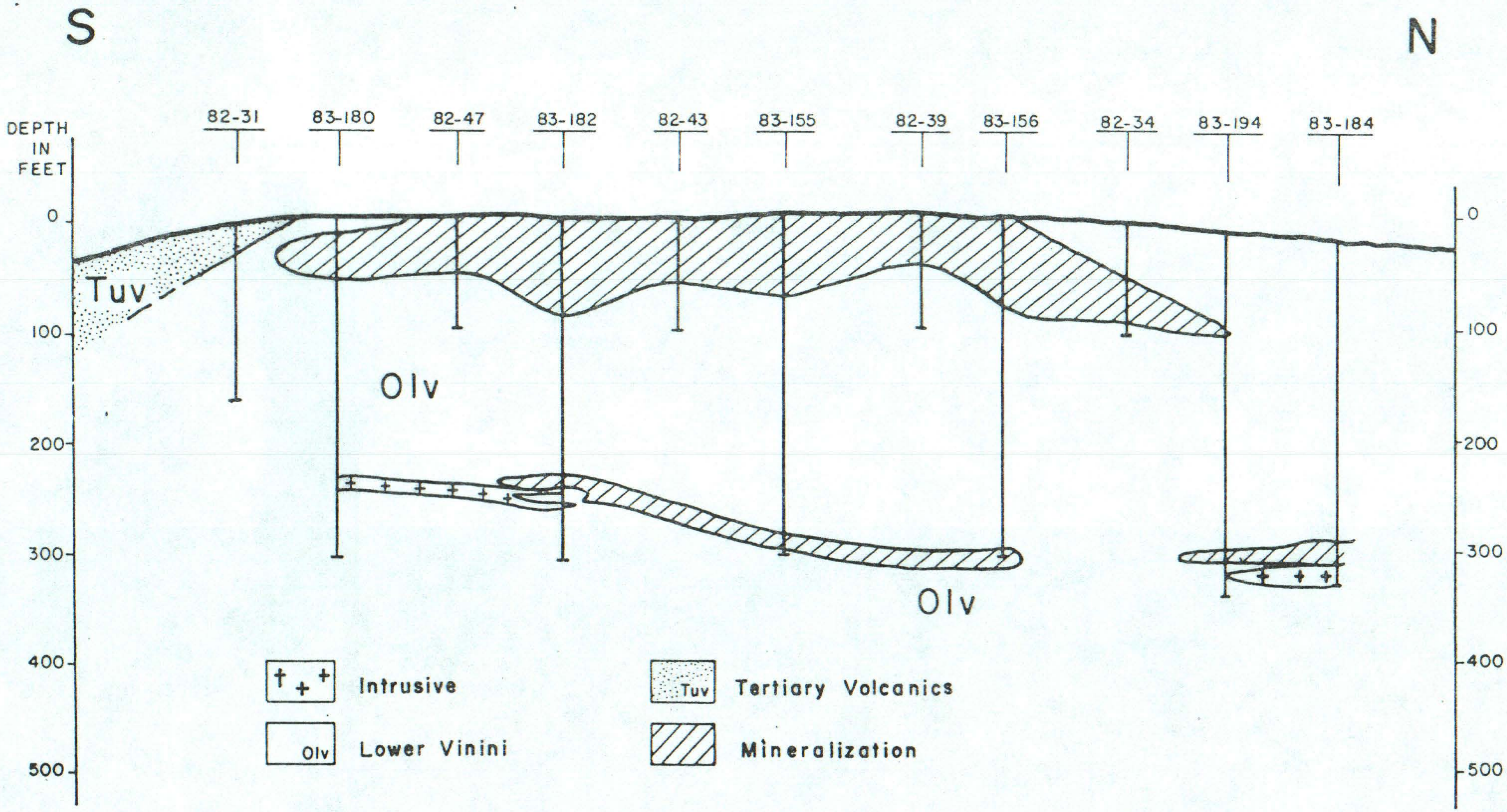

Fig. 10. NORTH - SOUTH GEOLOGIC SECTION ACROSS TONKIN SPRINGS MAIN DEPOSIT

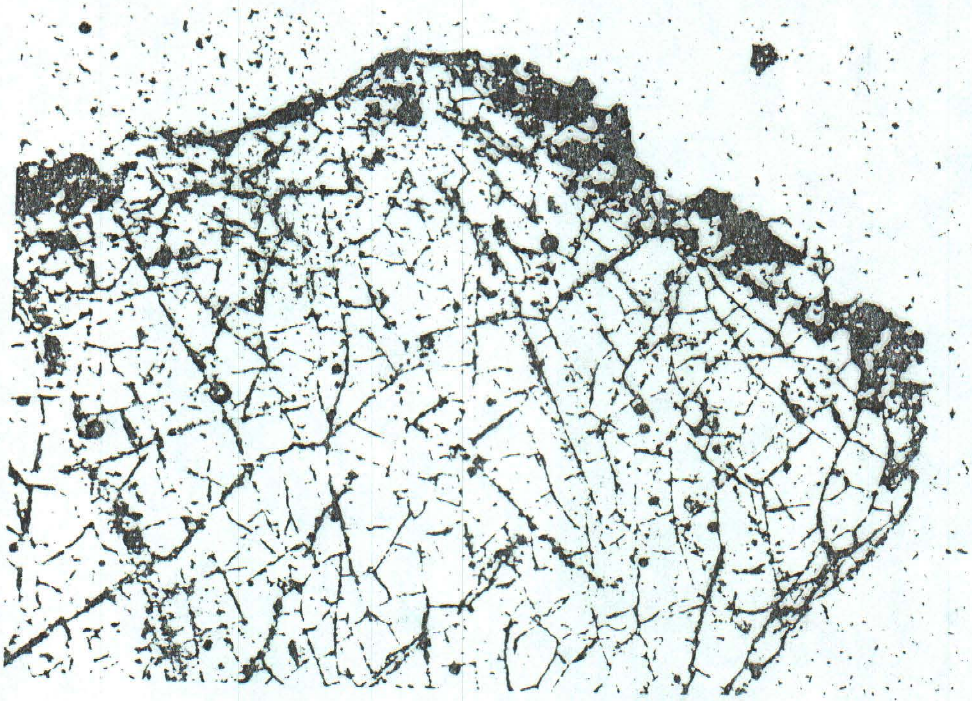

FIGURE 11 -- Photomicrograph, plane polarized light, 4x, fine grained jasperoid, black opaque mineral is framboidal pyrite, along a silica veinlet. Note microfracturing.

├──────┤ represents 1 mm.

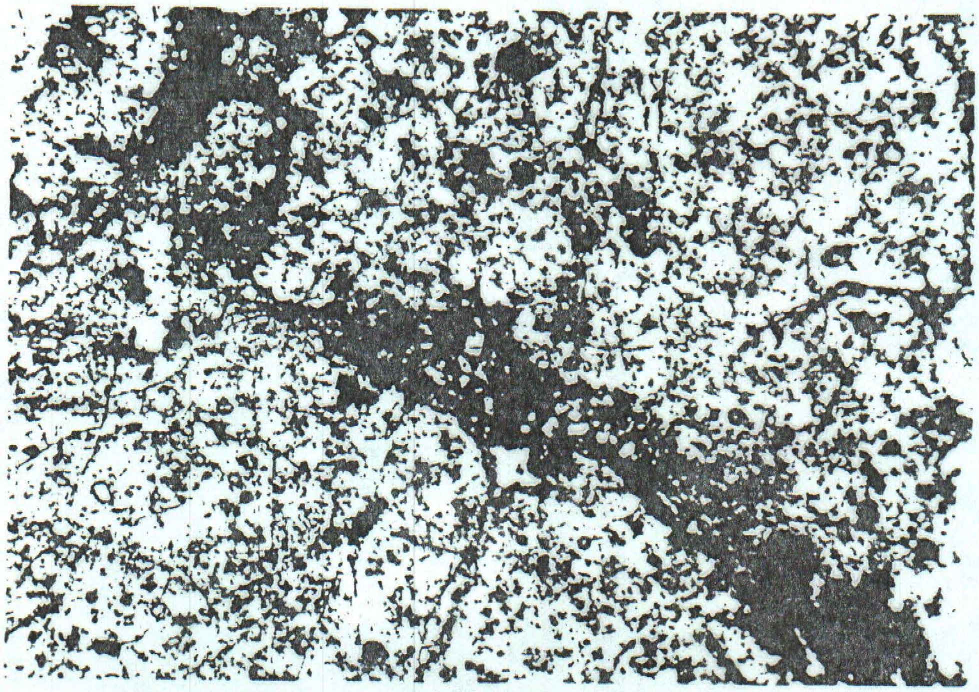

FIGURE 12 -- Photomicrograph, plane polarized light, 4x, jasperoid, framboidal pyrite along silica veinlet, and disseminated throughout matrix.

├────────┤ represents 1 mm.

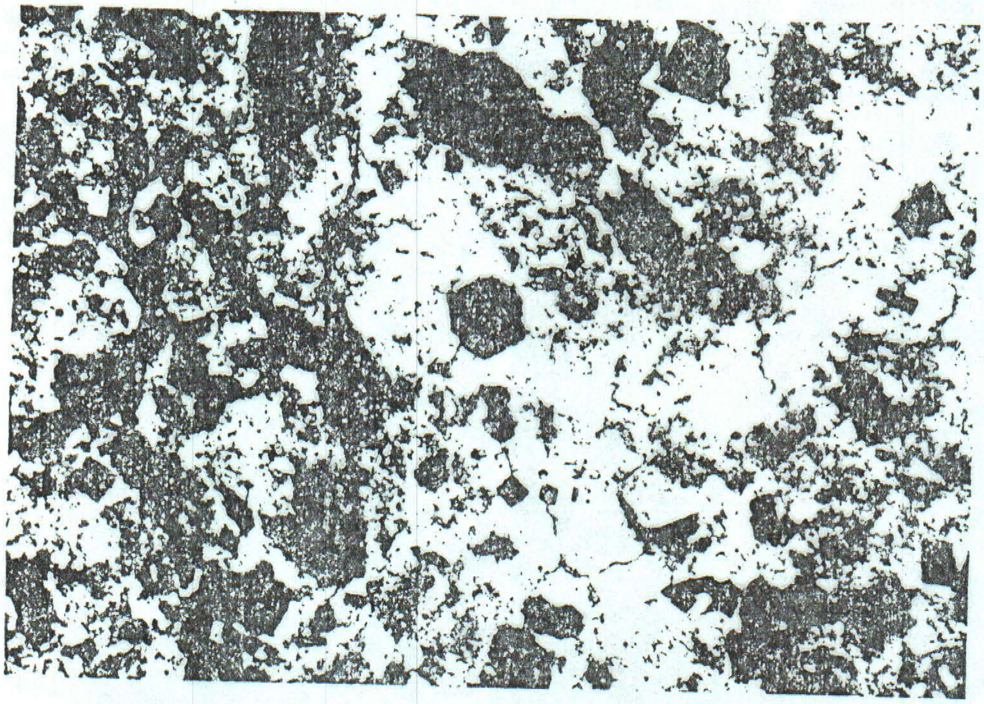

FIGURE 13 -- Photomicrograph, plane polarized light, 4x, opaque mineral is cubic pyrite, note pyritohedron in center of photo. Pyrite embedded in jasperoid matrix.

|————| represents 1 mm.

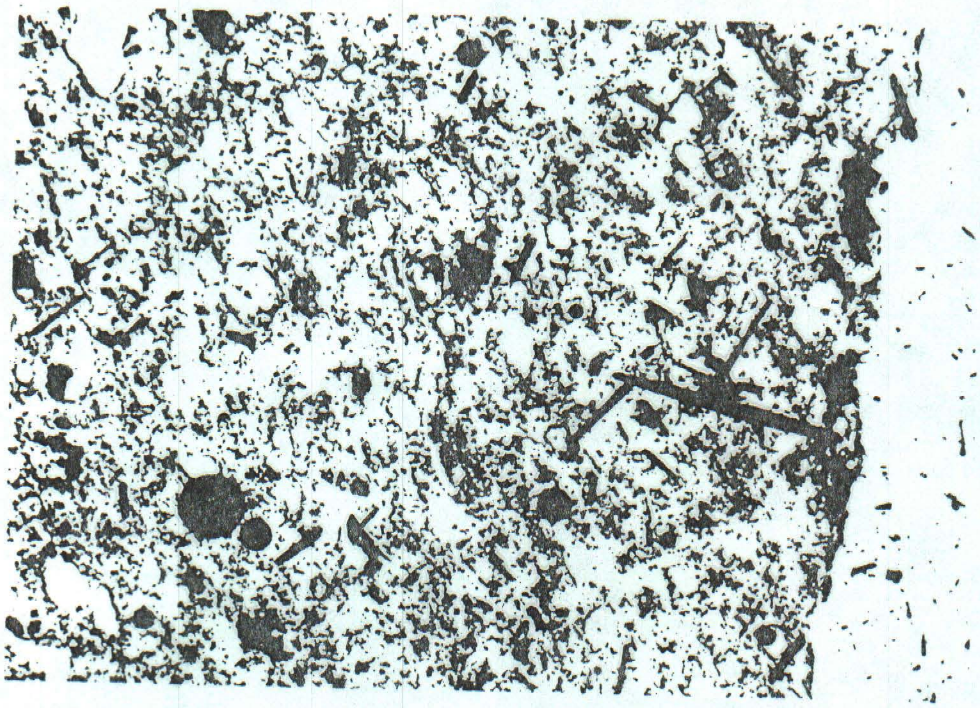

FIGURE 14. Photomicrograph, plane polarized light, 4x, opaque mineral is stibnite, blade is approximately 1 mm long, embedded in jasperoid matrix.

├──────────┤ represents 1 mm.

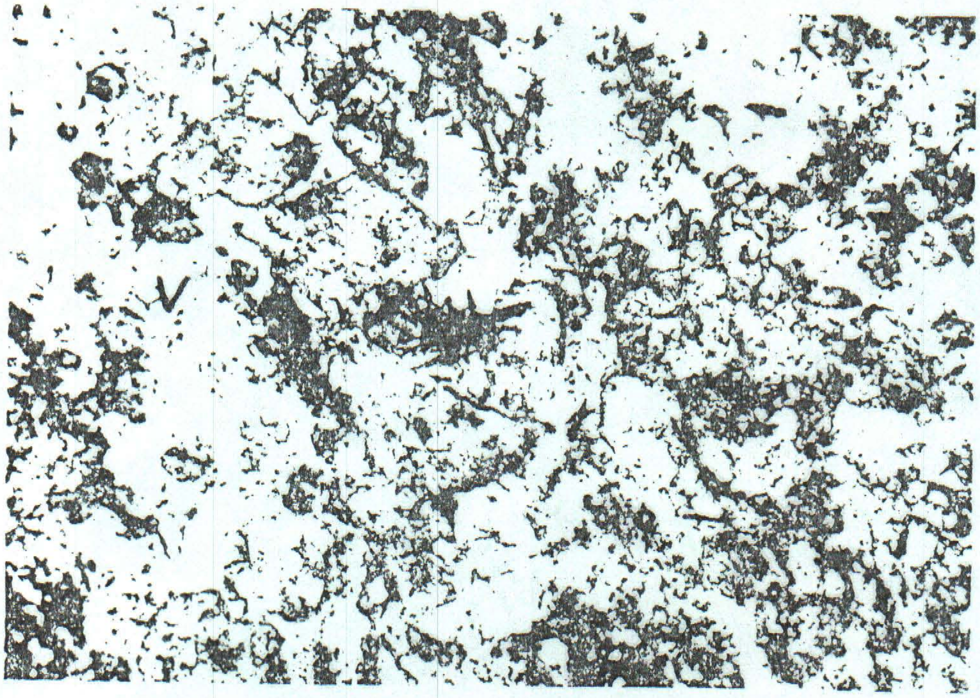

FIGURE 15. Photomicrograph, plane polarized light, 4x, opaque mineral cluster of stibnite, embedded in fine-grained jasperoid matrix. Unreplaced dolomite rhombohedrons show apparent relief.

├──────────┤ represents 1 mm.

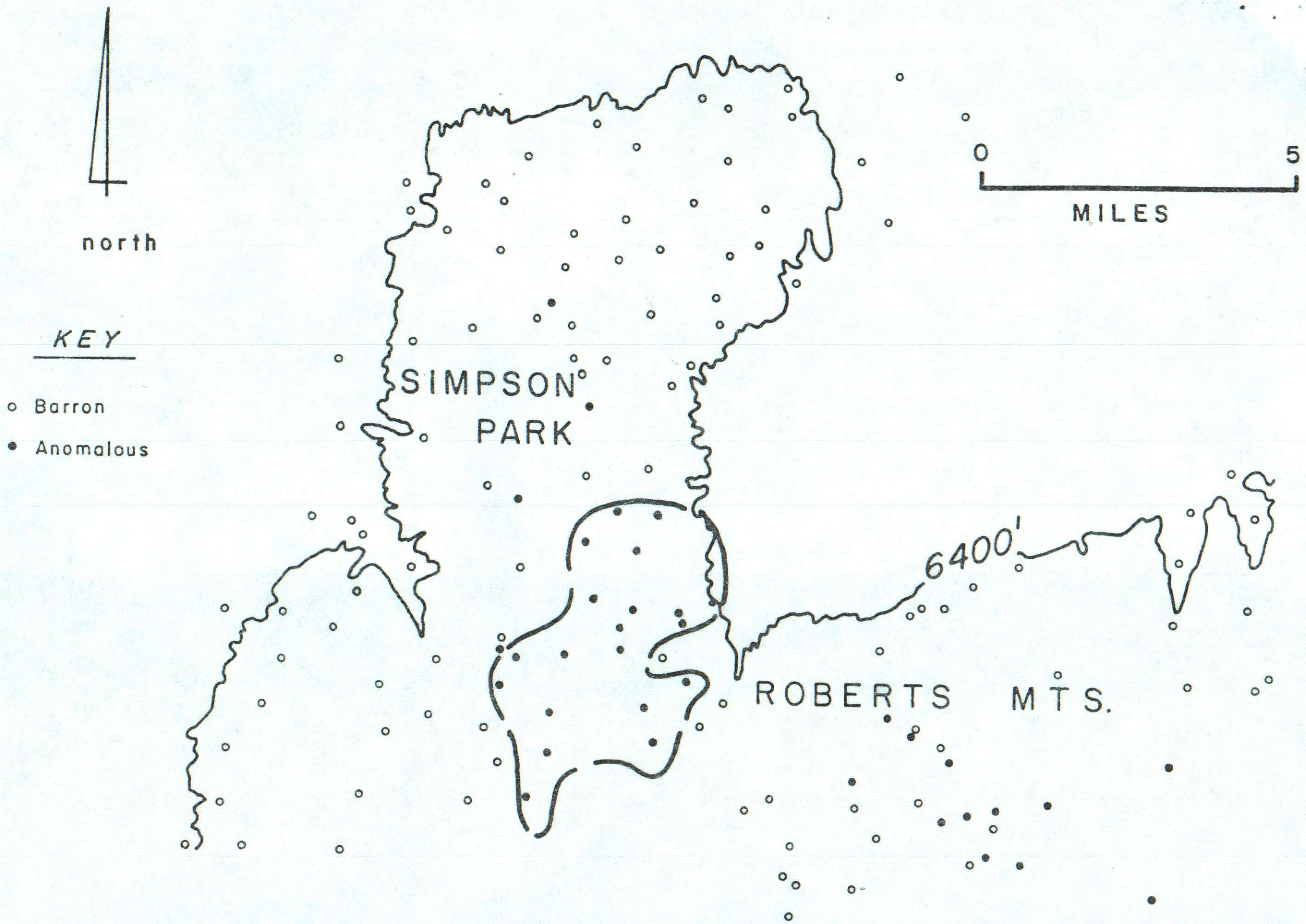

Fig. 16. GOLD DISTRIBUTION IN STREAM SEDIMENTS
Northern Simpson Park and Roberts Creek Mts.

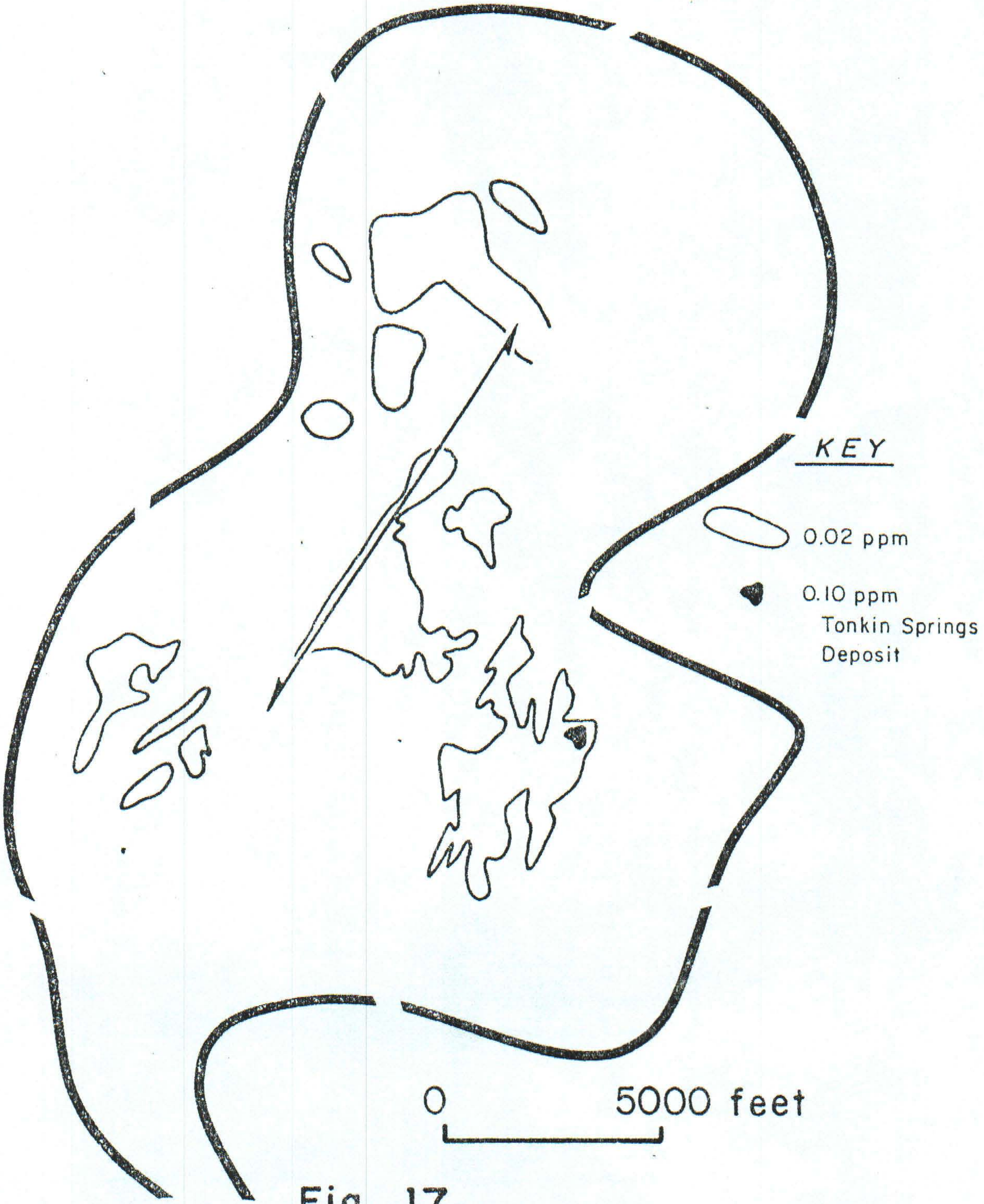

Fig. 17
Distribution of Anomalous Au Values
in drainage sediments & soils

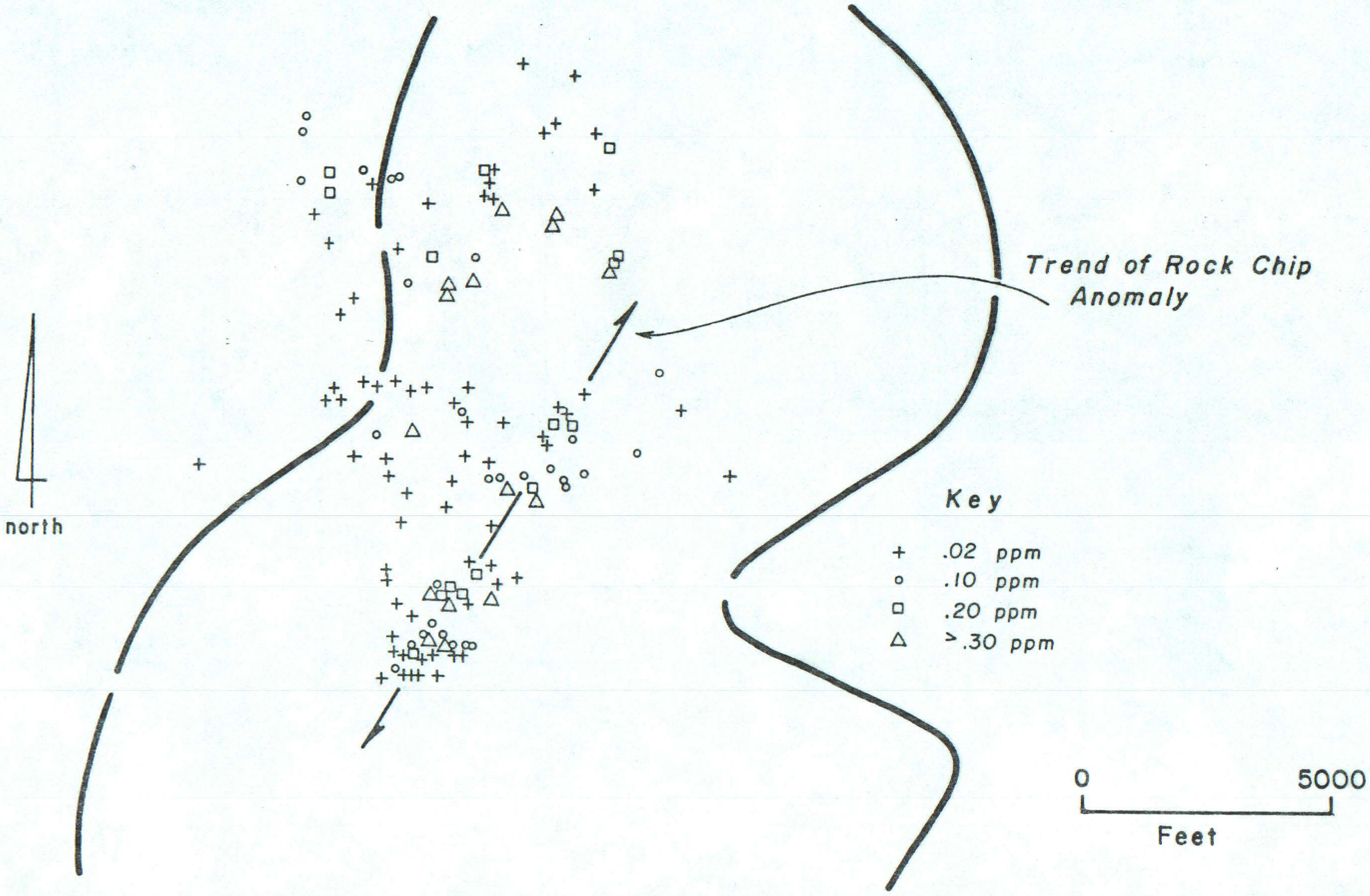

Fig. 18.
Au MINERALIZATION ROCK CHIP