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GEOLOGY OF THE CINOLA DEPOSIT, QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA

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ABSTRACT

The Cinola deposit is a gold orebody located on Graham Island of the Queen Charlotte Islands, British Columbia. Exploration by several different companies has been carried out since the discovery in 1970. Recent drilling has delineated a large tonnage, low grade gold deposit in a unique geologic setting. The deposit is found in Tertiary intrusive subvolcanic felsic rocks and volcaniclastic sediments that have been intensely brecciated and silicified. The mineralization is bounded at its base and on the west side by a younger normal fault that probably had substantial lateral movement.

Gold mineralization is closely associated with silicification and spatially asociated with the felsic intrusive rocks. The mineralization occurs in a quartz stockwork zone above a near surface rhyolite intrusive. Two modes of gold mineralization are present: thick, moderate grade disseminations and thin, high grade veins. Most of the gold is less than 0.5 microns in size but free gold may be visually observed in quartz veins. The sedimentary stratigraphy has no apparent control on the gold mineralization. Similarly, the gold content is not directly related to the pyrite or carbon content of the host rocks. The only sulfides of significance in the deposit are pyrite and marcasite. Other sulfides have been reported but occur in only trace amounts. Alteration consists of silicification and argillization. Reserves at the Cinola gold property are in excess of 45 million tons containing 0.054 oz gold per ton; significant gold has been encountered in drilling outside the area containing the reported reserves and additional surface exploration targets are present.

INTRODUCTION

Purpose and Location

The purposes of this report are to describe the geology of the Cinola gold deposit and present a genetic model. The Cinola gold deposit, formerly known as the Babe or Specogna deposit, is located at lat 53° 32' N., long 132° 13' W. The deposit is in the south central part of Graham Island in the Queen Charlotte Islands, British Columbia (fig. 1). The deposit occurs near the border between the Skidegate Plateau and the Queen Charlotte Lowlands on a small hill with an elevation of 90-220 m. The area is generally heavily timbered and the climate is mild but wet.

Exploration History

Champigny, Sinclair and Sanders (1980) have prepared an excellent report on the discovery and history of exploration of the deposit. In summary, the property was located by two local prospectors in 1970 and was optioned to a succession of companies through 1977. These early companies did extensive geochemical soil sampling, trench sampling and moderate amounts of drilling. Consolidated Cinola Mines Ltd. optioned the property in 1977 and excercised their option in 1978. In 1979 Energy Reserves Canada, Ltd. (a subsidiary of Energy Reserves Group, Inc.) formed a joint venture with Consolidated Cinola to explore and develop the property. The joint venture, which became active

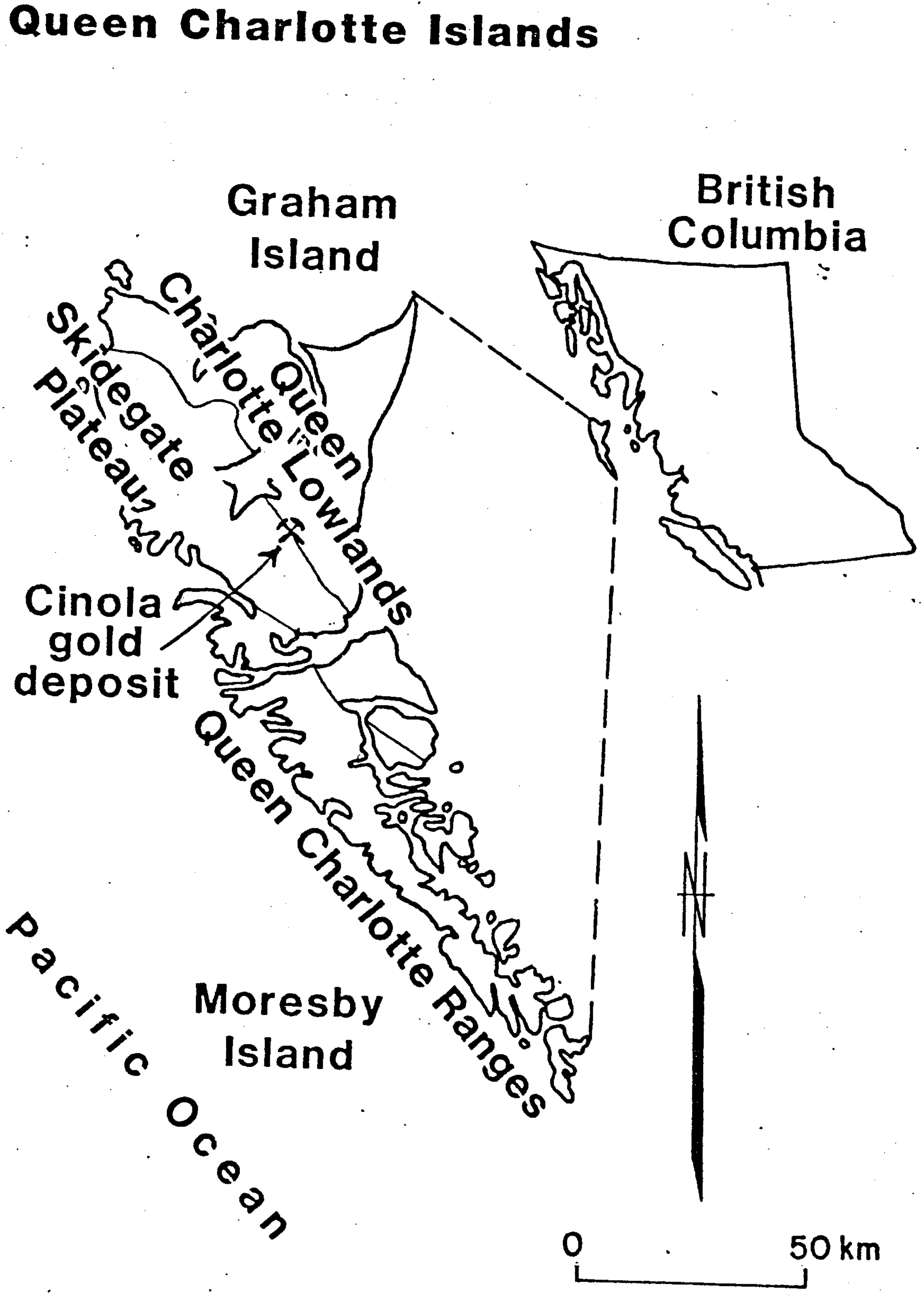

FIGURE 1. LOCATION MAP

in August of 1979, enlarged the higher grade ore reserves that had been discovered by Consolidated Cinola in late 1978 and early 1979. The dramatic increase in the price of gold during late 1979 and early 1980 strongly influenced the development decisions. Consolidated Cinola Mines, Ltd. is the operator for the joint venture.

The geology of the Queen Charlotte Islands is described by Sutherland-Brown (1968). Early reports on the Cinola deposit include Sutherland-Brown and Schroeter (1975 and 1977) and Richards, Christie, and Wolfhard (1976). Champigny and Sinclair (1979) have summarized the geology and exploration results prior to the formation of the joint venture.

The authors represent the principal geologic and administrative staff for the joint venture from August 1979 to the present. This included supervision of diamond core drilling and sample preparation. Over 13,700 meters of core were logged, split, and analyzed for gold. Supplemental work included relogging of old core and surface geologic reconnaissance. Contract and in-house laboratory work were carried out in support of the field operations. Principal laboratory methods included thin section analysis, microprobe scanning, and quantitative analysis.

Regional Geology

The Queen Charlotte Islands lie in the western system of the Canadian Cordillera within the Insular Fold Belt which contains late Paleozoic, Mesozoic, and Tertiary rocks. The Pacific continental shelf is narrow in this area and terminates a few miles west of the Islands. The Cinola property is located immediately west of the boundary between the Skidgate Plateau and the Queen Charlotte Lowlands. This physiographic break coincides with the Sandspit fault system (fig. 2). The Sandspit fault can be traced across Graham Island for more than 60 km and has a displacement of thousands of meters with the down dropped block to the east (Sutherland-Brown, 1968). A fault, believed to be part of the Sandspit fault system, displaces the Cinola orebody (fig. 3).

West of the Sandspit fault in the Skidgate Plateau, west-dipping rhyolite tuffs of the Masset Formation of Early Tertiary age unconformably overlie folded sediments of the Haida Formation of Cretaceous age (Sutherland Brown, 1968). East of the fault is the Queen Charlotte Lowland with limited exposures of unconsolidated clastics of the Mio-Pliocene Skonum Formation, the host for most of the Cinola gold orebody. Pleistocene glaciation has caused extensive modification of the plateau and thin till deposits mantle much of the lowlands and plateau.

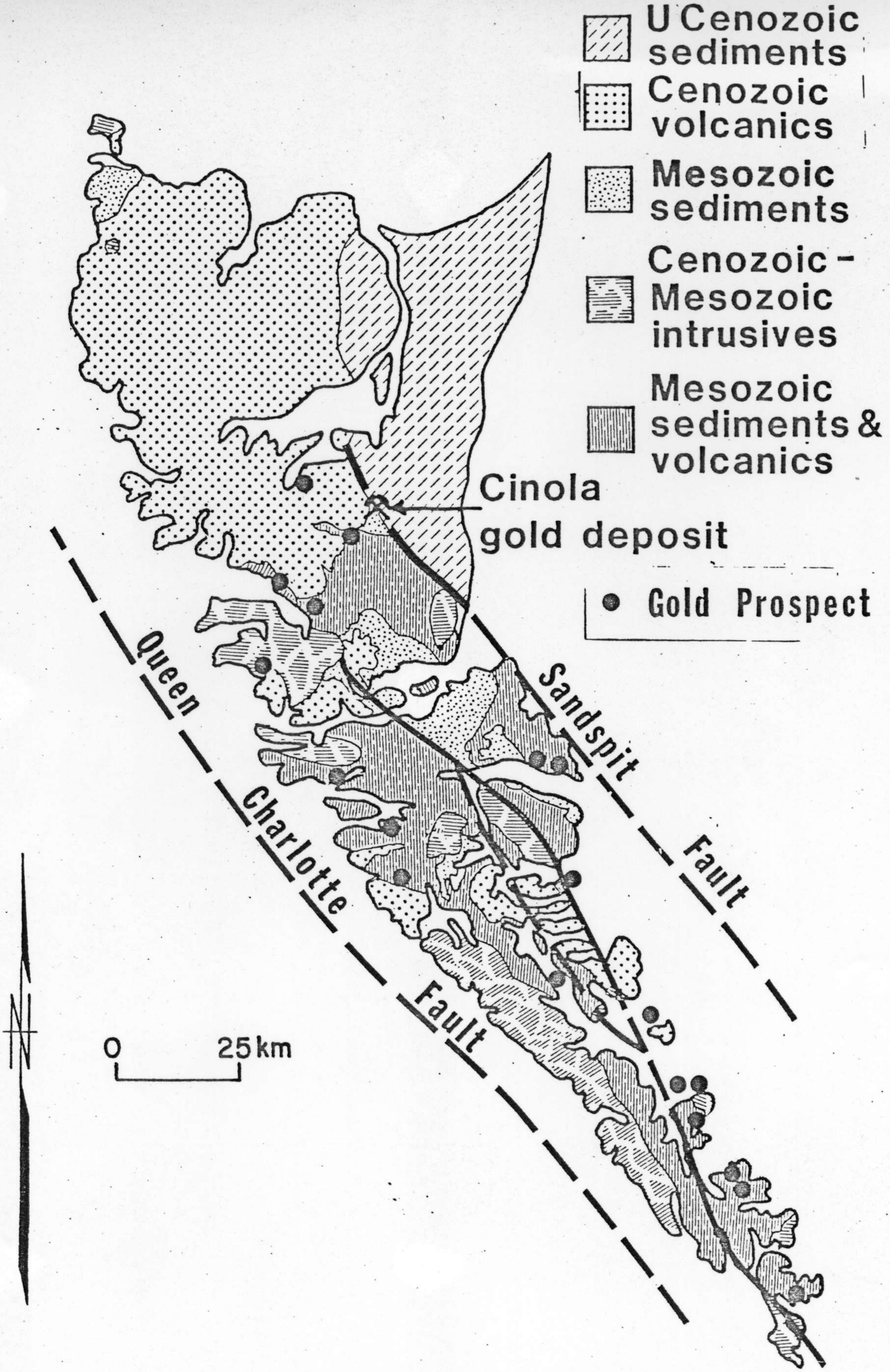

FIGURE 2. REGIONAL GEOLOGIC MAP

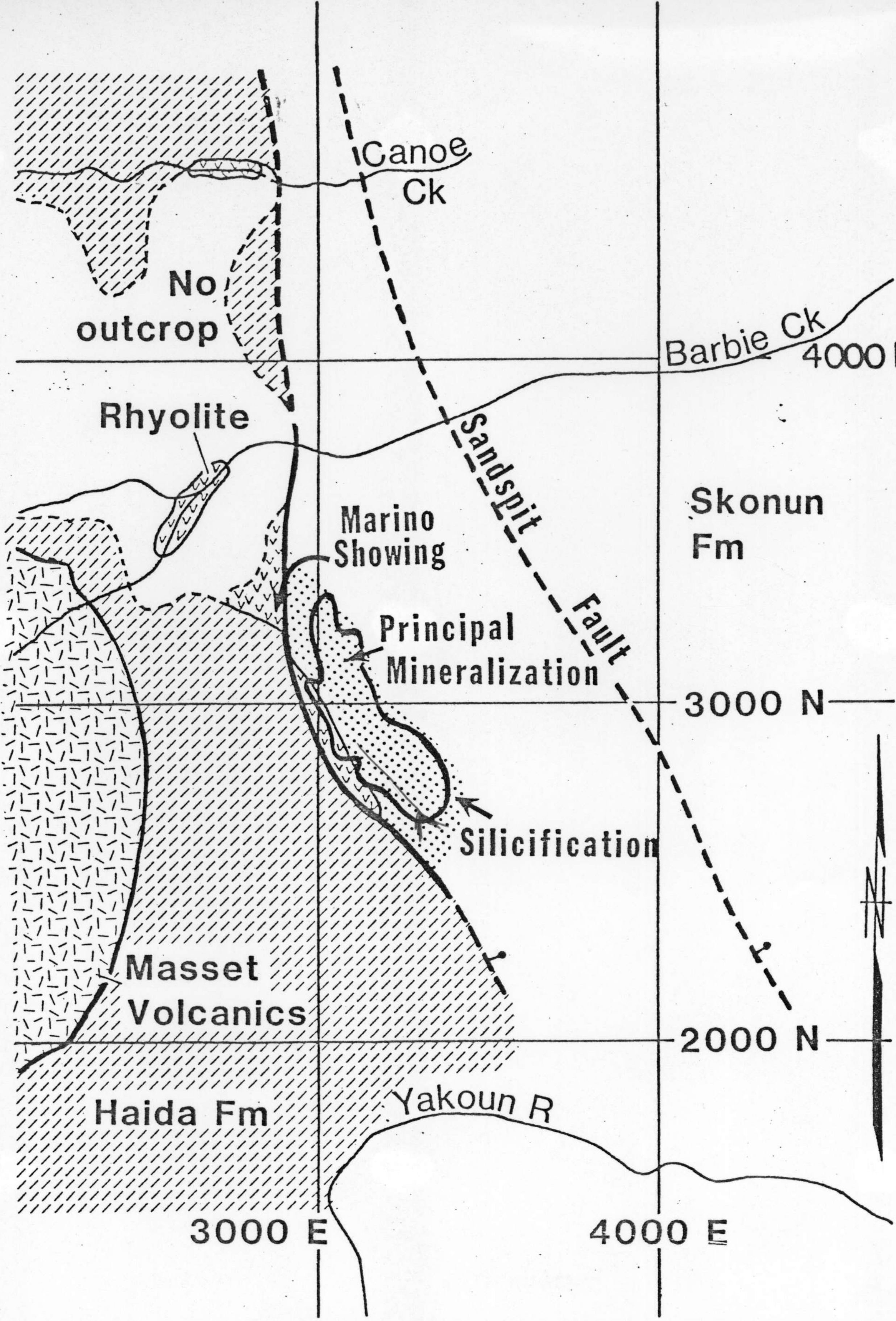

FIGURE 3. GEOLOGIC MAP OF THE CINOLA DEPOSIT
(grid in meters)

There are numerous other gold occurrences on the Queen Charlotte Islands. A belt of gold mineralization at least 30 miles wide and 150 miles long contains over 70 gold occurrences. Some of these active gold prospects are shown in figure 2.

STRATIGRAPHY

The rocks in the immediate vicinity of the deposit have been divided into two broad groups: the footwall section and the hanging wall section. This is illustrated by figure 4 and cross-sections A-A' and B-B' (fig. 5 and 6).

Footwall Section

The oldest rock unit found in the immediate vicinity of the deposit is a dark mudstone which is correlated with the upper member of the Cretaceous Haida Formation of the Queen Charlotte Group. The mudstone, which is not mineralized, forms the footwall fault block with the mineralized section. Only the upper 36 m of the mudstone has been penetrated by drilling and much of this section is sheared and fractured by the faulting.

The mudstone is massive with no visible indication of bedding. It is a soft, dark grey to dark brown mudstone that is carbonaceous and commonly calcareous. Irregular veinlets of white calcite less than 1.0 mm wide are common. Pyrite, that is likely syngenetic, occurs as disseminations and nodules in amounts up to 5 percent. For several meters within the fault zone, the mudstone is silicified and brecciated with clear quartz veins. Within this zone, the rock has the appearance of an argillite.

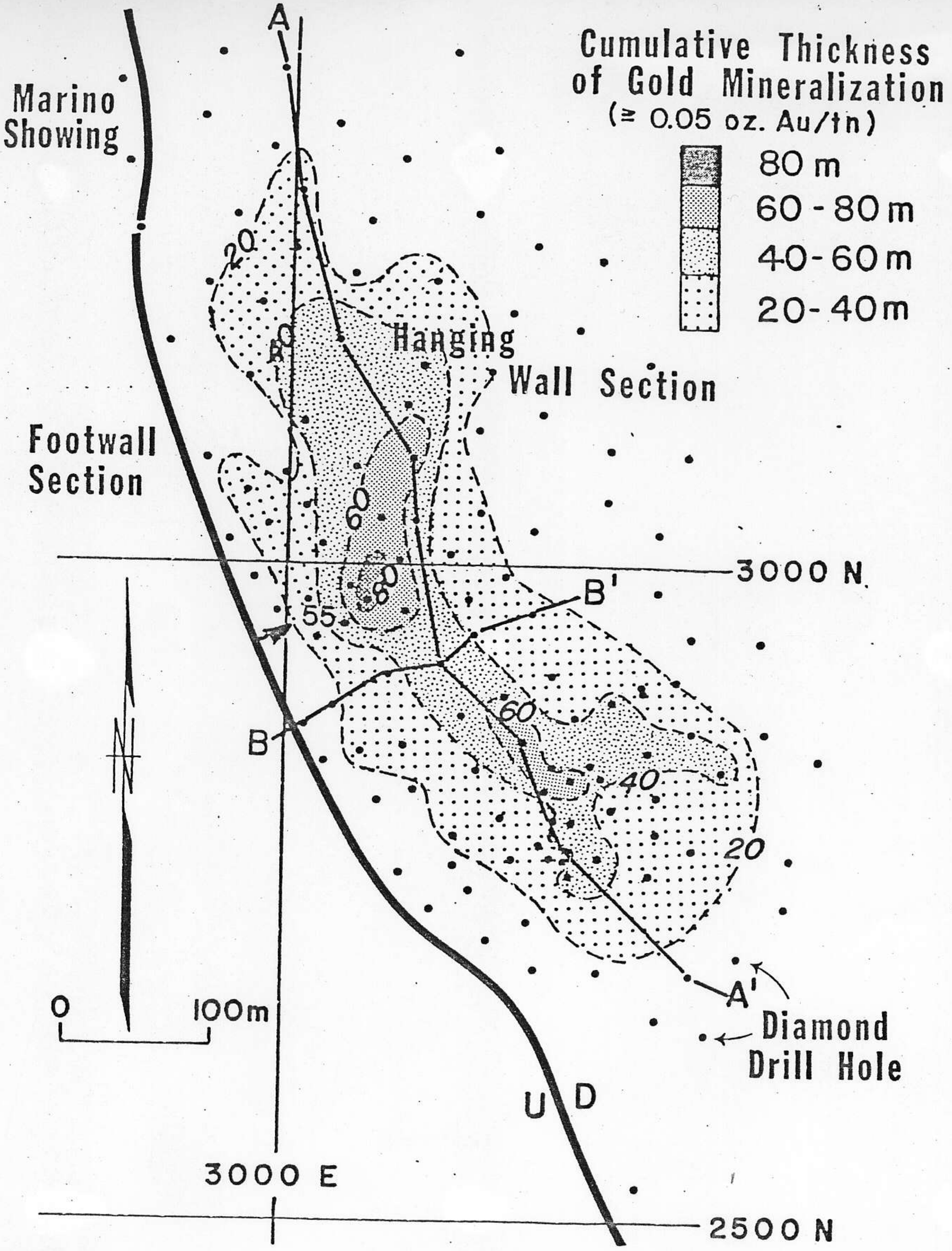

FIGURE 4. Cinola Deposit, showing drill hole locations, cross section lines, & cumulative thickness of gold mineralization.

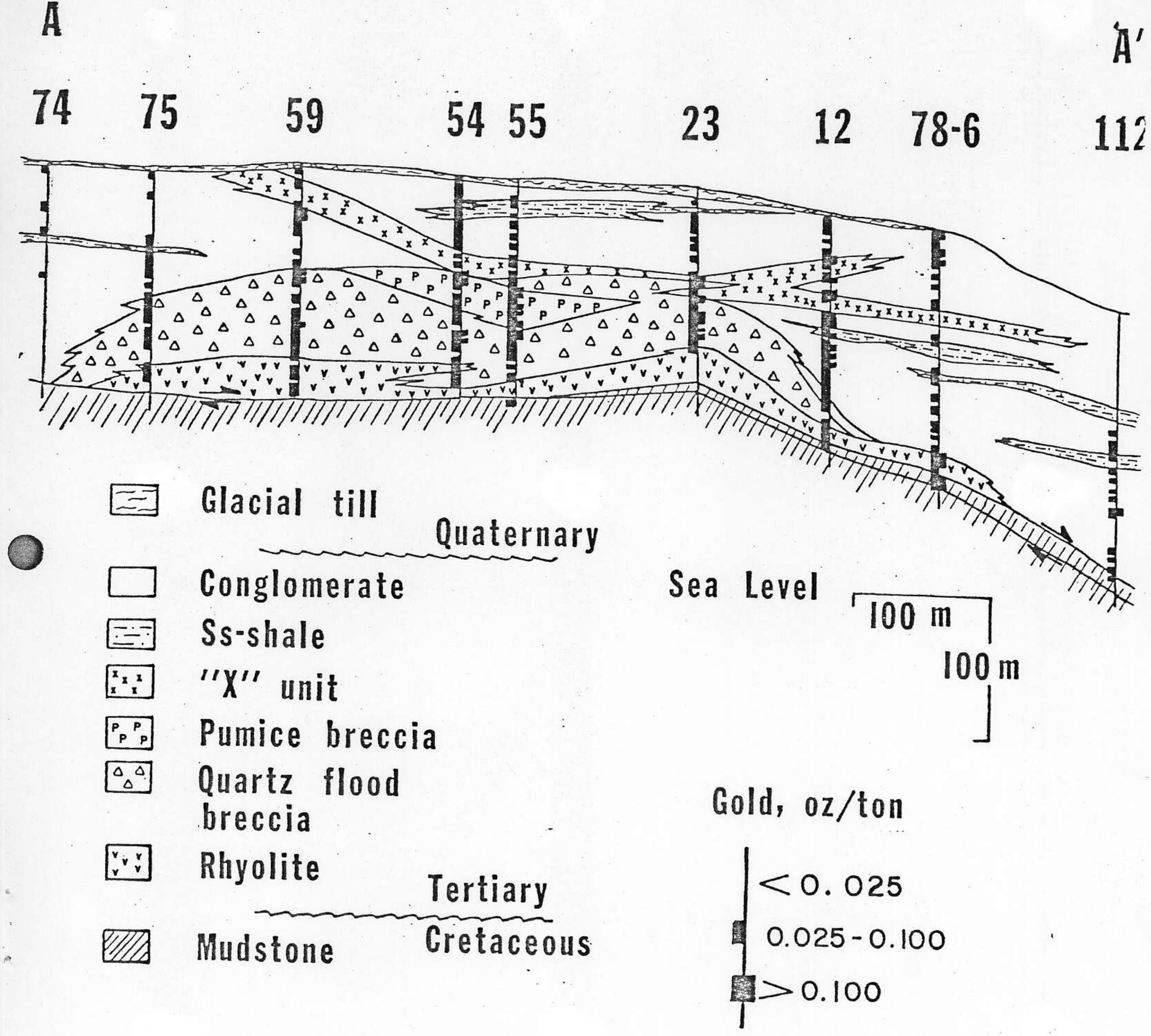

FIGURE 5. Geologic section A-A' with gold assay histograms through diamond drill holes.

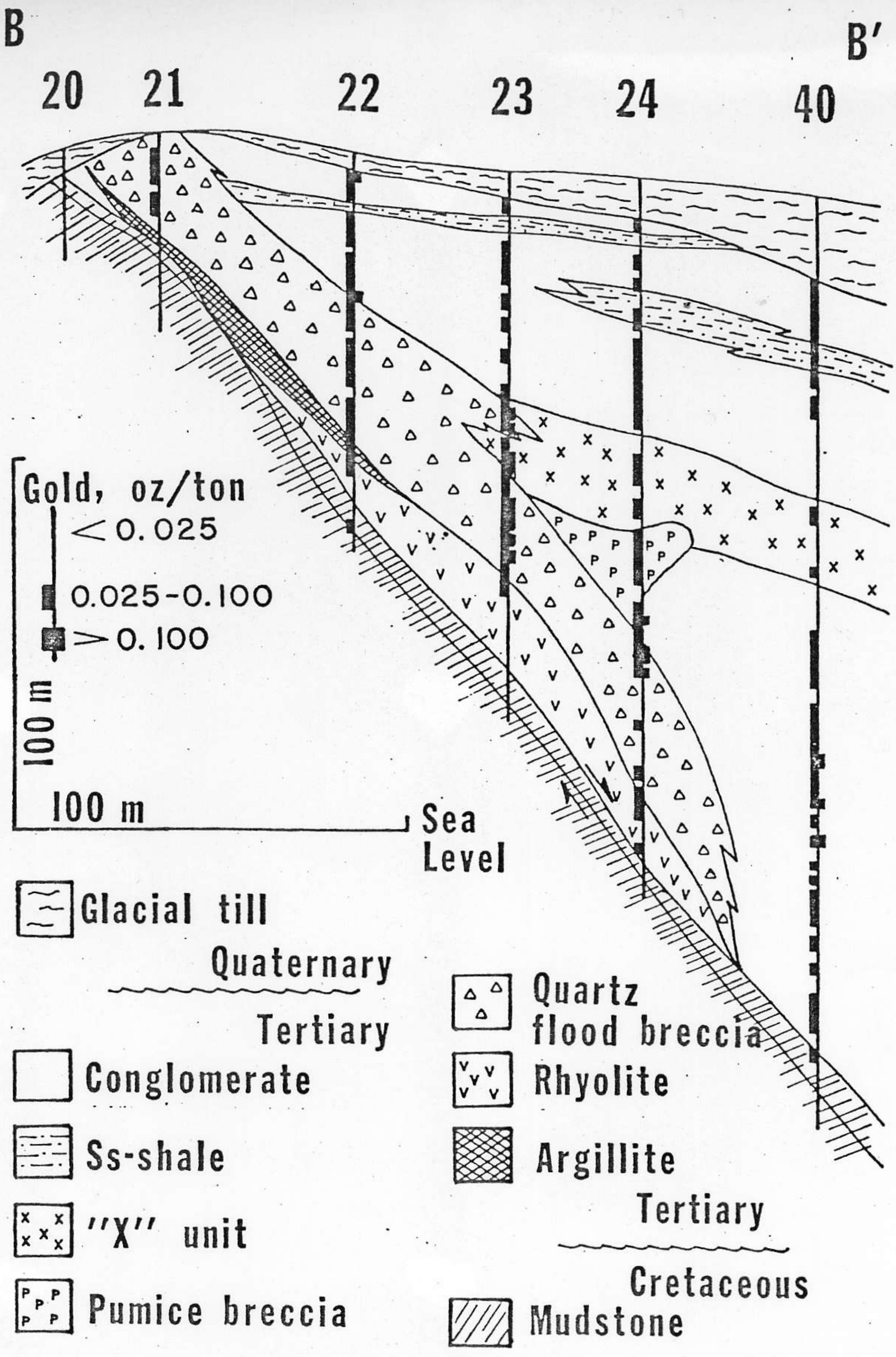

FIGURE 6. Geologic section B-B′ with gold assay histograms through diamond drill holes.

According to Sutherland-Brown (1969) the Haida Formation was deposited in a Lower to Upper Cretaceous marine basin. The mudstone member of the Haida Formation is at least 300 m thick.

Rhyolite porphry is found in the footwall block intruding the Haida shale at the Marino showing and in Barbie Creek northwest of the deposit (fig. 3). Identical rhyolite porphyry is found in the hanging wall block and is described in the section dealing with the hanging wall section.

Hanging Wall Sedimentary Section

The mineralized section on the hanging wall of the fault is a complex interfingering of coarse conglomerates and minor fine-grained clastics which are intruded by rhyolitic subvolcanic units. An extensive zone of brecciation, quartz veining, silica flooding, and argillic alteration obscures precise stratigraphic correlation of some of the units on the hanging wall.

The sedimentary section above the fault has been correlated with the Mio-Pliocene Skonun Formation based on lithology. Sutherland-Brown (1968) describes the Skonun as marine to nonmarine, poorly consolidated siltstones, sandstones and conglomerates that total over 1800 m in thickness. The section penetrated by drilling is over 400 m vertical thickness and consists of approximately 20 percent mature fine clastics and

80 percent immature coarse clastics that generally dip gently to the northeast. The hanging wall sedimentary section can be divided into two broad units: a massive lower conglomerate and an upper conglomerate with interbedded sands and silts.

Coarse clastic sediments predeminate in the lower parts of the deeper drill holes on the east side of the property. These sediments consist dominantly of tan, pebble to cobble size, rounded to subrounded fragments of aphanitic felsic volcanic rocks; but, boulder size clasts are not uncommon. A small percentage of the clasts are basic volcanic rocks, phaneritic plutonic rocks, and sedimentary rocks. The fragments are generally clast supported. Carbonized wood fragments and pyrite each make up less than 3 percent of the rock. No well developed bedding is present, but crude graded bedding is discernible in massive cobble-boulder conglomerate units greater than 60 m thick.

The upper portion of the sedimentary section consists of coarse clastics with interbeds of fine clastics. The dominant rock type is a tan to grey volcanic conglomerate composed of a sandy matrix with mostly felsic aphanitic volcanic fragments that are either clast or matrix supported. The clasts, which vary in size from 1-10 cm, make up 30-70 percent of the rock. The clasts are generally subrounded and often show a weathered or altered rind. Carbon fragments and pyrite are common constituents of this conglomerate. The conglomerates within the upper sedimentary section are up to 30 m thick but generally consist of fining upward sequences from conglomerates through sandstone to siltstone in thicknesses of 1-3 m.

Units that are interfingered with the upper conglomerate sequence and that are used for stratigraphic correlation between holes include a green pebble or mafic rich conglomerate, siltstones and sandstones, a crowded-pebble conglomerate and distinctive lithology termed the X-unit. The origin of the X-unit is uncertain; it may be a mud or debris flow or an intrusive pebble dike complex.

The green mafic conglomerate consists of a predominance of mafic volcanic pebbles. Most of the clasts have a distinct chlorite-epidote alteration. The subrounded clasts are 2-5 cm in size and generally show clast support. Carbon fragments and disseminated pyrite occur as common accessories. This mafic rich conglomerate is generally less than 5 meters thick and has a lenticular shape suggestive of a channel deposit.

Mature siltstones and sandstones that are used for correlations are grey to dark grey. (Tan siltstones and sandstones commonly cap the upward fining conglomerate sequences but these tan, fine clastics are generally not laterally continuous.) The grey siltstone and sandstone units are generally less than 10 m thick. These units are thin-bedded, well-sorted and organic-rich sediments. Ripple laminations are common in the sandstones. The sandstones are very fine to fine-grained with well-rounded grains. Pyrite is present in amounts up to 3 percent. Pelecypod shell fragments are found in a grey sandstone interbedded with a pebble conglomerate at the surface on the north end of the deposit. Minor glauconite is present in sandstone in a drill hole 200 m east of the mineralized zone. Both of these constituents are suggestive of a marine to nearshore environment for most of the sedimentary section. Deposition must have taken place during rapid sedimentation with periods of relative quiescence.

The crowded-pebble conglomerate and the X-unit are two closely related lithologies and have been combined on the cross-sections. Both are local units found above the rhyolite intrusive. The crowded-pebble conglomerate consists of 80-90 percent pea-sized clasts with very little matrix. The clasts are subrounded and are mostly aphanitic volcanic fragments. Carbon fragments and pyrite are again common constituents. The crowded-pebble unit commonly overlies the X-unit.

The X-unit has the lithology of a conglomeratic siltstone with a distinctive bimodal assemblage of constituents. It is a poorly sorted grey to greyish brown siltstone with pebbles of subrounded lithic clasts and angular carbon fragments evenly distributed in the siltstone matrix. The clasts, which are mostly volcanic, make up 10-20 percent of the rock and are completely matrix supported. Clay galls with a diameter of less than 1.0 cm make up a minor percentage of the clasts. Pyrite content is variable and can be up to 5 percent.

Hanging Wall Intrusive Section

A rhyolitic subvolcanic unit is found in both the foot wall and the hanging wall sections. The rhyolite phases are best developed on the hanging wall but rhyolite porphyry occurs on both sides of the fault. The rhyolite porphyry contains 5-15 percent phenocrysts set in a light grey aphanitic groundmass. The phenocrysts are typically 1-2 mm in diameter and consist of equal amounts of anhedral quartz and altered, subhedral potassium feldspar. Disseminated pyrite makes up less than one percent of the rock.

In addition to the rhyolite porphyry, several other distinctive rhyolitic phases are present in the mineralized zone above the fault. One of these phases is a rhyolite porphyry that has been brecciated and veined with medium grey quartz veinlets. Several stages of quartz veining are evident. The quartz veinlets are commonly 2 cm in width and often have vugs which are partially filled with clear terminated quartz. Also present is a rhyolite phase that has a crackle breccia appearance. This unit, called a rhyolite stockwork, is a rhyolite porphyry that has been shattered and cross-cut by numerous veinlets of quartz with pyrite and hematite. The aphanitic groundmass is generally tan to light grey but also has a greenish cast from the presence of finely distributed chlorite. An isopach map of the combined thickness of the rhyolite units above the fault is shown in figure 7.

Closely related to the rhyolite phases and occurring immediately above them are two other breccia units. The pumice breccia is a cream to pinkish tan rock which consists of finely, vesicular siliceous fragments, that resemble pumice in texture. Quartz veinlets are common and up to 5 percent disseminated pyrite is present. The pumice breccia may represent a frothy, volatile rich rhyolite phase or a siliceous sinter deposit above the rhyolite body (fig. 7). Occurring with the pumice breccia and generally forming the contact zone between the rhyolite phases and the sediments is a unit termed the quartz flood breccia. The quartz flood breccia consists of brecciated and silicified sediments, with minor pyrite, that have had much of their original texture destroyed. The quartz flood breccia is believed to represent the contact zone between the rhyolite intrusion and the sediments. Thin pebble or breccia dikes (less than 1.0 m thick) have been observed in this unit and also may be present in the normal sedimentary section where they are more difficult to recognize. A complex swarm of these dikes may overlie the pumice breccia and the thickest portion of the rhyolite.

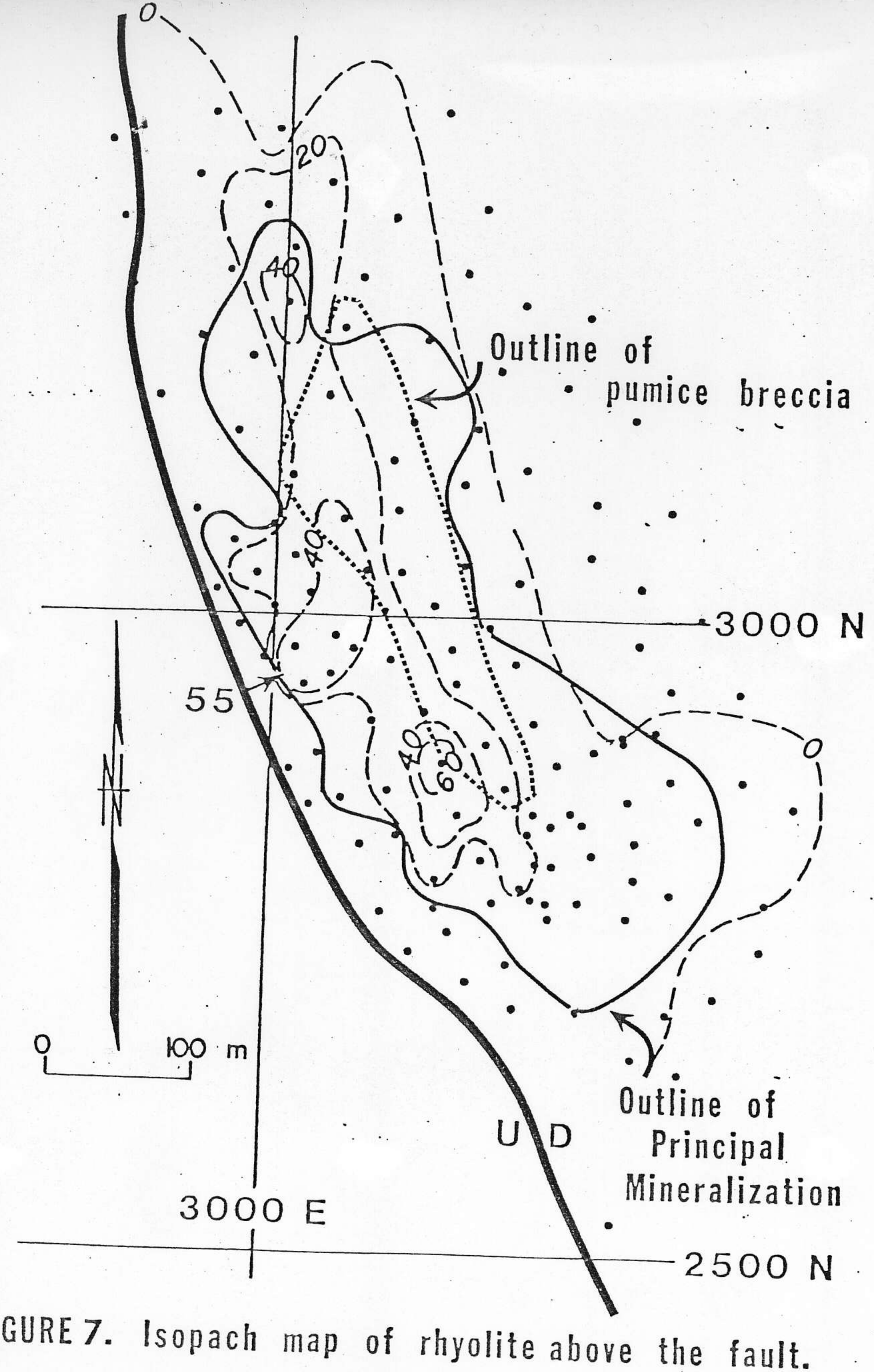

FIGURE 7. Isopach map of rhyolite above the fault.

STRUCTURE

Bedding

The lenticular shape of many of the stratigraphic units make structural interpretation difficult. Since no key marker beds have been recognized, the fine-grained clastic units are used to determine bedding attitude. The beds making up the mineralized section strike N5-10W and dip 20° to the northeast. No folding within the mineralized section has yet been recognized. The attitude of the mudstone in the footwall has not been determined.

Faulting

The major structural feature of the property is the fault that separates the silicified, gold bearing rocks from the mudstone. The fault zone consists of a 1-20 m zone of fault gouge separated by sheared and broken rock. The footwall section contains numerous slickenside surfaces on brecciated fragments of mudstone. There are also thin (0.2-3.0 m) fault slivers of non-silicified rhyolite porphyry faulted in with the mudstone.

The fault zone strikes N15-20W and dips 55° to the northeast (fig. 8). The amount of displacement has not been determined from core logging. Slickenslide striations in several holes indicate a major strike slip component. This fault is part of the major Sandspit fault that is traced across much of southeastern Graham Island. Regional studies suggest the system is a normal fault with some horizontal displacement (Sutherland-Brown, 1968).

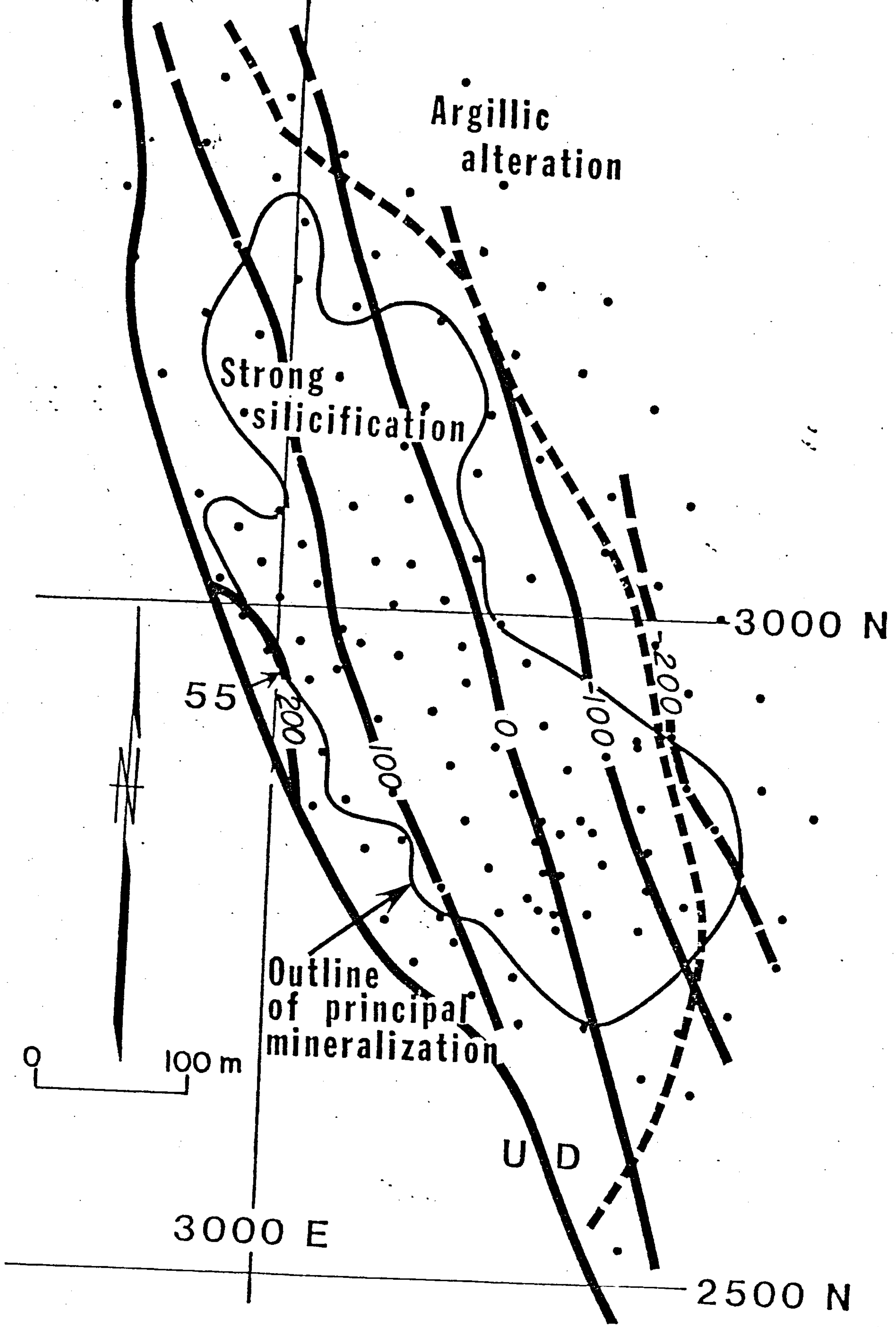

FIGURE 8. Structure contour on the fault plane & surface alteration (values in meters above or below sea level).

The faulting appears to be, in part, post-mineralization. The fault system may have controlled the location of the rhyolite intrusion initially, but more recent faulting has displaced the orebody. Limited amounts of deep drilling to the east side of the property indicate that the rhyolite is thin or not present to the east. Mineralized rhyolite porphyry is found below the fault to the northwest of the principal mineralization at the Marino showing, suggesting that this area may be the root zone of the rhyolite intrusion and the mineralization (fig. 3).

ALTERATION

Silicification

The rocks in the central portion of the Cinola deposit are moderately to strongly silicified. All rock types above the fault, including the rhyolite prophyry, have been subjected to silicification and veining. The strongly silicified sections often have a boxwork type of texture where much of the original rock has been leached away. The silica veining occurs in widths of 1 mm to greater than 2 m. Silica veining is of several generations with the color ranging from dark grey, light grey, white, brown and clear. The paragenetic sequence is complex and has not been clearly established. The veins are generally massive and only the clear or latest shape of quartz has open space filling.

The silicification is strongest above the rhyolite units and the pumice breccia. The quartz flood breccia unit is an extreme alteration phase in which the original rock texture has been obliterated by brecciation, silicification and silica veining. The silicification grows weaker away from the rhyolite units and grades into a halo of advanced argillic alteration as shown in figure 8.

Argillization

The advanced argillic alteration is typically developed in the sediments and equally affects both the fine and the coarse clastics. Within the conglomerates both the matrix and the clast are equally altered. The advanced argillic alteration causes an almost complete change to a light tan clay.

MINERALIZATION

Soil Geochemistry

Figure 9 is a regional geochemical contour map of gold in soils from the Cinola deposit and outlying areas. It is a compilation of three separate surveys with all the samples from the 'B' soil horizon. The outline of the principal gold mineralization indicates a good positive correlation between soil geochemistry and gold mineralization. Other elements analyzed were Hg, As, Ni and Cu. None of these elements exhibits a good positive correlation with the gold mineralization.

Mineralogy

Gold. The mineralogy of the deposit is quite simple with only iron sulfides occuring in any appreciable amount with the gold. The gold assays from the core range from trace amounts to over 4.00 oz per ton averaged over a 2.0 m interval. Much of the gold is evenly distributed throughout the silicified host. Because of this, the gold has no direct relationship to the pyrite-marcasite content or the carbon content. Within the conglomerates, approximately equal amounts of gold are found in both the clasts and the matrix indicating the pervasive nature of the mineralizing process.

Mineralogical studies (Gasparrini, 1979) have shown that much of the gold is too fine to be resolved by the highest microscope magnification of 1250 times (0.5 microns). Most of the free gold observed is found in transecting veinlets of quartz

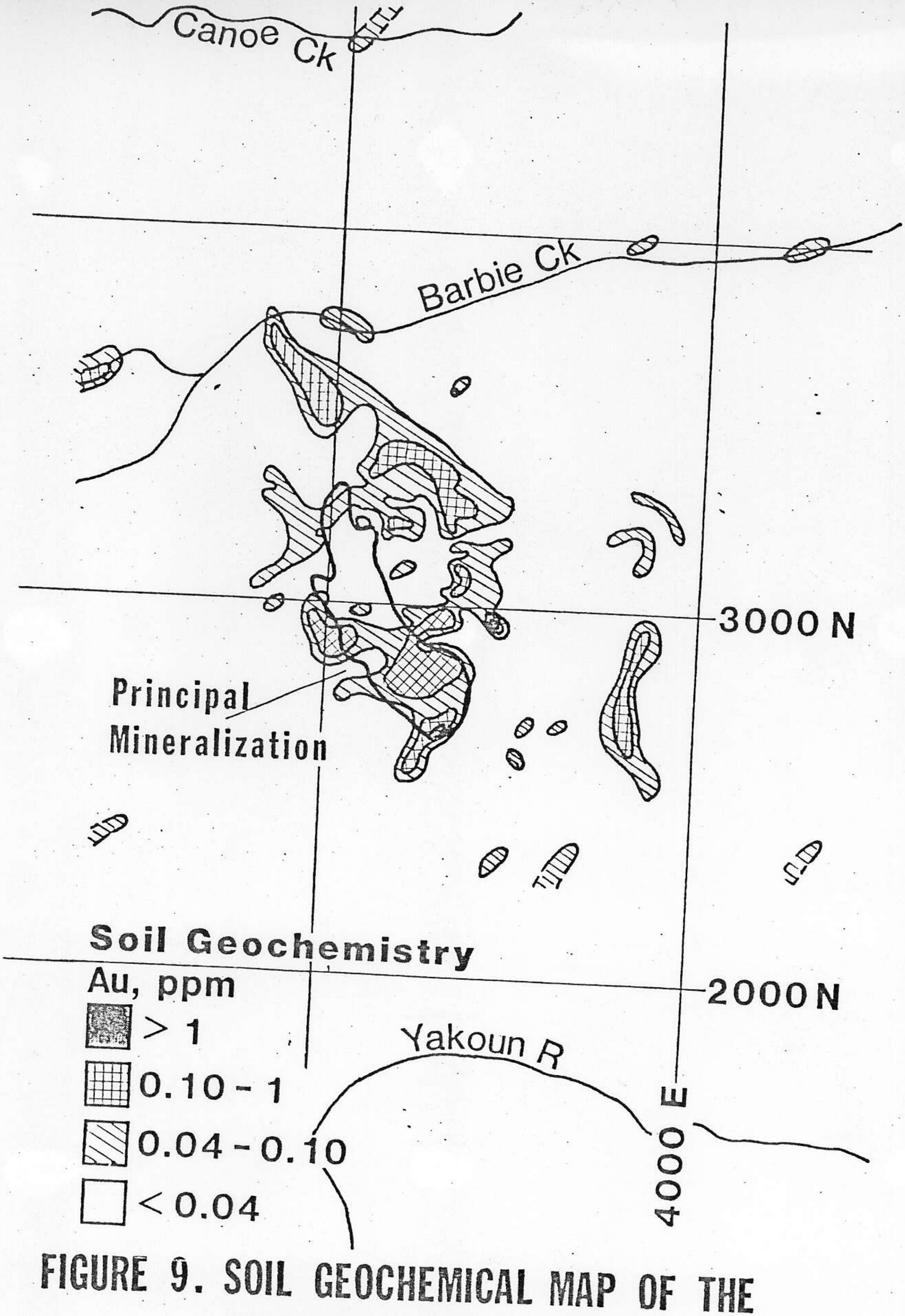

FIGURE 9. SOIL GEOCHEMICAL MAP OF THE CINOLA DEPOSIT (grid in meters).

with the free grains generally being less than 10 microns. This free gold is present in the native form, dominantly in discreet grains not associated with pyrite or other sulfides. The chemical content of the gold particles includes approximately 10 percent silver but no appreciable amounts of other elements (Gasparrini, 1979). The ratios of gold to silver within the host rocks vary widely, but overall is 0.5-0.3. No silver minerals have been recognized.

Sulfides. Iron sulfides are the dominant sulfide in the deposit and occur ubiquitously. Undoubtedly more than one generation of pyrite and marcasite occurs within the mineralized zone. Some of the pyrite in the sedimentary section is syngenetic. However, the marcasite and vein pyrite is related to the mineralizing process. Pyrite-marcasite forms 1-5 percent of the rock volume but locally ranges over 15 percent. The pyrite occurs as crystalline disseminations, replacement of rims and centers of pebble and breccia fragments, and replacement of carbon fragments. Pyrite is also present in thin quartz veins in the rhyolite stockwork. The pyrite form is commonly granular to massive but crystal forms such as cubes and octahedrons are also present. Marcasite, which is mixed in with the pyrite and is hard to distinguish, generally occurs as radiating blades.

Other sulfides that have been reported but occur in only trace amounts are sphalerite, chalcopyrite and pyrrhotite (Gasparrini, 1979).

Other Minerals. Native copper, cinnabar and rutile also occur in minute amounts in the deposit. Mercury concentrations as high as 19,200 ppb have been noted. Other anomalous element concentrations include arsenic and antimony. White calcite veins less than 10 cm wide are present, but rare, within the silicified section. The calcite is apparently late in the mineralization sequence. Hematite is found in the quartz-pyrite veins in the rhyolite stockwork and also disseminated in the groundmass of this particular unit.

Orebody Shape

In plan view, the main mineralized zone covers an oval area of 700 by 200 meters (fig. 4). The contour map of gold mineralization shown in figure 4 does not take into account the depth of the hole. Because holes to the east are considerably deeper than those to the west, our contour map has slightly shifted the mineralized zone to the east. Gold is present from the surface to depths of 300 meters. The fault zone forms a lower boundary to the main zone of gold mineralization. The gold mineralization has a close association with the degree of silicification and proximity to the rhyolite units (fig. 5 and 6). Where the rock is moderately silicified, regardless of lithology, gold values generally exceed 0.025 oz/ton. The argillically altered rocks generally have very low gold values. Individual quartz veins carry gold values in excess of 0.100 oz/ton. The gold mineralization is genrally thicker and of higher grade above areas where the rhyolite units are greater than 20 m thick (fig. 7).

Gold Distribution

In general there are two types of mineralization. A low grade, disseminated type is characterized by sub-microscopic gold and grades of 0.020-0.100 oz/ton. The high grade type occurs in silica veins, has visible gold and has grades in excess of 0.100 oz per ton. In Figure 10, the close association between quartz veining and high grade gold values is apparent in hole 40. Also illustrated is the strong gold mineralization above the rhyolite in the intensely silicified quartz flood and pumice breccia units in hole 55.

Table 1 presents the results of four duplicate assays of core from hole 16. The higher grade intervals are more erratic because of the presence of coarse, visible gold. The low grade assay intervals indicate that the gold is very evenly distributed throughout the rock. Separate assays of both the clasts and the matrix in the mineralized conglomerate give near identical results, indicating that the mineral-bearing fluids were quite penetrative.

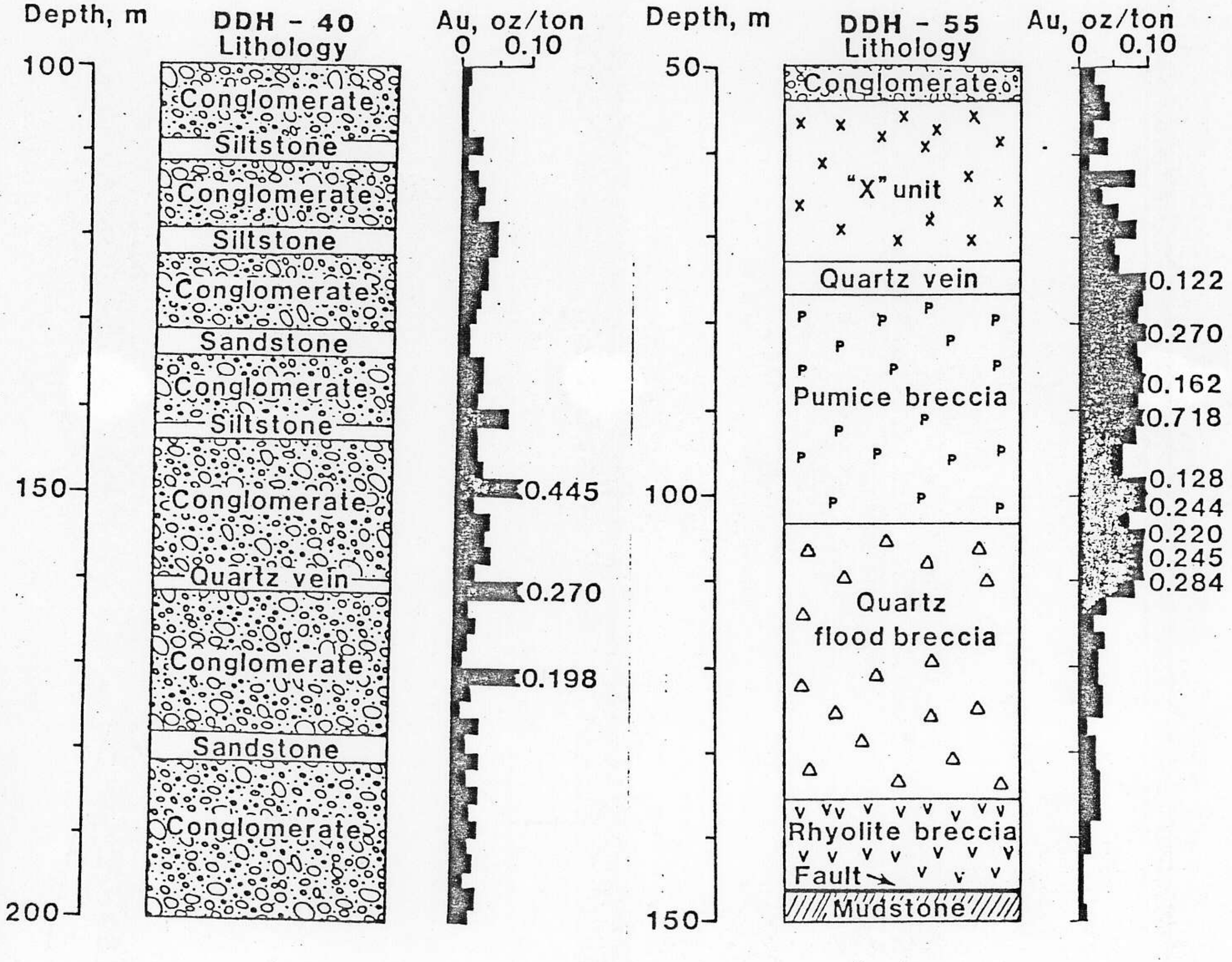

FIGURE 10. Lithologic logs & gold assay histograms of diamond drill holes 40 & 55.

DEPTH, m	BW	S 1	S 2	UN
	Values in oz. Au/tn.			
14 - 16	0.065	0.065	0.070	0.076
16 - 18	0.035	0.025	0.030	0.030
18 - 20	0.088	0.110	0.110	0.056
20 - 22	0.030	0.020	0.020	0.028
22 - 24	0.025	0.020	0.020	0.018
24 - 26	0.025	0.025	0.020	0.036
26 - 28	0.360	0.320	0.310	0.300
28 - 30	0.240	0.150	0.120	0.070

TABLE 1. COMPARATIVE ASSAYS OF DIAMOND DRILL HOLE 16 FROM FOUR DUPLICATE ANALYSES.

GENESIS

The gold mineralization is directly related to the degree of silicification. The silicification appears to be controlled by proximity to the rhyolite. As suggested by Champigny and Sinclair (1979), the intrusion of the prophyry in a near surface environment created a hydrothermal system in which fluids rich in gold migrated through the clastic sequence. Cooling of these hydrothermal fluids resulted in supersaturation and precipitation of quartz and gold with traces of silver, mercury, arsenic and antimony. In summary, the Cinola deposit occurs in a quartz stockwork zone above a rhyolite intrusion.

Subsequent to the intrusion of the rhyolite, faulting displaced the orebody. Outcrops of rhyolite with minor amounts of gold to the northwest suggest that this area may have been the root zone of the rhyolite prophyry of the hanging wall.

Richards, Christie and Wolfhard (1976) suggested that the Cinola deposit be classified as a Carlin type based on metallic mineral assemblage, alteration mineralogy, permeability control of mineralization, occurence of gold and proximity to a major structure. Differences between the Cinola deposit and the Carlin type are regional geologic setting, lithology of the host rocks, the extensive nature of the alteration and the close association of the rhyolite intrusion. Better analogues may be the Pueblo Viejo deposit in the Dominican Republic (Argall, 1975), deposits in the Hauraki goldfields, New Zealand (Williams, 1965), or the Porgera deposit in Papua New Guinea (Cotton, 1975). These deposits may represent a new class of large-tonnage, low-grade gold deposits in which gold is associated with quartz stockworks above near surface felsic intrusives emplaced in a complex tectonic setting.

SUMMARY

The Cinola deposit occurs in a silicified breccia zone immediately above a subvolcanic rhyolite intrusive complex. Argillic alteration forms an outer concentric zone around the silicified core. There are no apparent stratigraphic influences on mineralization but the gold is disseminated in an unusual suite of coarse volcaniclastic sediments. There are two types of gold mineralization. One is low grade, sub-microscopic and disseminated and the other type is structurally controlled and consists of visible, high grade gold mineralization in quartz veins. Much of this high grade mineralization has not been fully evaluated. Current reserves for the Cinola deposit are 45 million tons of 0.054 oz gold per ton.

Acknowledgements

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