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LAWYERS GOLD-SILVER DEPOSIT, BRITISH COLUMBIA

by

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INTRODUCTION

The Lawyers prospect is a gold-silver project located in north-central British Columbia in the Toodoggone River area, Omineca Mining Division. The property lies approximately 280 kilometres north of Smithers, B.C. Currently, access is by air to a 1525-metre all-weather gravel strip at Sturdee Valley followed by a 24-kilometre road to the property via the Baker Mine, 8 kilometres to the southeast. The airstrip is approximately 80 kilometres north of the terminus of the Omineca Road, an extension of which would be over relatively easy valley terrain (Fig. 1).

All the known showings outcrop at or above the 1700-metre elevation within gently sloping, plateau-like alpine topography. This terrain is broken by abrupt erosional creek valleys which drain northward into the Toodoggone River forming part of the Arctic watershed.

Based on exploration to date, the drill indicated mineable reserves on the Amethyst Gold Breccia Zone (Amethyst Zone), after applying assay cutting factors and an allowance for anticipated mining dilution, have been calculated by the Company as 561,733 tons grading .211 oz/ton gold and 7.11 oz/ton silver. These reserves are found within the central core of definition drilling on 15-metre separations carried out principally from underground set-ups. Not included in this calculation are step-out intercepts greater than 15 metres along strike and at depth as well as a newly discovered hanging wall structure on the Amethyst Zone and possible reserves from the Cliff Creek and Duke's Ridge Zones.

Preliminary metallurgical test work by an independent consultant has indicated that overall recoveries of 97% gold and 90% silver, using conventional treatment methods, may be expected. Based on the foregoing reserve and recovery estimates, the Company has concluded that acceptable operating profits could be derived from the Amethyst Zone at current metal prices, but that reserves must be expanded to provide a viable operating life.

This paper discusses the history of exploration, geologic setting of the Lawyers property within the Toodoggone River area, and in particular the local geology of the Amethyst Zone with modes of occurrence of chalcedony breccia and associated vein-related alteration and mineralogy.

HISTORY

The discovery of gold in the Toodoggone River area is credited to Charles McClair who mined placer deposits in 1925, reportedly valued at $17,500. After he and his partner went missing in 1927, efforts to relocate their workings resulted in the formation of "Two Brothers Valley Gold Mines Ltd." in 1933, in which the legendary Grant McConachie played an active role. Cominco was active in the area at the same time, staking and working several base-metal showings. However, these early workers did not recognize the lode gold potential in the area.

In 1968, Kennco Explorations (Western) Ltd. prospector Gordon Davies, while following-up geochemical anomalies, noted quartz float samples which assayed gold and silver. Subsequent exploration in the period 1969-1974 by Kennco resulted in the discovery of most of the gold and silver occurrences on the Chappelle and Lawyers properties. Several other gold and silver occurrences were found by other mining companies working the district at the same time. Conwest optioned the Chappelle in 1973 and explored underground by adit entry as part of a one year program. In 1974, Du Pont of Canada Exploration Ltd. optioned the Chappelle claims and in March 1980, using reserves developed on the "A" vein, placed the Baker Mine into production at a rate of 100 tons per day.

The Amethyst Zone on the Lawyers property was found in 1973 by continued, persistent follow-up prospecting of silver silt geochemical anomalies. A subsequent program, totalling 671 metres of trenching and 1151 metres of drilling in 10 holes, was completed in 1974/75. The best intersection yielded 3.15 oz/ton silver and .19 oz/ton gold over 27.5 metres. With the drop in gold prices to below $150/oz in 1975, and the decision by Kennco to option-out the Chappelle claims, work on the adjoining Lawyers was terminated and the property lay idle until 1979.

In May 1978, Kennco optioned the Lawyers property to Semco Mining Corporation. Serem examined the property in late July 1978 and decided that the brecciated nature of the mineralization could potentially yield a deposit with commercial sizing. The Company obtained an assignment of agreement from Semco in 1979 and commenced exploration with a small program of trenching and drilling on the Amethyst Zone in the same year. Since 1979, the Company has completed 10,445 metres of surface diamond drilling, 1,209 metres of trenching, 764.5 metres of underground horizontal adit development on one level and 2,148 metres of underground definition diamond drilling on the Amethyst Zone. In addition, the Company has established two additional zones on the Lawyers property, the Duke's Ridge Zone and the Cliff Creek Zone, which are relatively unexplored at this time. The nature of the mineralization and silicified breccia indicates similar potential to that of the Amethyst Zone at an equivalent stage of exploration. Approximately 4,825 metres of trenching and 1,990 metres of surface diamond drilling have been completed on these zones to date.

REGIONAL GEOLOGIC SETTING

The Toodoggone River Area represents an erosional remnant of Late Paleozoic sedimentary rocks through younger Mid-Triassic to Mid-Jurassic volcanically derived rocks and their coeval Omineca intrusions (Fig. 1 and 2). The volcanic exposures are in structural contact with the Pitman Batholithic Complex and as yet un-named mylonitic assemblage of the Peak Ranges to the northwest. The Late Cretaceous to Tertiary Sustut Group unconformably overlies the Toodoggone older rocks to the west. Southeasterly extensions of Mid-Jurassic volcanism are terminated by the southerly extensions of the Finlay Fault System.

Late Paleozoic rocks consist of wedges of crystalline limestone up to 150 metres thick that correlate with the

Asitka Group of Permian age. Outcrops occur principally near the margins of younger Mid-Jurassic quartz monzonite and granodiorite stocks belonging to the Omineca intrusions. The limestone is partially skarnified near intrusive contacts, with several showings of base metal sulphides assaying appreciably in gold and silver.

The first recognizable volcanic activity consists of basaltic flows and pyroclastic rocks including augite-tremolite andesite porphyries and crystal and lapilli tuffs that belong to the Takla Group of Late Triassic age. Contacts between Takla and underlying Asitka limestone are not well understood. At Castle Mountain, and near Duncan Lake, limestone beds appear interbedded with Takla volcanics. This may simply be a fault relationship near intrusive contacts.

As with the Asitka Group, the Takla is best exposed on the flanks of the Omineca intrusions as evident from the spatial relationship around the Black Lake stock (Carter 1971) Steeply dipping and varied bedding attitudes usually dipping away from the stock and alteration of the Takla suggest a normal intrusive contact relationship with the stock. Auriferous quartz veins near the stock, and in particular the "A" vein currently being exploited at Baker Mine, are hosted by Takla volcanics. Detailed mapping at Baker

Mine (Barr, 1978) subdivided the Takla into four principal units. These consist of tremolite andesite porphyry, fine-grained andesite, pyroclastic breccia and porphyritic feldspar andesite. Takla is also exposed at the northern end of the Toodoggone district south of Chukachida River. This likely represents an erosional remnant adjacent to the Pitman Batholith.

The "Toodoggone" volcanic rocks, named informally by Carter in 1971, where observed, rest structurally on the Takla Formation (Panteleyev, 1982 and Diakow, personal communication 1983). This assemblage forms a northwesterly-trending belt at least 90 kilometres long and 35 kilometres wide preserved between the Hazelton Group to the east and the Sustut Group to the west.

The Toodoggone is considered to be chrono-stratigraphically correlative with lower Hazelton Group rocks. Although evidence is sparse for this assumption, ashfall crystal tuffs of the basal Toodoggone lie on the Takla Formation with very little disconformity. This association between Toodoggone and underlying Takla is similar to contacts observed in the Sustut Ranges between Hazelton and Takla (Tipper & Richards, 1976). Radiometric dates from biotite in Toodoggone volcanic rocks (Panteleyev 1982) and alunite from Albert's Hump (Schroeter 1982) along with hornblende and rubidium-strontium samples from Toodoggone and related intrusive rocks (Gabrielse et al 1980), suggest that the Toodoggone volcanics extruded over a period from 200 to 180 Ma (Panteleyev 1983). This corresponds to a Lower to Middle Jurassic age of volcanism arrived at for the Hazelton Group.

Within the Toodoggone area, the major difference between Hazelton rocks to the east and Toodoggone rocks to the west is the lack of observable quartz in the Hazelton. The Toodoggone volcanics represent a relatively undifferentiated magma of predominantly andesitic composition whereas the Hazelton represents a varying assemblage of basaltic to rhyolitic composition. Textures are similar between Hazelton and Toodoggone, both exhibiting primarily subaerial deposition. However, the relationship between Toodoggone volcanics and the Hazelton Group is generally poorly understood. The Hazelton Group in the Toodoggone River area has not been studied because the Toodoggone, along with Takla Group volcanics, host most of the known precious metal prospects found to date in the district.

Early studies of the Toodoggone volcanics were carried out on a preliminary basis on a scale of 1:250,000 by Gabrielse et al (1975). More recently, utilizing mapping on a scale of 1:25,000, the regional aspects of stratigraphy and structure have been described by Panteleyev (1982-83), Schroeter (1981, 1982, 1983), and most recently by Diakow (personal communication 1983) whose descriptions of the lithostratigraphic sections form the basis of the following discussion.

The oldest members of the stratigraphic subdivision outcrop on the northwest and southeast extremities of the Toodoggone region and younger members occupy the central portion of the map area. The region as a whole resembles a synclinorium in section from northwest to southeast. The oldest rocks are represented by predominantly explosive periods of volcanism in which at least three stratigraphic units can be identified. The basal member outcrops north of Adoogacho Creek and consists of ashfalls with minor flow unit components. A similar ashfall unit resting on Takla is described by Panteleyev (1982) east of Thutade Lake. From the north, near Adoogacho Creek, these are successively overlain to the south by a lithic tuff unit with minor discontinuous members of subaqueous limestones, lava flows and epiclastic volcanic greywackes near the top. Approaching Moyez Creek, an ashfall, in part flow unit, stratigraphically overlies the lithic tuffs. The ashfall/flow occupies the central portion of the district. Outcrops 5 kilometres east of Baker Mine are likely correlative with outcrops on the flanks of Tuff Peak. The Ashfall/

flow unit contains interbeds of flows and epiclastic strata which may be correlative to the footwall quartzose pyroclastic andesites and younger basinal trachy-andesites, lapilli tuffs and volcanic greywackes seen on the Amethyst Zone at the Lawyers property. Deposition of this late stage of explosive volcanism was influenced by intra-half-graben development as seen on the Amethyst Zone.

Following deposition of the pyroclastic Central Ashfall/flow member associated with the early explosive period, the character of igneous activity appears to change and become more quiescent. On Tuff Peak, north of Toodoggone, continued volcanic activity consists of lava flows of trachy-andesitic composition with crowded porphyritic textures and no observable quartz phenocrysts. Minor epiclastic and interformational clastic members are present. These compositions and textures resemble characteristics found in the overlying youngest members south of the Toodoggone River at Lawyers property (Fig. 3). The deposition of non-quartzose andesitic flows with interbeds of shallow marine facies found at Metsantan and possibly correlative to non-quartzose andesites on Duke's Ridge represents the last stage of volcanism for the quiescent period.

Correlative to the graben structure are late-stage mafic dykes which cut all the host rocks as well as the quartz breccia veins. The dykes likely are feeders to the pyroxene basalt observed in a down-drop block east of the Amethyst Zone. A gabbroic intrusion is also seen to cut the Central Ashfall/flow tuffs on Adoogacho Creek. No rocks of basaltic composition have been observed cutting lava flows of the quiescent period.

The structural regime, observed to influence deposition during the early eruptive cycles and later quiescent lava deposition with half-graben development west side down, appears to change with the last phase of re-occurring eruptive volcanism. This youngest phase of volcanism is represented by a distinctive Grey Dacite unit (Panteleyev, 1982-1983) which occupies an area spatially internal to the Toodoggone region. It is the most continuous mappable unit extending for 40 kilometres from Kemess Creek to the Toodoggone River. The unit is unaltered and no mineralization has been found to date within it. The Grey Dacite unit appears to overlie the eruptive cycle in the central area and is not found west of Cloud Creek. A major internal syndeposition graben zone likely limited its extension to the west.

Structure

The Toodoggone rocks display broad open folds with dips generally less than 25^{o} predominantly to the west. The overlying Sustut Group sedimentary rocks have relatively flat dips and are structurally unaffected.

The region, however, is dominated by a northwest-trending set of structures represented by younger steeply-dipping faults and syn-volcanic half-graben margins exhibited in Toodoggone volcanics, as discussed earlier. As postulated by Schroeter (1981), major structural breaks may have been caused, or be the result of, a northwest-trending line of volcanic centres. This structural regime appears to have influenced deposition of the Toodoggone volcanics within the later stages of the early eruptive cycles and lasting to the youngest Grey Dacite member. The Black Lake stock and the smaller McClair stock on the Toodoggone River are also aligned northwesterly, implying that they were also influenced by the same structural trend. Youngest post volcanic and intrusive faults, recognizable as lineaments in the topography, also traverse the district in a northwesterly direction. To the east, the Saunders-West Jock Creek Fault system has been documented by Panteleyev, and early mapping by Gabrielse et al postulated the Moosehorn McClair Fault north of the Toodoggone River. South of Finlay River, Diakow (1983) mapped along the southerly extensions of the Moosehorn McClair in the Writch-Awesome area southeast of Finlay River. To the west, these younger faults are represented by the Attorney 'system', observable at Baker Mine and extending northwesterly through Lawyers, west of Tuff Peak and Adoogacho Creek where it can be correlated by recent mapping of Diakow (personal communication 1983). Most of the very prominent gossans are aligned along this same configuration of faults.

Silicification, as reported by Diakow at Cloud Creek and east of Albert's Hump (Schroeter 1981), exhibits a crude alignment along a line extending from Adoogacho Creek to Baker Mine. Although auriferous quartz breccia vein orientations at Albert's Hump, Metsantan, Moosehorn, Kodah and Lawyers, vary, they likely represent subsidiary structures along a similar northwesterly alignment.

GEOLOGY IN THE VICINITY OF THE LAWYERS PROSPECTS

On the Amethyst Zone at the Lawyers property, a half-graben is evident, traceable by surface mapping along a northerly-trending direction for 3 kilometres (Fig. 3). The graben margin developed in an older pyroclastic andesite crystal tuff sequence containing recognizable millimetric quartz eyes and interbedded narrow lapilli tuff horizons. Quartz andesite crystal tuff is identifiable in hand specimen and in thin section by the presence of quartz grains and plagioclase and K-feldspar crystals (Fig. 12). The K-feldspar content varies but normally constitutes less than 5% of total feldspar. Quartz grains make up about 15% of rock volume (Carne 1981). Two whole rock analyses have returned compositions of dacite and trachy-andesite (Schroeter, 1982). As evident from drilling (Fig. 6), the quartz andesite unit formed a horst to the east. Downdrop, west side down, of at least 300 metres can be recognized within the unit.

A pyroclastic trachy-andesite sequence filled the basin developed to the west. This sequence consists of trachy-andesite and crystal lapilli tuff with interbedded epiclastic/volcanic greywacke and minor flow members. The trachy-andesites differ from the older quartz andesites by not containing visible quartz and having a higher content of potash-feldspar crystals.

The basinal trachy-andesite lapilli tuffs are best exposed along Duke's Ridge where upwards of 300 metres of stratigraphy can be measured. The stratigraphy can also be interpreted from the detailed drilling on the Amethyst Zone (Fig. 5, 6, 7 and 8).

The immediate vicinity of the graben margin (within 100-200 metres) is recognizable by welding of lapilli fragments within the tuffaceous members and flow-top breccias consisting of porphyritic trachy-andesite blocks within finer matrix.

The graben margin is most evident in the vicinity of the Amethyst Zone. Here the younger trachy-andesitic sequence consists of trachyte crystal and lapilli tuffs with minor flows and interbedded volcanogenic greywackes, welded trachyte tuffs and fine-grained to aphanitic chocolate brown tuffs which dip gently to the west. These units appear to wedge out in contact with the older quartz andesite to the east. The contact, where the younger units wedge out against the quartz andesite, varies from 45° in the north to 70° in the south. Deep drill holes suggest that the trachyte crystal tuffs and interbedded greywackes thicken considerably to the west.

Stratigraphically, the quartz andesite is overlain by very fine-grained to aphanitic chocolate brown tuff. It consists of about 5% K-feldspar grains in an aphanitic maroon groundmass (Carne, 1981) (Fig. 11). It varies in thickness from a metre in the south to over 30 metres in the north. In the underground 1+65 North drift and cross-cut on the 1750 level of the Amethyst Zone, the tuff is intermixed with fragments of the underlying quartz andesite and overlying welded tuff, as well as fragments of plutonic quartz intermixed with the aphanitic tuff.

Welded trachyte tuff overlies fine-grained chocolate brown tuff and the quartz andesite. The unit wedges out against the chocolate brown tuff and quartz-andesite toward the east. The unit also becomes unwelded away from the easterly contact. This suggests that the source for the trachy-andesite sequence is at the easterly contact with the underlying quartz andesite. The tuff is distinguished by cream-coloured clay-altered, to chloritic flattened fragments up to 2 centimetres long (Fig. 10). Fragment orientation and layering is about 30^{o} to stratigraphic contacts. Thin-section studies show the fragments are porphyritic in texture with sanidine feldspar in a devitrified groundmass (Carne, 1981).

Trachyte crystal tuffs and crystal lapilli tuffs with interbedded volcanogenic greywacke overlie the welded tuffs (Fig. 9). Thin-section studies of the trachyte crystal tuffs indicate varying compositions of latite and andesite composition suggesting that the unit is not uniformly composed. Breccia blocks of trachyte porphyry are present where the unit overlies the welded tuff, making them in part lava flows.

To the west, in the area of Duke's Ridge and Cliff Creek, the youngest rocks consist of volcanic flows still containing a high content of crystal fragments. On Lawyers' Ridge and Duke's Ridge, a distinctive megacrystic potash feldspar member lies on top of the basinal sequence (Fig. 3). Outcrops of this unit display lensoid shapes suggesting deposition within troughs oriented normal to the graben margin. The megacrystic potash feldspar Ashfall/flow member is on-lapped westward by a medium-grained andesitic crystal tuff, in part flow, and crystal lapilli tuffs and their reworked equivalents.

Andesite crystal tuff is recognized in hand specimens by the presence of plagioclase and K-feldspars in varying proportion with hornblende laths in a fine-grained groundmass. Pyrite is ubiquitous, and constitutes up to 5% by rock volume. Andesite crystal lapilli tuff is distinguished from crystal tuffs by flattened chloritic or clay-altered fragments up to 2 centimetres long. The reworked equivalents, mainly volcanogenic greywackes, exhibit graded bedding, and consist of interbedded fine-grained and coarse-grained layers.

At the Duke's Ridge prospect, a thin, 10-metre, aphanitic brown tuff member, which dips 40^{o} southwesterly, is interbedded within the andesite crystal tuff near the lower contact with the lower megacrystic feldspar unit. Although not conclusive, speculation is that the capping andesites deposited westward within a graben basin, the margin of which developed along the southeasterly trend of Duke's Ridge. The agglomerate sequence on the southeast flank of Duke's Ridge would represent basinal deposition along the graben-horst margin developed in the same manner as observed on the Amethyst Zone.

The volcanic stratigraphic sequence is intruded by mafic andesite dykes which trend north-northwest and dip nearly vertically (Fig. 4, 5, 6, 7 and 8). The dykes may be feeders to the pyroxene basalt preserved in the downthrown block east of the Attorney Fault and in fault contact with the quartz andesites in the portal area (Fig. 8). Pyroxene basalt appears to be flat-lying overlying the trachy-andesite sequence. The texture is porphyritic with pyroxene crystals (pigeonite) in a very fine-grained maroon groundmass.

The volcanic pile on the Amethyst Zone, is cut by several north-northwest and west-trending faults (Fig. 4). The major fault system is the D1 which strikes about north-northwest and dips approximately 60^{o} to the west. From the patterns of host rocks and mineralized zones, the D1 Fault appears to have a left-lateral movement with a major normal component. Movement is also taken up by the andesite dyke during post-mineral faulting. Called the Gopherite Fault, it has a northerly strike and dips vertically, appearing to be a splay of the D1. Several minor east-west trending F1 Faults, subsidiary to the D1, also occur in the area.

MODE OF OCCURRENCE OF MINERALIZATION AND ASSOCIATED CHALCEDONY-QUARTZ BRECCIA ZONES: AMETHYST GOLD BRECCIA ZONE

Mineralization, consisting predominantly of native gold, native silver, electrum and argentite with minor chalcopyrite, sphalerite and galena, is present in chalcedony and quartz. This forms fracture fillings occurring as stockwork veins as well as the matrix within breccia zones. The stockwork veins and breccia zones are controlled by a north and north-northeast trending fracture system which dip steeply to the west (Fig. 4, 5, 6, 7 and 8).

Geometrically, the resulting veins and breccia zones cross-cut the stratigraphy emerging from the older footwall quartz andesites and passing through the younger overlying trachy-andesite sequence. At lower levels within the quartz andesite, the zone appears as a single distinct vein system, whereas in the upper levels the system splays into two prominent zones. In cross-section, the whole system resembles a "Y" configuration north of the 0+30 N section (Figs. 6 and 7). The splay occurs approximately at the 1720-metre elevation where the controlling fracture system is refracted along the contact of underlying quartz andesites with overlying trachy-andesitic sequence. The resulting refracted vein system forms the North Footwall Zone. The westerly splay, which transgresses the aphanitic tuff, welded tuff and crystal lapilli tuffs of the overlying trachy-andesitic sequence forms the more economically important North Hanging Wall Zone.

South of the 0+30 N section, the Hanging Wall and Footwall Zones merge to form a bonanza shoot over 20 metres wide (Fig. 5). This ore shoot is cut off at higher elevations and along strike by the D1 Fault (Fig. 4 and 5). Minor drag mineralization occurs along the footwall of the D1 Fault south of the 0+45 S section.

South of the 0+60 S section, surface exposures and drilling indicate a distinct mineralized zone separated from the main northern zones by the Dl Fault. This zone is cut off at depth by the Dl Fault and disperses into narrow chalcedony and quartz veinlets and microbreccias to the south.

A mineralized zone, consisting mainly of narrow chalcedony veinlets up to 2 centimetres wide over a width of approximately 15 metres, was intersected about 60 metres west of the main Footwall Zone in Drill Hole 83-2 (Fig. 6). The Zone occurs near the contact of overlying trachyte crystal tuffs and interbedded greywackes with the underlying quartz andesite. From the orientation of the chalcedony veinlets in the drill core, it appears that the zone is steeply dipping to the west and is parallel to the main Amethyst Zone. The zone was also intersected 60 metres down dip in Drill Hole 83-4.

From the patterns of breccia observed on hand specimen scale, and on a mine-wide scale, intensity of veining and associated fractures increases towards a breccia zone. This suggests that formation of chalcedony breccia is dependent on fracture density and intersection of two or more fracture directions. Brecciation is also dependent on physical and chemical characteristics of host rocks. In general, brecciation is more intense in quartz andesite but the zones are narrow, with narrow alteration envelopes. This may be due to quartz andesite being less amenable to chemical reaction with mineralizing fluids due to relative lack of potassium-bearing minerals. In the aphanitic to fine-grained tuffs, the breccia zones are restricted to narrow hairline fractures (Fig. 13,14 & 20). In the overlying welded tuffs and trachyte crystal tuffs, the breccia zones are thick and widespread and alteration (mainly argillic) is also intense.

Within the breccia zones, at least four periods of chalcedony and quartz mineralization are observed. The colour of chalcedony varies from white to cream, green, grey to dark grey, red and opaque brown. Quartz, amethyst, and to a minor extent calcite, are present in the centres of veins and breccia zones representing the last stages of open-space filling (Fig. 19). The presence of various kinds of chalcedony, as well as banding in chalcedony veins and veinlets, is probably due to multiple stages of silica precipitation caused by changes in pH, temperature, Eh and episodic boiling of the mineralizing fluids. The changes in pH, temperature and Eh occur during reaction of mineralizing fluids with host rock.

Chalcedony breccias and stockwork veins are often rebrecciated in areas cut and offset by post-mineral faults, such as the D1. The matrix in the rebrecciated chalcedony breccias is predominantly limonite, various clay minerals, and to a minor extent hematite. In places, chalcedony fragments of various periods exhibit pull-apart textures as well as subtle and ill-defined fragment boundaries in silicified gouge-like matrix (Fig. 22). This suggests that some of the breccia zones were emplaced along fault zones which were active to some extent during the time of chalcedony-quartz mineralization.

Preliminary geological mapping, drilling and trenching on the Duke's Ridge and Cliff Creek prospects suggest that chalcedony breccia zones are similar in occurrence to zones on the Amethyst Zone. The breccia zones are generally better defined with sharper vein boundaries. At least four periods of chalcedony and quartz mineralization were observed. Near the surface and near post-mineral faults, the breccia zones are broken up, with wall rock fragments completely altered to clay.

On Duke's Ridge, the breccia zones appear to be refracted along the contact between andesite crystal tuffs and a fine-grained tuff member. Breccia zones, as in the case of the Amethyst Zone, do not form strong and well defined zones in the fine-grained tuffs. This may be due to the fine-grained tuff not being readily amenable to fracturing.

CHALCEDONY BRECCIA AND VEIN-RELATED ALTERATION, AMETHYST GOLD BRECCIA ZONE

Breccia zones and stockwork veins within the Amethyst Zone have narrow argillic alteration envelopes. This alteration consists of various clay minerals likely consisting of kaolinite, illite, dickite + montmorillonite ± limonite ± goethite ± hematite. The envelopes vary between 1 centimetre and 50 centimetres wide. The argillic zone, based on information known to date, appears to be more widespread in the overlying trachy-andesite sequence relative to the quartz andesite, due to the presence of potassium-bearing minerals in the upper trachy-andesite sequence. Silicification appears to be restricted to wall rock fragments within the chalcedony breccia zones and stockwork veins. From hand specimens, silicification appears to be caused by introduced silica and breakdown of feldspars and mafic minerals (Fig. 17, 18 and 21).

As the breccia zones and veins are approached in the quartz andesite crystal tuffs, the ferromagnesian minerals display breakdown to chlorite and plagioclase to minor epidote with calcite vein development. Bleaching and silicification of wallrock with the formation of hematite within the veinlets occurs with initial development of quartz and chalcedony veinlets. The formation of hematite is due to complete conversion of mafic minerals into iron oxides, silica and clay minerals. The ferromagnesian minerals in wallrock, bordering the bleached and silicified zones, are altered to chlorite. The bleaching of wallrock appears to take place in an area up to 50 metres away from the vein or breccia zone. Intensity of chalcedony veining and microbreccias increases with more extensive bleaching and silicification of wallrock and formation of argillic alteration zones. Chalcedony matrix within breccia zones and veinlets is impregnated with hematite and various other iron oxide minerals. Minor jasper is also observed (Fig.17 and 18).

Drill hole data and underground mapping suggest that the argillic zone is more prevalent at higher levels, generally associated with the trachyte crystal tuffs and welded tuffs, with smaller peripheral propylitic zones. This is likely due to a relative lack of mafic minerals and plagioclase feldspars compared to the quartz andesite crystal tuffs.

Sericite is observed to be very restricted, present only in minor amounts within the breccia zones and as narrow envelopes. This suggests that the temperature and pH are not high enough for the widespread formation of sericite.

On the Cliff Creek and Duke's Ridge Zones, chalcedony breccia zones and stockwork veins are associated with pervasive argillic alteration zones. The argillic alteration consists of various clay minerals (illite, montmorillonite and kaolinite) with or without limonite, goethite, hematite and manganese oxides. The alteration varies in thickness from about 5 metres to approximately 50 metres. Propylitic alteration comprised mainly chlorite, epidote and to a minor extent calcite, and is present peripheral to the argillic zone. Superimposed on this is a supergene argillic alteration consisting mainly of various clays and limonite. This is caused by the break-down of indigenous pyrite present in the host andesitic volcanic rocks by surface waters. Results from drilling indicate the supergene alteration extends down to a depth of 30 metres. Gold and silver assays are generally low within supergene altered areas. This may be due to minor leaching of gold-silver mineralization through the chemical breakdown of chalcedony breccia and wallrocks by acidic surface waters, or in other words, during the formation of supergene argillic alteration.

Examination of polished and poly-thin sections of chalcedony-quartz breccia samples from both the Amethyst and Duke's Ridge Zones revealed two types of mineralization. One group is characterized by the presence of argentite, electrum, gold with minor sphalerite, galena and chalcopyrite, with up to 5% pyrite, and the second group by argentite, native gold and electrum with mainly hematite, goethite and lepidochrosite. In both groups of samples, the various ore minerals occur in microfractures, vugs, and grain and crystal boundaries of nonsulfide and nonmetal vein constituents. All the ore minerals appear to coexist with each other. Very few instances of cross-cutting relationships were observed. In some examples, argentite is seen growing from walls of vugs with calcite in fillings. The main gangue vein constituents are banded chalcedony and quartz, calcite and minor barite. Calcite and barite occur in centres of veins and breccia matrix (Figs. 25, 26, 27 and 28).

The pyrite-poor group appears to be supergene derived from the pyrite-rich group. Hematite, goethite and lepidochrosite occur disseminated through the gangue constituents, and pseudomorph the pyrite grains. Furthermore, argentite was observed in limonitic cavities or box works. This may also explain the reason for the lack of other sulfide minerals in the pyrite-poor samples. Sphalerite, chalcopyrite and galena may have been leached out by acidic solution formed due to the break-down of pyrite.

METAL ZONATION

Assay data from drill holes and trenches show a general metal zonation with respect to gold and silver in the Amethyst Zone. Studies, with respect to other metals such as copper, lead, zinc and mercury, and trace elements, e.g., barium, selenium, tellurium, thallium and manganese, etc., are in progress. Contouring of silver to gold ratios shows that silver values generally increase towards the north and at depth (Fig. 23). The values range from less than 20:1 in the south to more than 80:1 in the north and at depth. Variations within the higher ratios occur. This may be due to multiple mineralizing events superimposed upon one another and also to some extent the preferential remobilization of silver with respect to gold where post mineral faults cut through the breccia zones.

Superimposing the silver to gold ratio contours on the mineralized zones of the Amethyst Zone, it appears that the margins of the zone are richer in gold relative to silver (Fig. 23). Trace element data may suggest the same conclusions.

It is interesting to note that the silver to gold ratios of the South Zone, occurring west of the D1 Fault, are similar to the Main North Hanging Wall Zone. This suggests that the two zones are one and the same and are now separate and discrete due to the left-lateral and normal movement of the D1 Fault.

DISCUSSION

The Amethyst Gold Breccia Zone and the Cliff Creek and Duke's Ridge Zones exhibit several significant characteristics. As the data for Duke's Ridge and Cliff Creek are relatively incomplete and preliminary, detailed discussion will be limited to the Amethyst Zone.

Gold-silver mineralization in the form of native gold, electrum, argentite and native silver, along with minor amounts of chalcopyrite, galena and sphalerite, is associated with chalcedony-quartz breccia zones and stockwork veins. Several periods of chalcedony and quartz mineralization were observed.

Stratigraphic and structural reconstruction based on drill hole data and geological mapping suggest mineralization and associated alteration took place after the final eruptive cycle of the trachy-andesitic volcanism. Quartz andesite appears to have structural contact relationships to the overlying trachy-andesitic sequence. Lapilli tuffs are welded near the structural contact with the quartz andesites. From the structural contact patterns of the quartz andesite with the overlying trachy-andesite sequence observed in various drill holes, it appears that the trachy-andesitic volcanism took place along graben margins. The graben structures can be visualized on Section 0+45 N, Amethyst Zone (Fig. 5, 6, 7, 8 and 24). The contact between quartz andesite and the overlying trachy-andesitic sequence changes dip from about 70^{o} to 15^{o} and again to 80^{o} in a step-like fashion. The steep-dipping contacts appear to be graben margins. Breccias and stockwork vein systems filled with chalcedony and quartz with gold and silver values are emplaced along these graben margins.

Mafic dykes are emplaced along the same graben structures during the final eruptive cycle of the trachy-andesitic volcanism (Fig. 4, 5, 6, 7 and 24). These dykes cut the chalcedony breccia zones and therefore are later than the mineralizing episode. They are probably feeders to the pyroxene basalt preserved on the downthrown block east of the Attorney Fault exposed near the 1750 portal of the Amethyst Zone. Pyroxene basalt does not exhibit any hydrothermal alteration and quartz veining.

Subsequent young northwest-trending faulting through reactivation of graben margins along the same trend has off-set the stratigraphy and mineralization. The D1, subsidiary Gopherite and F1 Faults are evidence of the youngest structural control which has affected the mineralization.

Mineralized chalcedony breccia zones transgress volcanic units of varying composition on the Amethyst Zone. Alteration zonation was observed to vary according to the host rock composition as well as the various levels at which mineralization occurs.

As mentioned earlier, argillic alteration zones are predominant in the upper trachy-andesitic sequence, whereas in the quartz andesite the propylitic zone is more widespread. This may be due to the relative lack of ferromagnesian minerals in the trachy-andesitic sequence compared to quartz andesite. The following chemical reactions show how a propylitic zone is formed in the quartz andesite. Sodium-calcium-iron-magnesium minerals break down to form iron oxides, silicates and silica, for example:

$$NaCa_2(Mg_2Fe_3)(Si_6Al_2)O_{22}(OH)_2 + 22H^+ \rightleftharpoons Na^+ + 2Ca^+ + 3Fe^{+3} +$$

(hornblende)

$$2Mg^{+2} + 2Al^{+3} + 6H_4SiO_4$$

$$5\left[Na^+ + 2Ca^+ + 3Fe^{+3} + 2Mg^{+2} + 2Al^{+3} + 6H_4SiO_4\right] \rightleftharpoons$$

$$2Al(MgFe)_5AlSi_3O_{10}(OH)_8 + 5Fe^{+3} + 8Al^{+3} + 3H_4SiO_4 + 3SiO_2 + 6H_2O$$

(chlorite)

Chlorite combines with aluminum and potassium to form sericite and/or clay minerals with large amounts of iron liberated to form pyrite or hematite, depending on whether sulphur is available. Clay minerals may include dickite and alunite, such as the reactions below:

$$2Al(MgFe)_5AlSi_3O_{10}(OH)_8 + 5Al^{3+} + 3Si(OH)_4 + 3K^+ + 2H^+ \rightleftharpoons$$

(chlorite)

$$3KAl_3Si_3O_{10}(OH)_2 + 10(FeMg)^{++} + 12H_2O$$

(sericite)

$$5KAl_3Si_3O_{10}(OH)_2 + 3H_2O \rightleftharpoons 3KAl_5(SiO_{20})(OH)_4 + 4H^+ + 2K^+$$

(sericite) (dickite)

$$KAl_3Si_3O_{10}(OH)_2 + 4H^+ + SO_4 \rightleftharpoons KAl_3(SO_4)_2(OH)_6 + 3SiO_2$$

(alunite)

Similarly, biotite breaks down to chlorite, which in turn alters to sericite and various clay minerals with the liberation of iron, as shown below.

$$KFe_3(AlSi_3O_{10})(OH)_2 + 10H^+ \rightleftharpoons K^+ + 3Fe^{+2} + Al^{+3} + 3H_4SiO_4$$

$$K^+ + 3Al^{+3} + 3H_4SiO_4 \rightleftharpoons \underset{\text{(sericite)}}{KAl_3Si_3O_{10}(OH)_2}$$

In an oxidizing environment or in a reducing environment, iron liberated forms hematite or pyrite as the case may be.

$$3Fe^{+2} + 4O^{+2} \rightleftharpoons Fe_3O_4 \quad \text{(magnetite)}$$

$$\text{or} \quad Fe^{+2} + 2S^{+2} \rightleftharpoons FeS_2 \quad \text{(pyrite)}$$

$$\text{or} \quad 4Fe^{+3} + 6O^{+2} \rightleftharpoons 2Fe_2O_3 \quad \text{(hematite) if valence state is +3}$$

The assemblages shown in the above reactions are present as narrow envelopes around the breccia zones in quartz andesites of the Amethyst Zone. Within the potassium-rich rocks such as the trachy-andesitic sequence the K-feldspar alters to sericite and/or clay minerals with the liberation of silica. For example:

$$3KAlSi_3O_8 + 2H^+ \rightleftharpoons \underset{\text{(sericite)}}{KAl_2AlSi_3O_{10}(OH)_2} + 3SiO_2 + 2K^+$$

On Duke's Ridge and Cliff Creek, indigenous pyrite (up to 5%) is present within the andesitic host rocks. Hydrothermally altered wall rocks (argillic and propylitic) are further altered to clays by acidic surface waters formed by the breakdown of the pyrite. This surface argillic alteration extensively masks the hydrothermal hypogene zones in places.

The mode of occurrence of mineralization with associated alteration zones discussed above and described in detail earlier suggests that the Lawyers prospects are typical epithermal gold-silver vein-type deposits. Gold and silver values occur in banded chalcedony-quartz veins and breccias cross-cutting stratigraphy. Lawyers prospects are similar in their modes of origin and occurrence to many of the well known epithermal districts in Nevada, Colorado and New Mexico. Lawyers prospects and other mineral occurrences in the Toodoggone River area are unique in one respect. They were emplaced during the Jurassic period, whereas the more famous districts of south-western United States are Tertiary in age.

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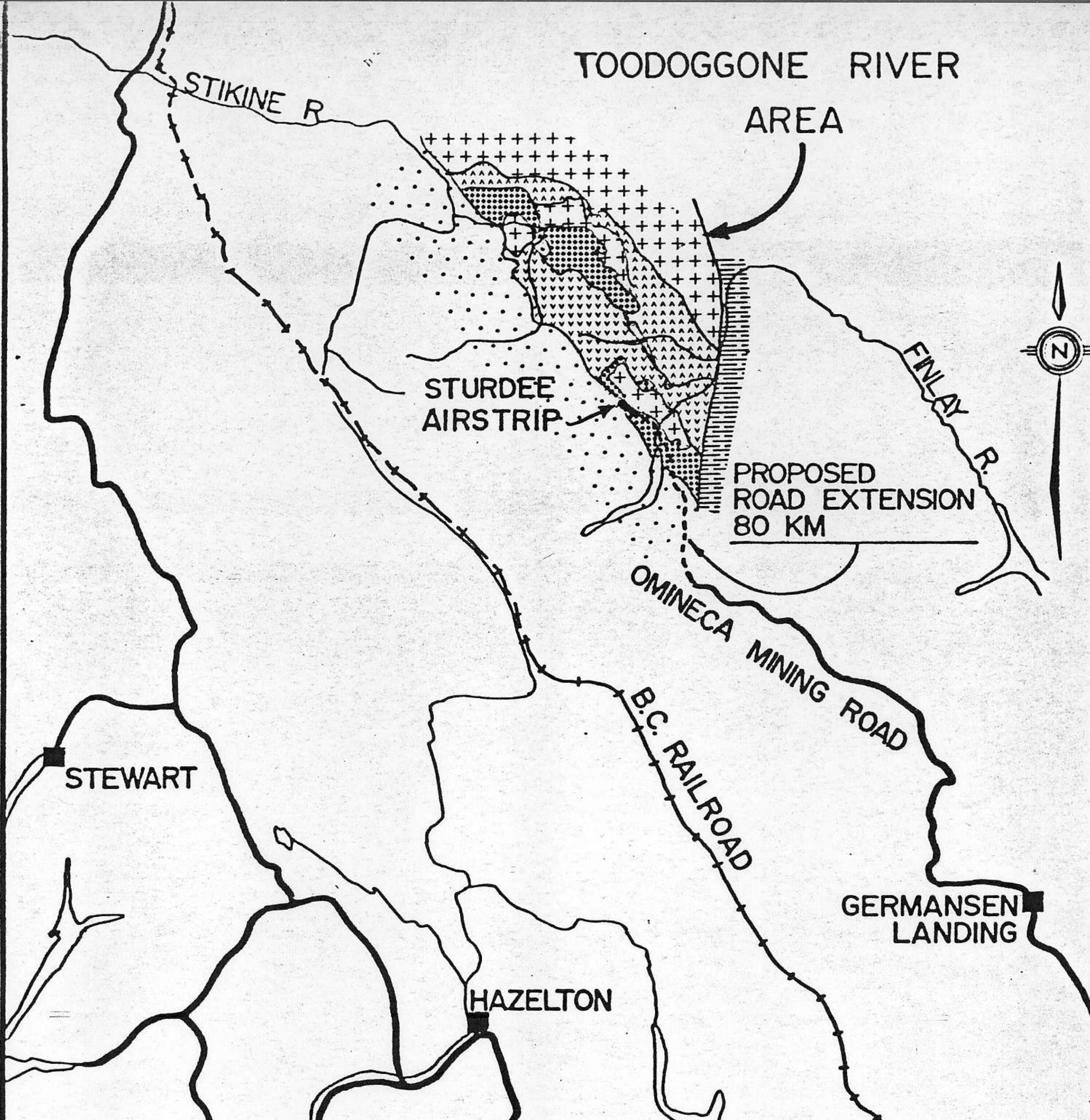


LOCATION & ACCESS

Fig. 1

REGIONAL GEOLOGY

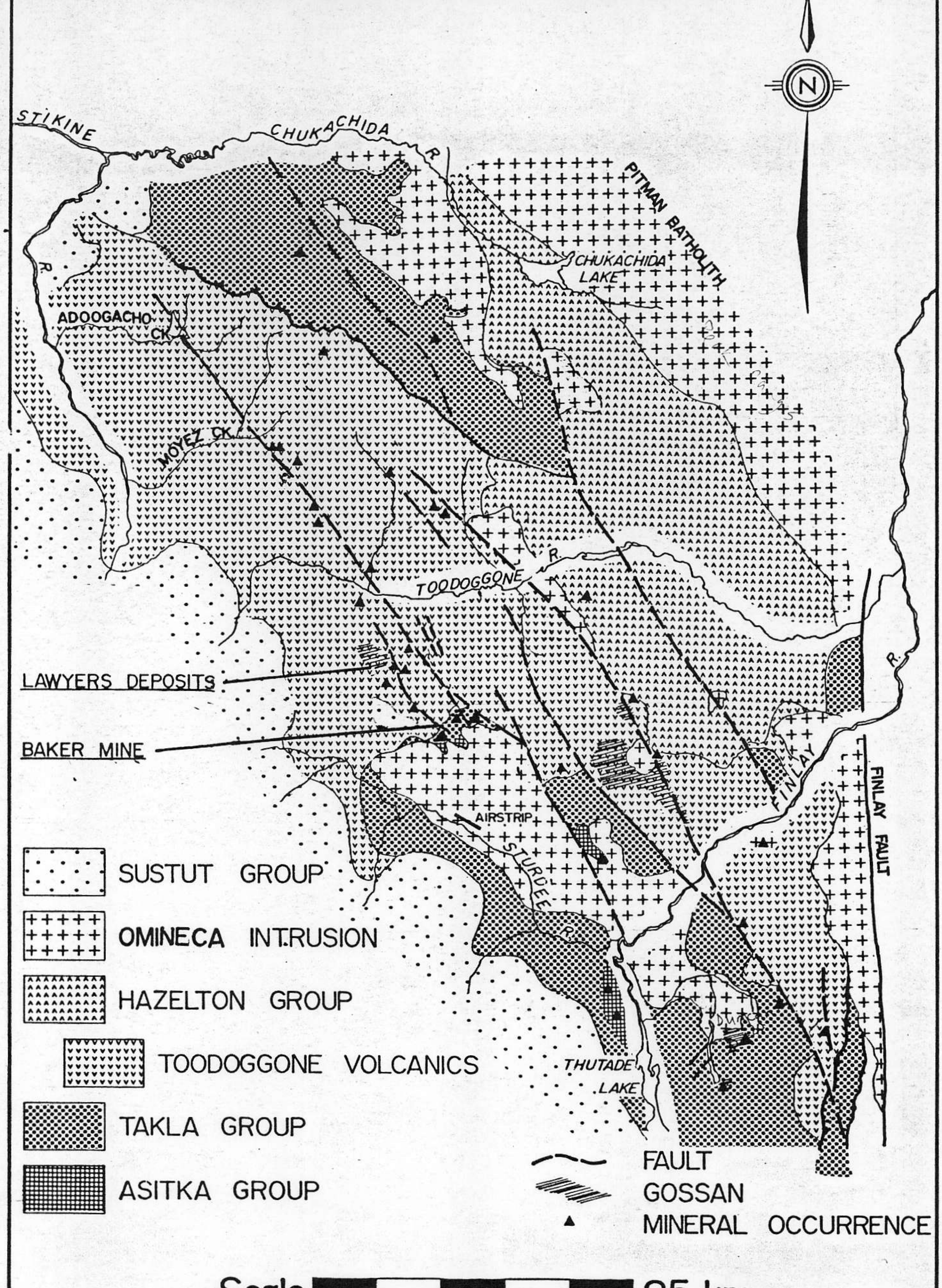
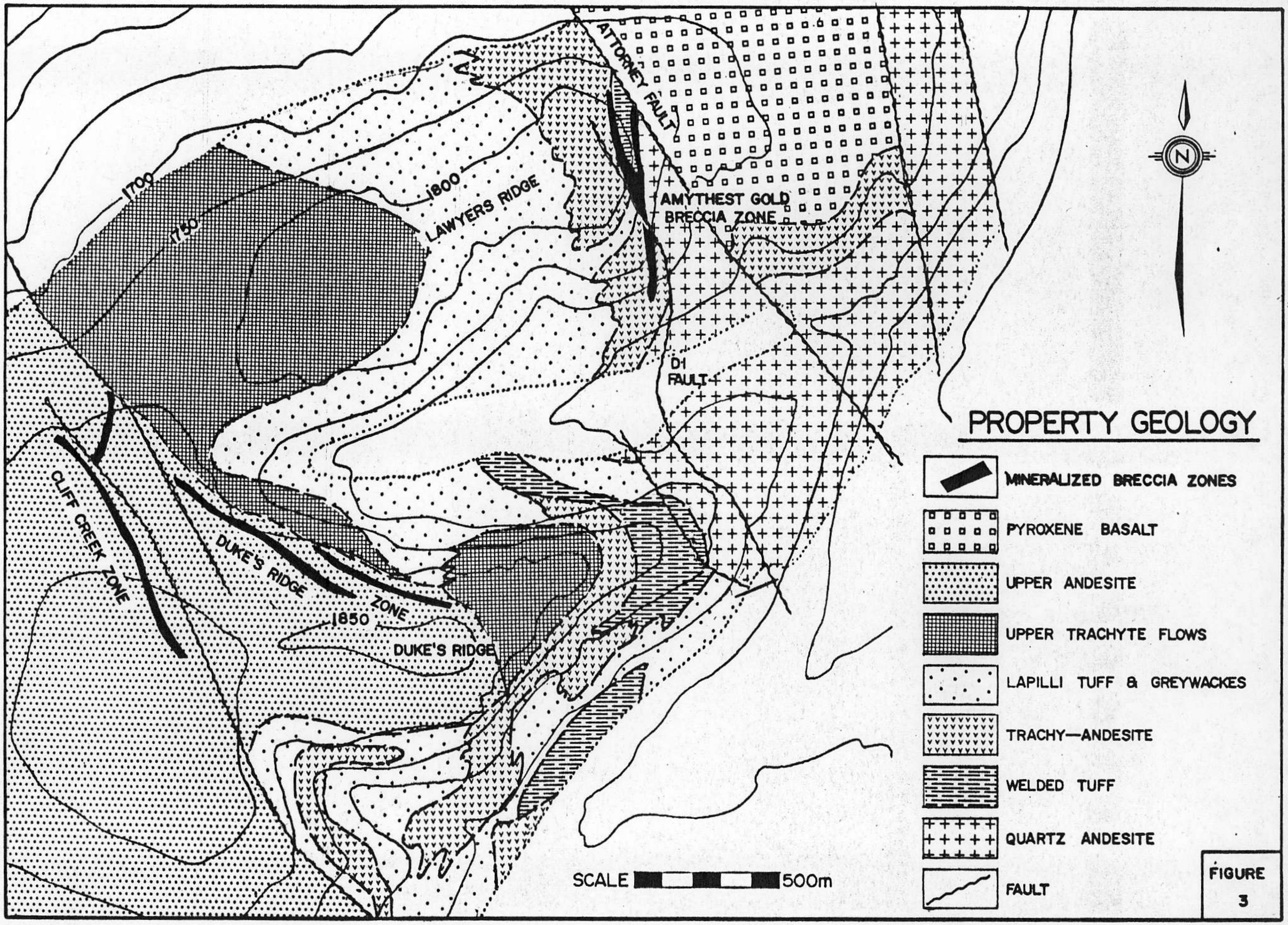
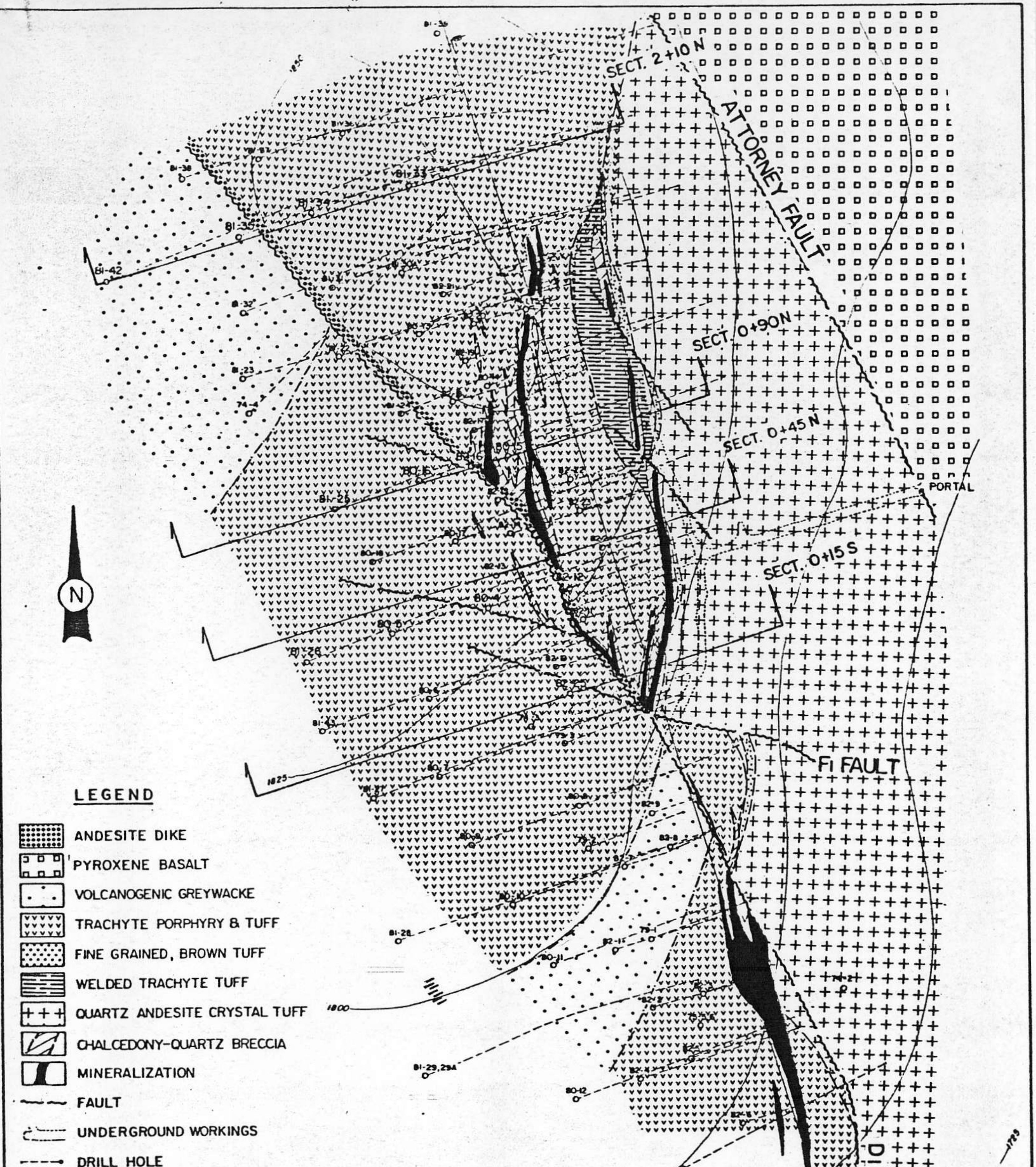


FIGURE 2



ATTORNEY FAULT
AMYTHEST GOLD BRECCIA ZONE
LAWYERS RIDGE
1700
1750
1800
1850
D1 FAULT
CLIFF CREEK ZONE
DUKE'S RIDGE ZONE
DUKE'S RIDGE
N
SCALE 500m
PROPERTY GEOLOGY
MINERALIZED BRECCIA ZONES
PYROXENE BASALT
UPPER ANDESITE
UPPER TRACHYTE FLOWS
LAPILLI TUFF & GREYWACKES
TRACHY—ANDESITE
WELDED TUFF
QUARTZ ANDESITE
FAULT

FIGURE 3



AMETHYST GOLD BRECCIA ZONE SURFACE PLAN

Fig. 4

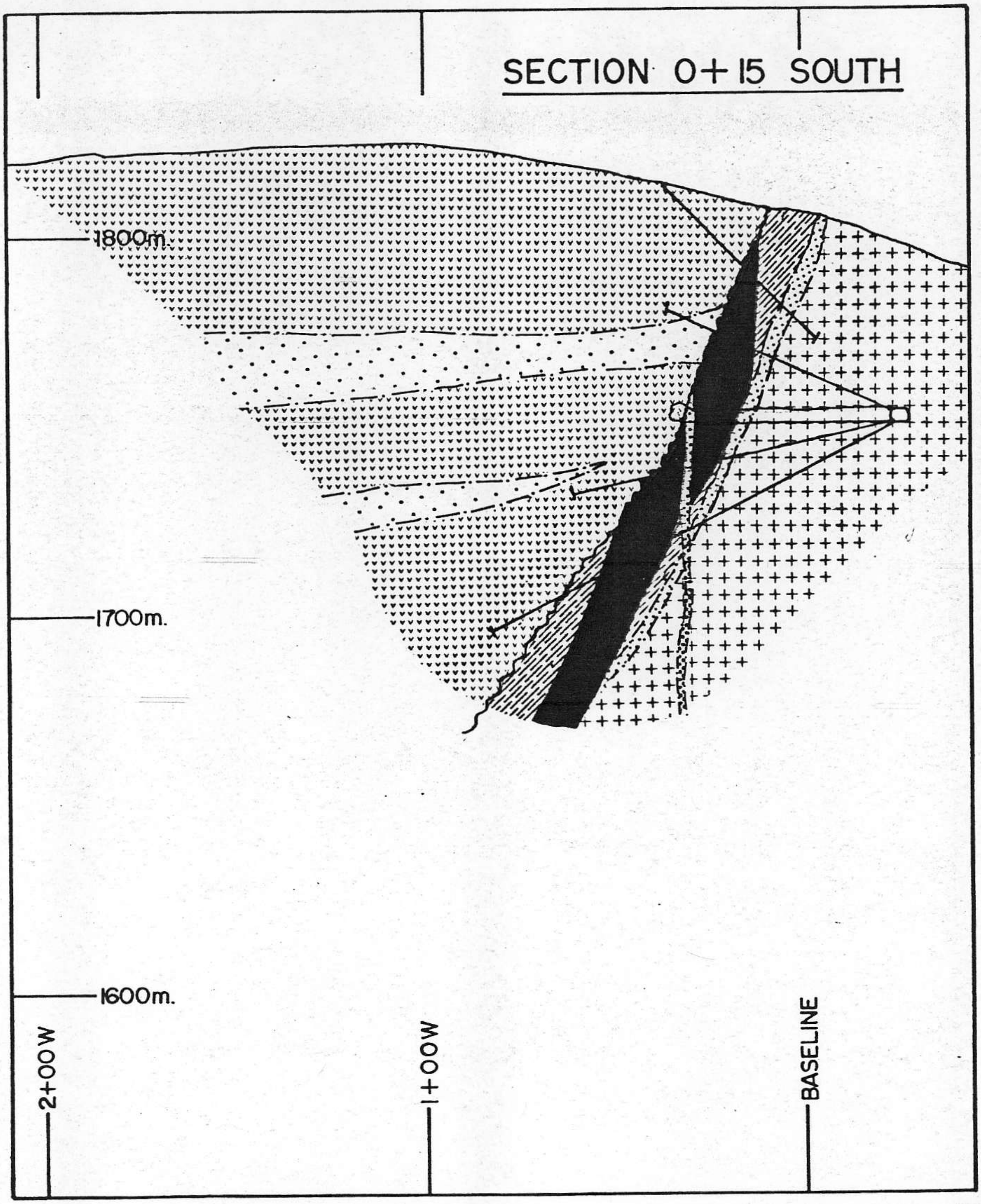


Fig. 5

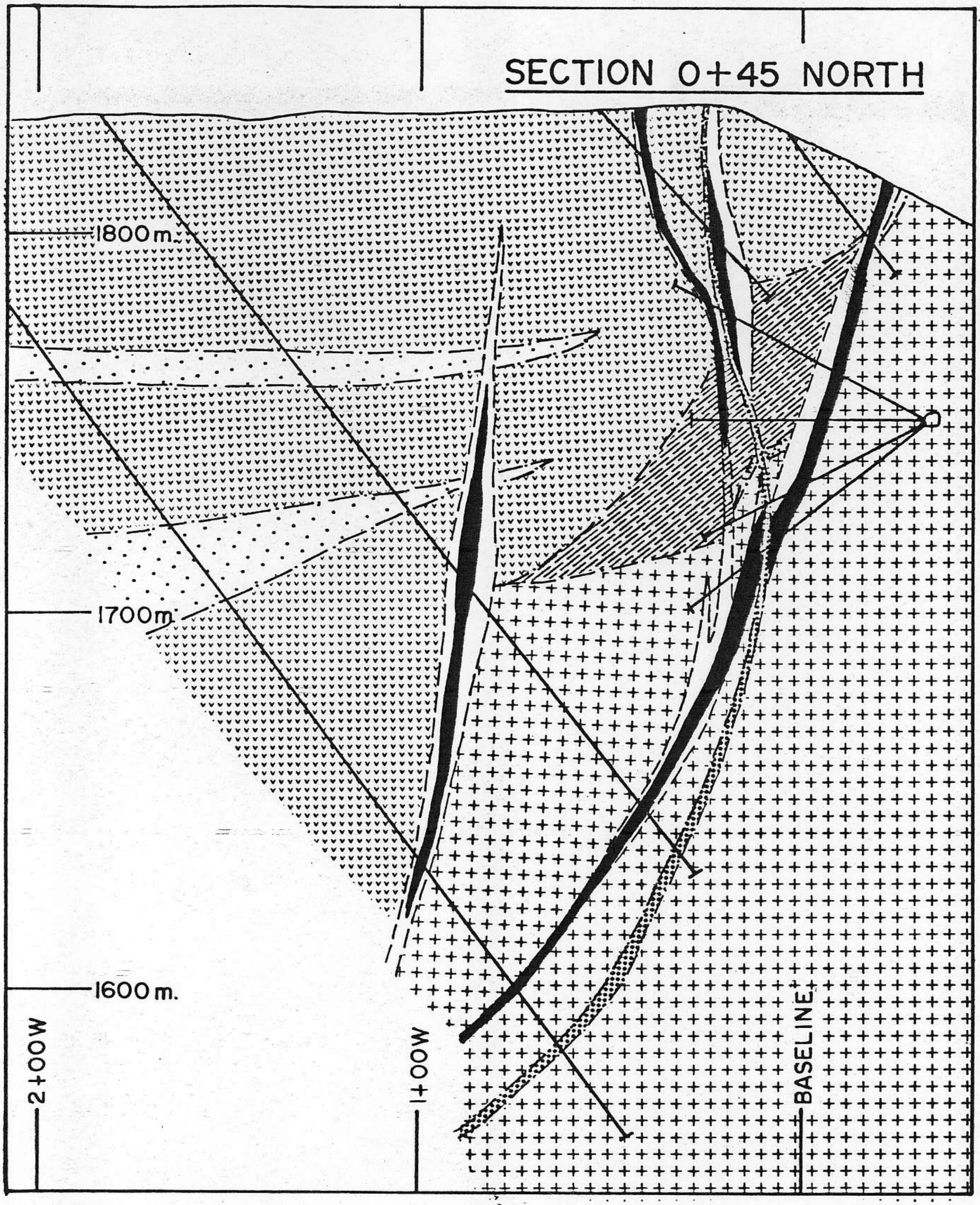


Fig. 6

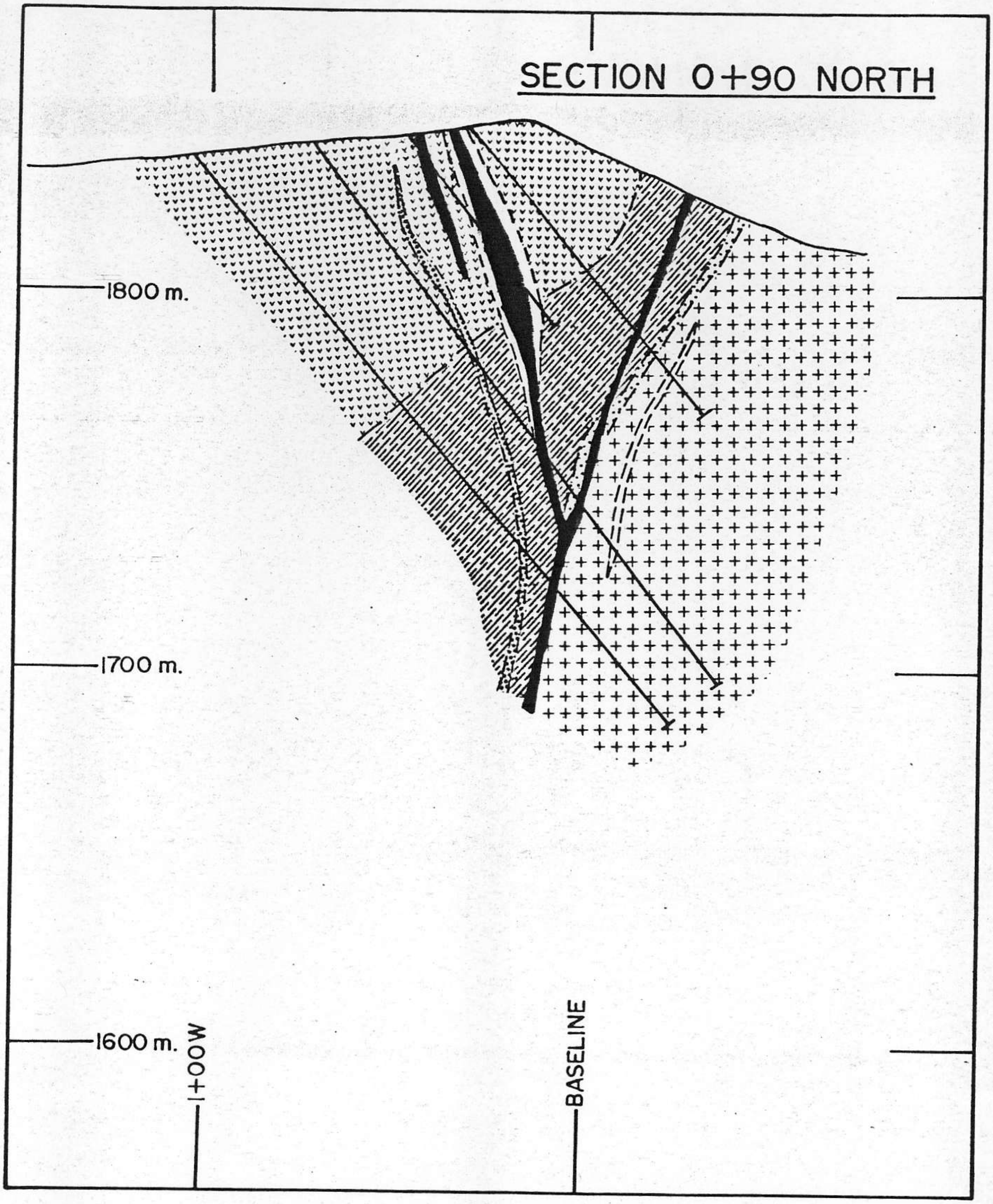


Fig. 7

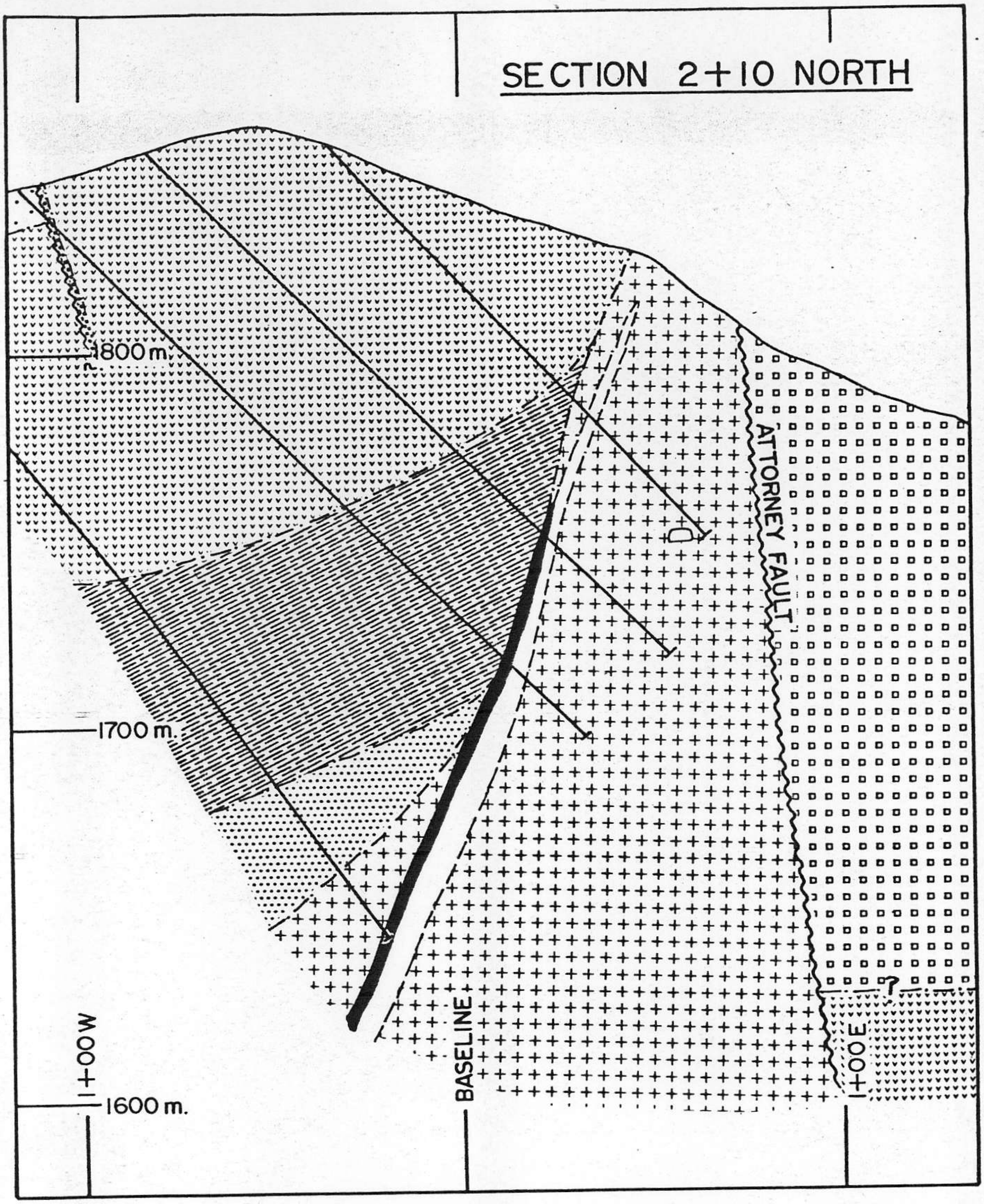

SECTION 2+10 NORTH
1800 m.
1700 m.
1600 m.
ATTORNEY FAULT
1+00W
BASELINE
1+00E
?

Fig. 8

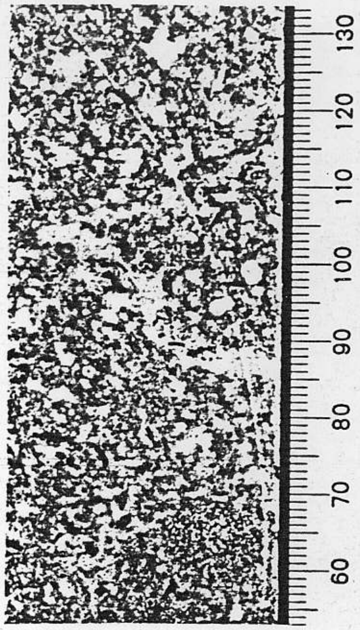


FIG. 9

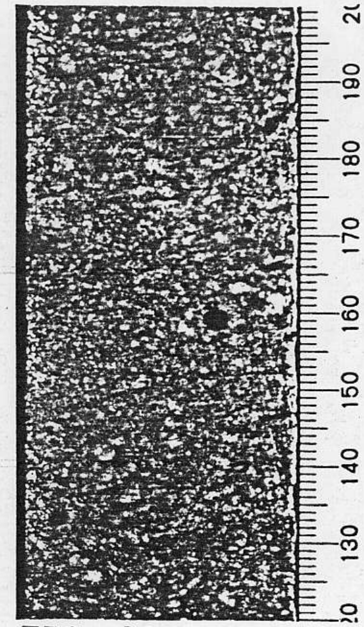


FIG. 10

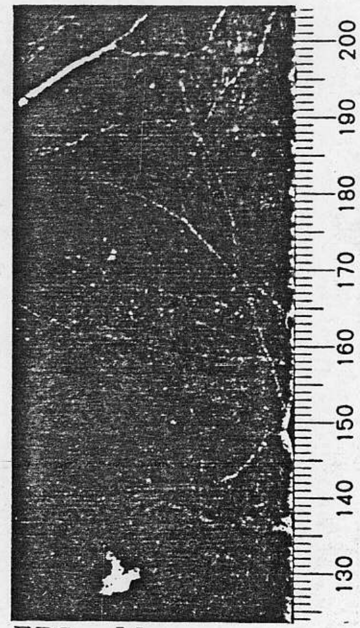


FIG. 11

FIG. 9 TRACHYTE CRYSTAL TUFF WITH FRAGMENTS. NOTE HORNFELSED FRAGMENT LOWER RIGHT CORNER

FIG. 10 WELDED TRACHYTE TUFF WITH FLATTENED LAPILLI AND FRAGMENTS

FIG. 11 FINE-GRAINED TO APHANITIC TUFF WITH COARSER-GRAINED LAYERS

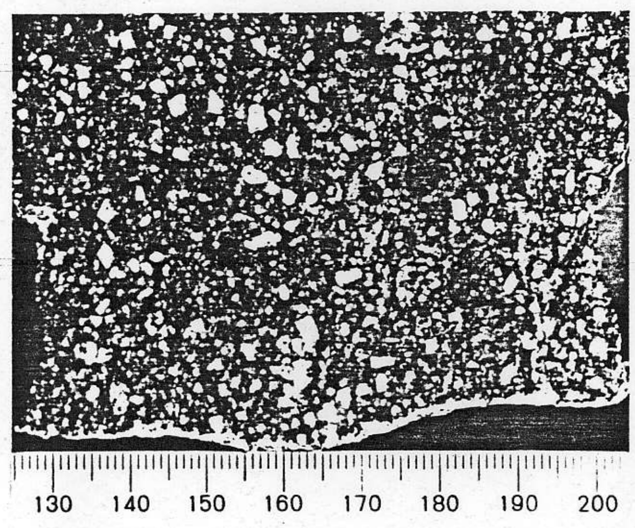


FIG. 12

QUARTZ ANDESITE CRYSTAL TUFF WITH CRYSTAL AND WALLROCK FRAGMENT IN A FINER-GRAINED MATRIX. NOTE THE ROUND QUARTZ GRAINS MARKED

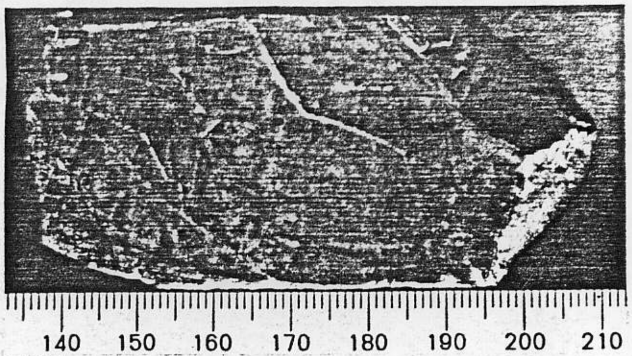


FIG. 13

Fine-grained to aphanitic tuff with hairline fracture-fillings of chalcedony, quartz and amethyst.

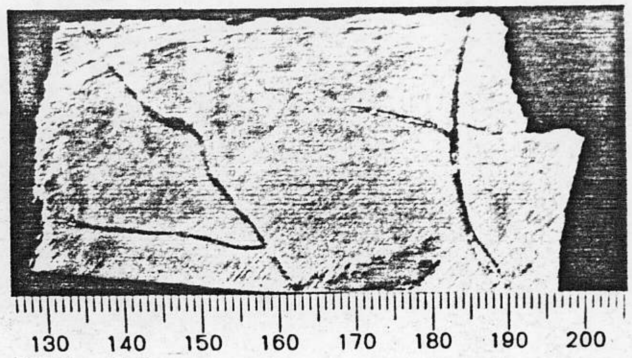


FIG. 14

Intensely clay altered fine-grained to aphanitic tuff. Note complete bleaching of mafics, and hairline fracture-fillings of quartz, chalcedony and amethyst.

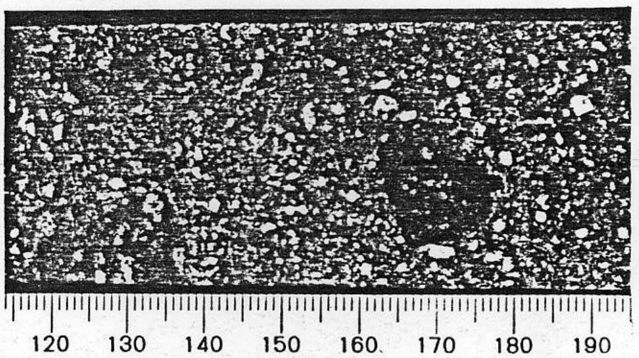


FIG. 15

Welded trachyte tuff with chlorite-altered lapilli.

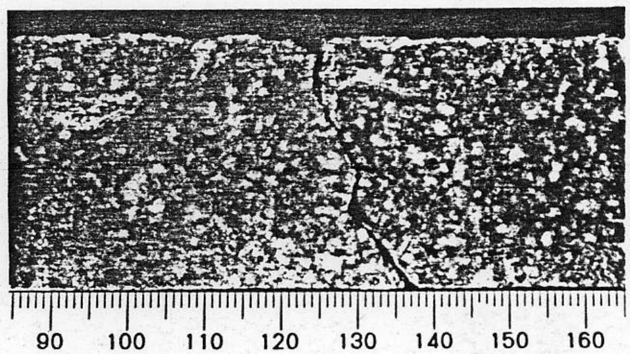


FIG. 16

Clay-altered quartz andesite with relict feldspar phenocrysts, and hematite after mafics.

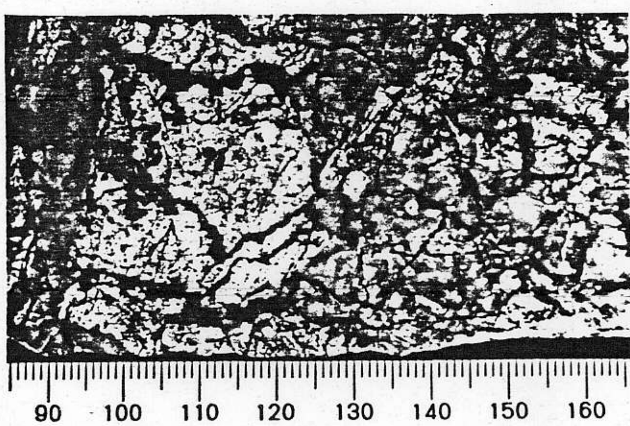


FIG. 17

Chalcedony-quartz breccia with various stages of chalcedony matrix. Wallrock fragments intensely altered to clay, with complete destruction of mafics and formation of goethite.

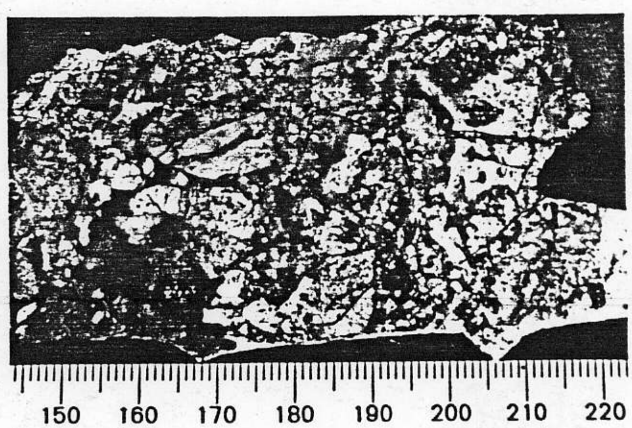


FIG. 18

Chalcedony-quartz breccia with multiple generations of chalcedony, quartz and amethyst centres. Wall rock fragments intensely silicified, clay altered, with complete destruction of mafics and formation of goethite.

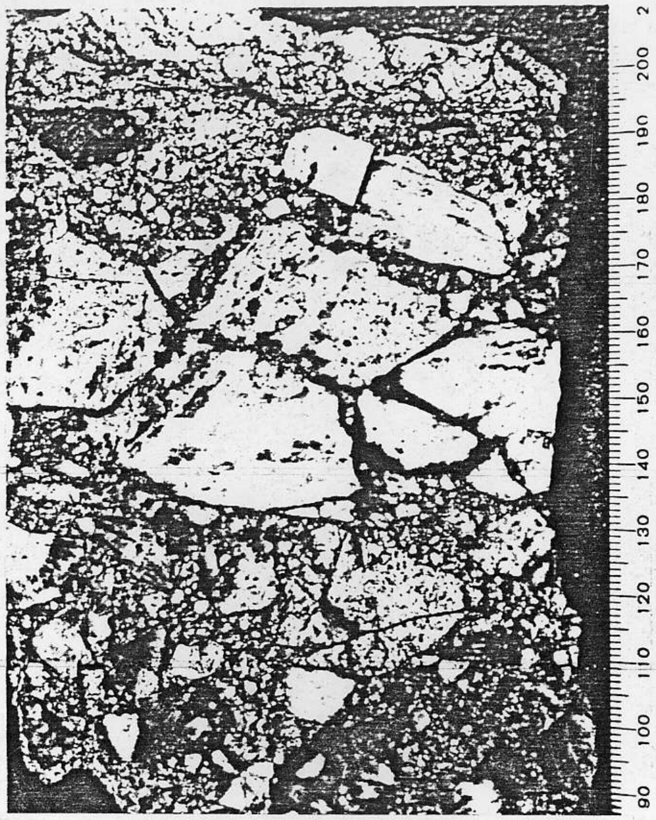


Fig. 19. Rebrecciated fragments with multiple stages of chalcedony, quartz, amethyst, minor calcite, and wall rock fragments in a hematite, siliceous matrix.

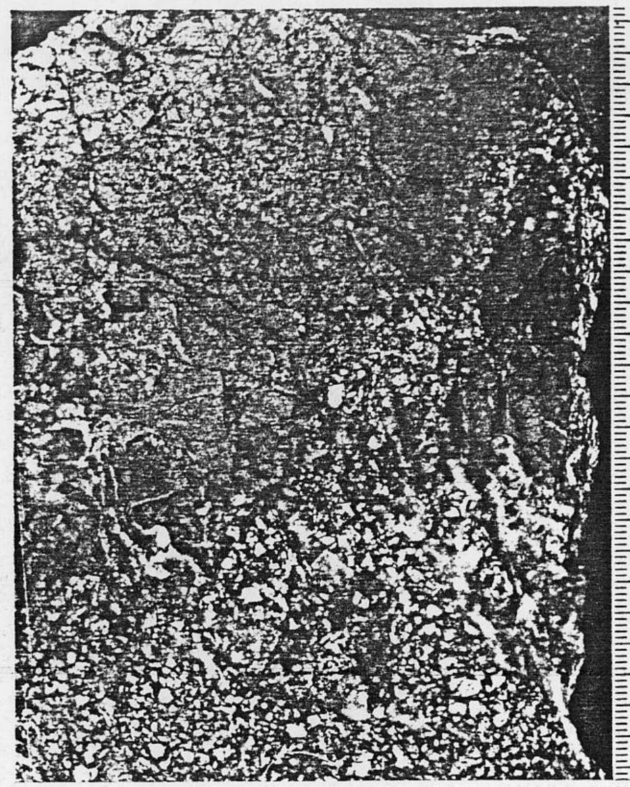
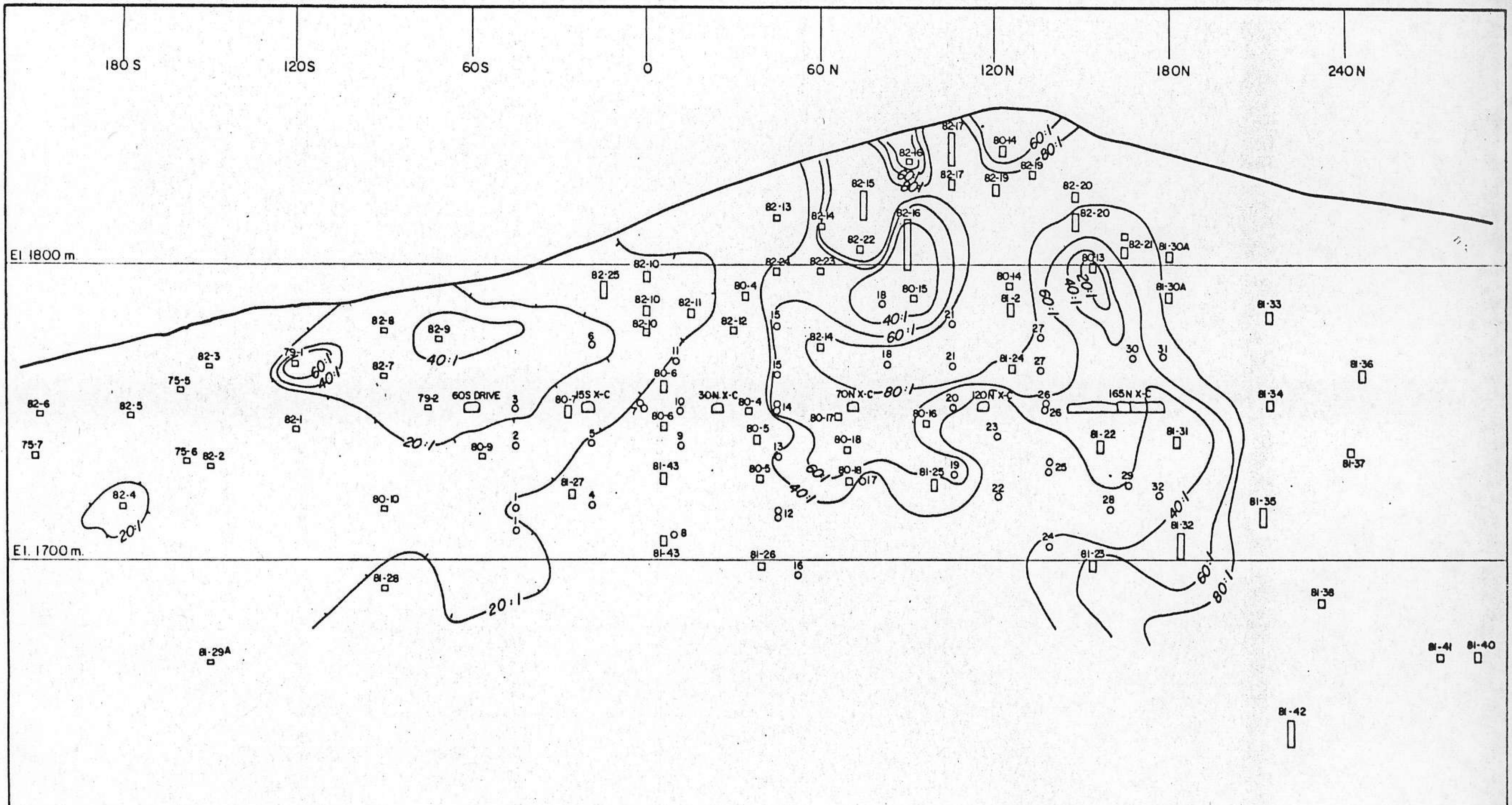


Fig. 20. Nature of brecciation in aphanitic tuff and quartz andesite. Note hairline quartz-chalcedony fracture fillings in aphanitic tuff compared to quartz andesite.

Fig. 21. Chalcedony-quartz breccia with altered wall rock fragments.

Fig. 22. Pull-apart textures in chalcedony fragments in silicified gouge-like matrix.



AMETHYST GOLD BRECCIA ZONE
SILVER TO GOLD RATIOS ON LONGITUDINAL SECTION

0 20 40 60 80 100 METRES

LEGEND

—40:1— SILVER : GOLD CONTOUR

□ 82-2 SURFACE DRILL HOLE INTERCEPT

○ 4 UNDERGROUND DRILL HOLE INTERCEPT

Fig. 23

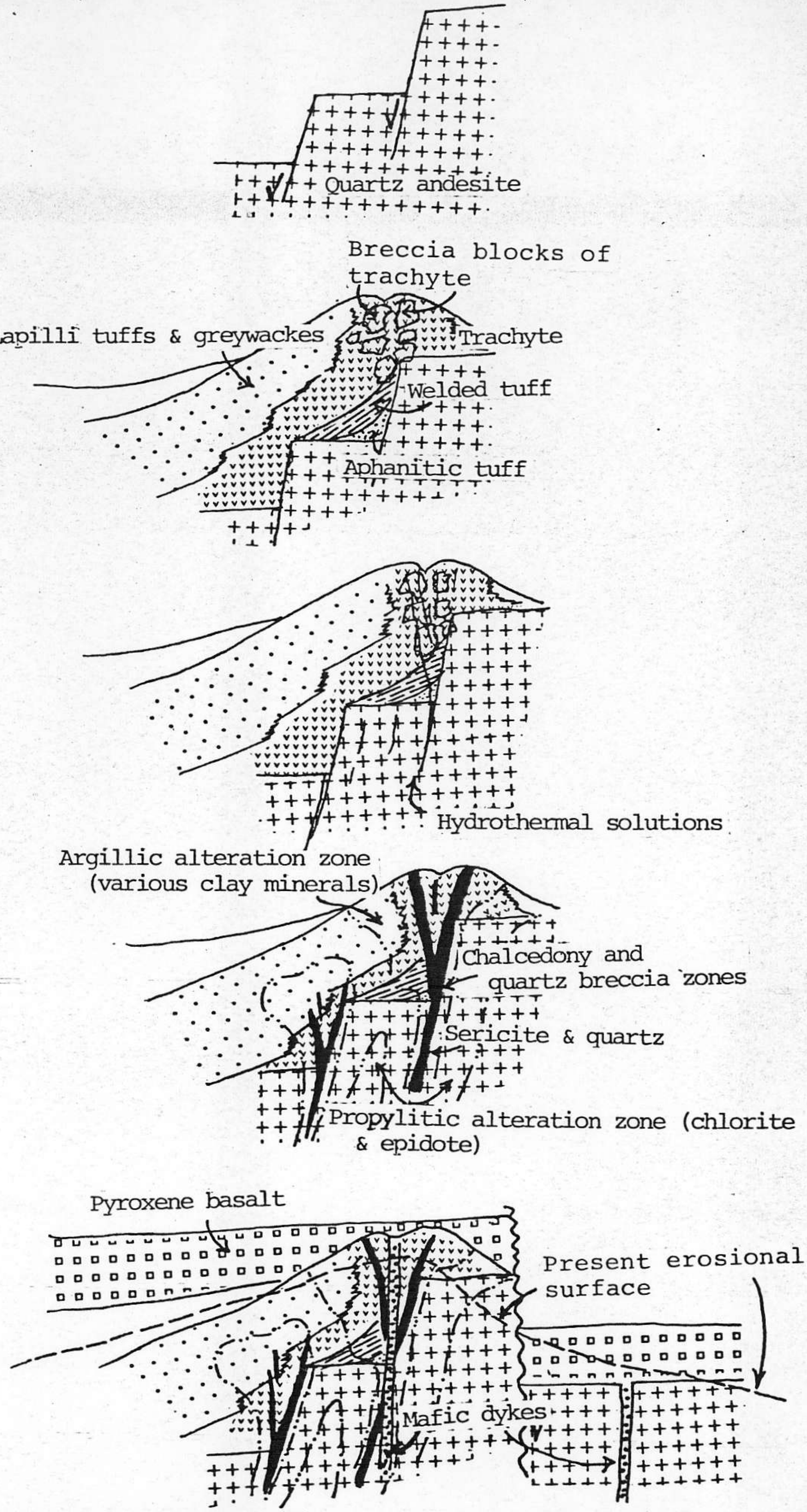


Fig. 24. Cartoon illustrating volcanism along graben margins and subsequent emplacement of mineralization along associated structures.

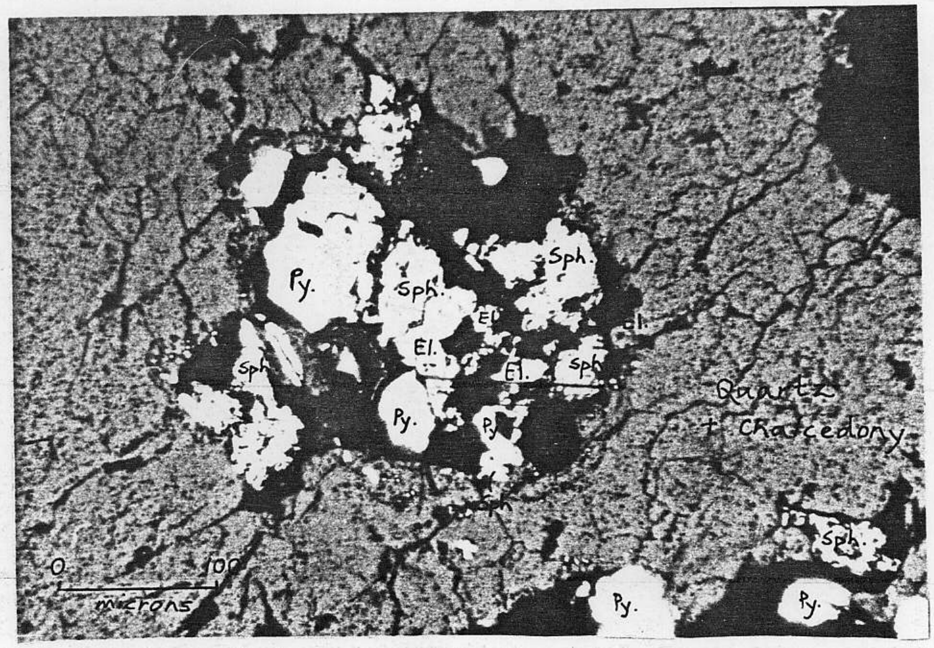


Fig. 25. Pyrite, electrum and sphalerite intergrown in vug in quartz vein material.

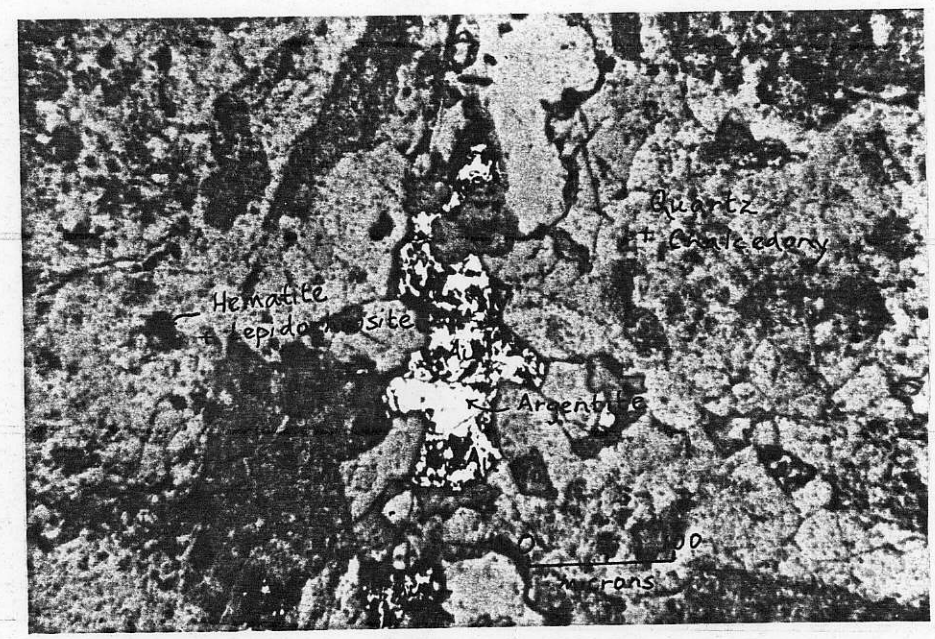


Fig. 26. Argentite and gold coexisting along quartz grain boundaries.

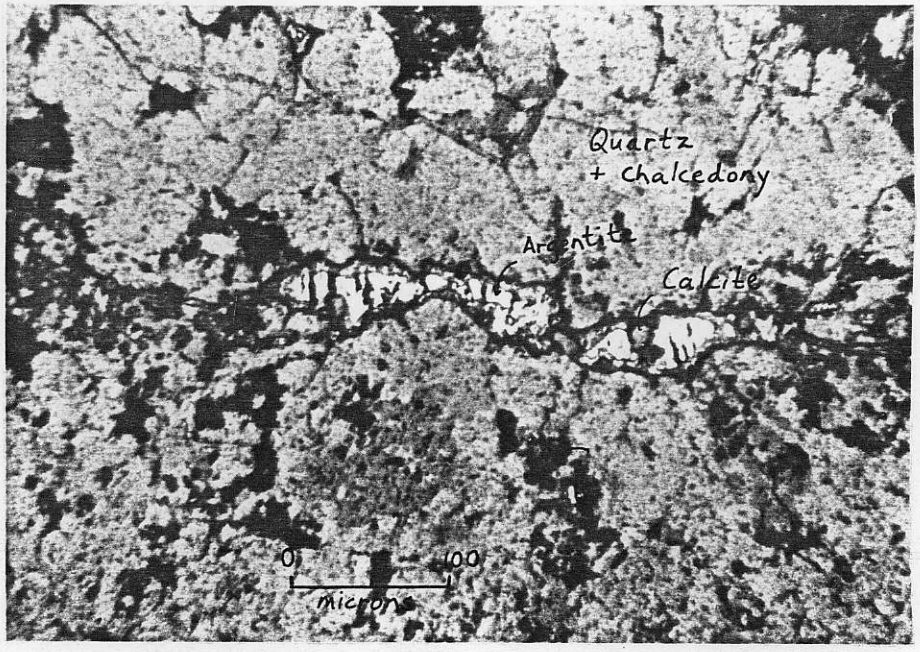


Fig. 27. Argentite in calcite veinlet.

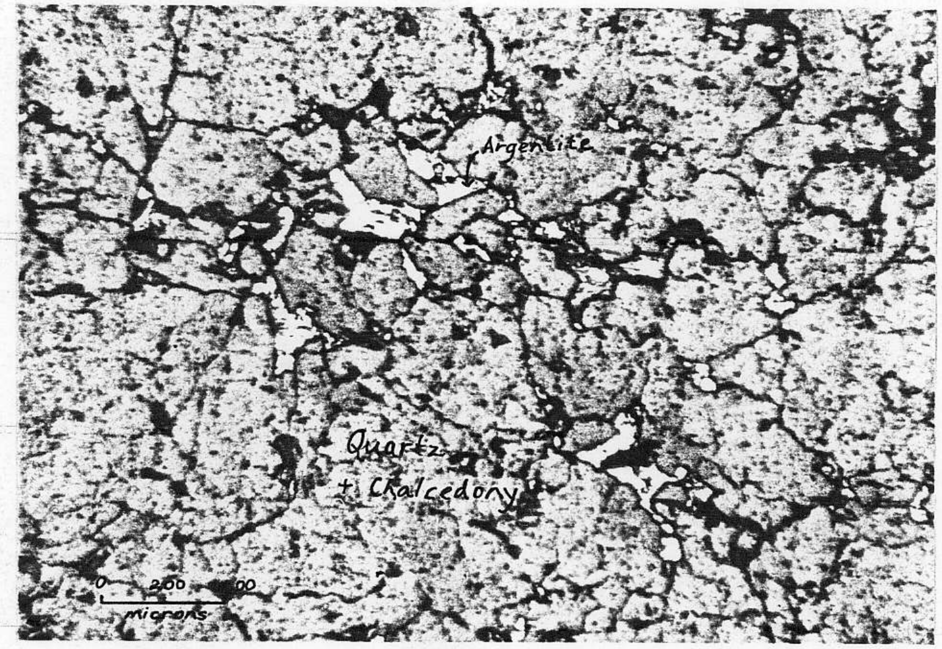


Fig. 28. Argentite in small vugs and along grain boundaries in chalcedony-quartz breccia.