



**CINOLA GOLD DEPOSIT,
QUEEN CHARLOTTE ISLANDS
(103F/9E)**

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KEYWORDS: Economic geology, Cinola, gold, silver, epithermal hot springs, quartz veins, hydrothermal breccias, silicification, argillization, Miocene, Haida Formation, Skonun Formation, Masset Formation.

INTRODUCTION

The Cinola epithermal gold deposit (also known as the Babe or Specogna deposit; MINFILE 103F-G034) is located on Graham Island of the Queen Charlotte Islands (Figure 2-9-1). Access is via forestry roads from the towns of Port Clements or Queen Charlotte City.

The deposit was discovered in 1970 by two prospectors, Efreem Specogna and Johnny Trico (Champigny *et al.*, 1980; Hollister, 1985). Subsequently a succession of companies carried out exploration work on the deposit and, by early 1987, 323 drill holes, totalling 39 594 metres, had been drilled and 586 metres of underground workings excavated. The current owner of the property, City Resources (Canada) Limited, has estimated mineable reserves of 23.8 million tonnes at 2.45 grams gold per tonne with a cut-off grade of 1.1 grams gold per tonne (City Resources, 1988a). In June 1988 City Resources applied for government approval to open-pit mine the deposit (submission of Stage II report) and in October 1988 it completed a 49-hole diamond-drilling program for geotechnical investigations and the exploration of peripheral areas.

The British Columbia Ministry of Energy, Mines and Petroleum Resources supported previous research on the Cinola gold deposit by Champigny (Champigny, 1981; Champigny and Sinclair, 1980, 1982). Since then, additional exploration on the prospect has provided new information that is relevant to the genesis of the deposit. A reinvestigation of the deposit was considered timely, particularly with regard to the recently recognized epithermal hot-spring nature of the mineralization (Tolbert *et al.*, 1987) and the current exploration interest in epithermal gold deposits in British Columbia. This project was initiated in 1988 with the award of a British Columbia Ministry of Energy, Mines and Petroleum Resources Geoscience Research Grant, and aims to investigate the deposit genesis from the standpoint of geological, fluid inclusion and stable isotope studies. Some preliminary field observations of the veins and breccias made during the 1988 field season are presented here, together with a summary of existing data. Petrographic and analytical work on samples collected during the season is now in progress.

GEOLOGY

The Cinola deposit is located on the Specogna fault, a splay of the regionally important Sandspit fault (Figure 2-9-1). South of Masset Inlet, the Sandspit fault forms a major physiographic and geological boundary on Graham Island, striking northwesterly and separating the western hilly and mountainous Mesozoic and Tertiary rocks of the Skidegate Plateau from the predominantly flat terrain of the Late Tertiary rocks in the Charlotte Lowlands (Sutherland Brown, 1968). At Cinola the Specogna fault juxtaposes Late Cretaceous shale of the Haida Formation against Late Tertiary coarse clastic sediments of the Skonun Formation. These formations are intruded along the fault by a porphyritic rhyolite dyke tentatively correlated with the Miocene rhyolitic rocks of the Massett Formation west of the deposit (Figure 2-9-1).

Work by Champigny (Champigny, 1981; Champigny and Sinclair, 1982) and City Resources (1988b; unpublished drill-hole logs and sections) provided a detailed account of the lithologies present at the deposit and these are summarized here, together with some observations made during this study.

HAIDA FORMATION SHALE

At Cinola the Haida Formation consists of indurated dark grey to black shale with minor sandstone and siltstone beds. It occurs on the western side of the Specogna fault and extends below the Tertiary volcanics west of the deposit.

SKONUN FORMATION SEDIMENTS

Coarse clastic sediments of the Skonun Formation crop out east of the Specogna fault. City Resources recognized several units within the sequence at the deposit (Figure 2-9-1):

Boulder conglomerate represents the deepest unit encountered. It is a medium grey to pale brown coarse conglomerate with clasts of volcanic rocks up to 0.5 metre in diameter in a consolidated mud and sand matrix.

Pebble conglomerate with intercalated sandstone, siltstone and mudstone beds occurs between: (1) the boulder conglomerate and the lower mud-flow breccia (*see below*), (2) between the lower and upper mud-flow breccias, and (3) above the upper mud-flow breccia. The sediments are pale to dark grey or brown, depending on the type of hydrothermal alteration. The dominant lithology is a clast-supported pebble conglomerate in which clasts average 3 centimetres in diameter. Also present are beds of matrix-supported pebble

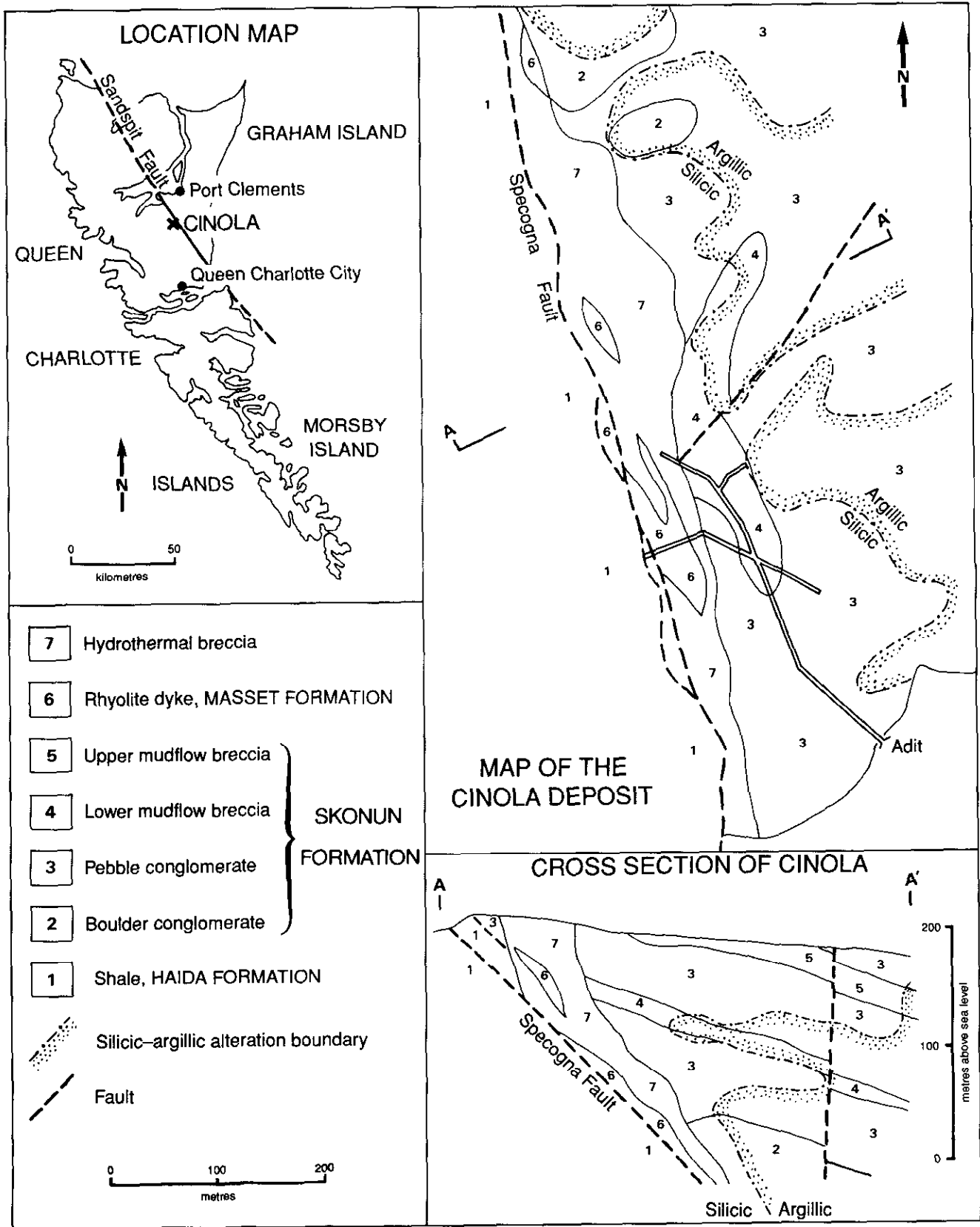


Figure 2-9-1. Location map, and geologic map and cross-section of the Cinola deposit (modified from City Resources (Canada) Ltd., 1988b).

conglomerate, sandstone, siltstone and mudstone. The strata dip 15 to 25 degrees east.

The pebble conglomerates are polymictic. Clasts are predominantly felsic volcanic and plutonic rocks, although clasts of sedimentary (including argillite and shale) and metamorphic rocks are also present.

The sandstone and siltstone units have primary sedimentary structures which include plane and ripple laminations, graded bedding and crossbedding. Penecontemporaneous deformation structures, including convolute bedding and flame structures, are also present. Wood fragments are common (particularly in the finer grained units) and are generally aligned parallel to the stratification. These fragments are generally only a few millimetres long but rare logs range up to a metre or so in length.

The lower mud-flow unit is a sedimentary breccia with rhyolite and sedimentary rock (mainly pebble conglomerate) clasts in a mud matrix. The unit is both distinctive and consistent in appearance. It contains approximately 30 per cent pale-coloured clasts in a brown to reddish brown matrix. The clasts are predominantly 1 to 5 centimetres in size but sedimentary rock clasts up to 2 metres in diameter occur sporadically. Rhyolite clasts often have wispy angular outlines. Some wood fragments are present, including logs. The unit has a restricted distribution and is lobate in plan view (Figure 2-9-1).

The upper mud-flow unit is a grey to brown, sandy, matrix-supported sedimentary breccia containing angular to subangular clasts. The clasts are typically 1 to 5 centimetres in diameter but parts of the unit exposed in the Northwest pit contain coarse clasts ranging up to a metre in diameter. They are predominantly volcanic and sedimentary rocks but some quartz-vein clasts were also noted. The upper part of the unit contains beds of sandstone with abundant shells of bivalve molluscs [*Spisula (Mactromeris)* sp., *Chione (Securella)* sp. and *Macoma* sp; Champigny *et al.*, 1981].

The upper mud-flow unit differs from the lower mud-flow unit in that it has matrix-rich sections with few clasts, beds of apparently conformable stratified fine sediment, concentrations of bivalve mollusc shells, and a much wider distribution.

Champigny and Sinclair (1982) concluded that the Skonun sediments were deposited in a braided river system discharging into a marine basin, whereas City Resources (1988b) preferred an alluvial fan environment adjacent to the Specogna fault scarp. The latter was considered a better explanation of the fining-upward trend of the sediments and the incursion of the mud-flow breccias.

RHYOLITE

A dyke of porphyritic rhyolite intrudes the Haida shale and Skonun sediments along the Specogna fault. The rhyolite is pale grey to bluish grey and has quartz and feldspar phenocrysts up to 5 millimetres in size. Some parts are flow banded. It is tentatively correlated with rhyolitic rocks of the Masset Formation by Champigny and Sinclair (1982).

SPECOGNA FAULT

The Specogna fault strikes between 150 and 180 degrees and dips east at about 50 degrees. The fault zone is up to 70

metres wide and encloses blocks of Haida mudstone and porphyritic rhyolite. The fault is defined in drill core by zones of clay fault gouge and adjacent sheared mudstone and brecciated rhyolite.

HYDROTHERMAL ALTERATION

A zone of moderate to intense hydrothermal alteration has been defined over an area of about 2 square kilometres by geophysical surveys, outcrop mapping and drilling. Peripheral, less intense alteration occurs over a larger area but its distribution is not well known because of sparse outcrop and extensions of the alteration under covering rocks. Silicic and argillic (kaolinite, quartz and pyrite) types of alteration predominate over lesser, restricted occurrences of chloritic and remnant "phyllitic" alteration (illite in the argillic zone; Champigny and Sinclair, 1982). Generally, rocks within the ore zone are extensively silicified and flanked to the east by a peripheral zone of argillic alteration (Figure 2-9-1). Silicification of the Haida Formation rocks quickly dissipates in a westerly direction beyond the Specogna fault. Recent drilling along the eastern border of the deposit (about 600 metres east of the Specogna fault) intersected patches of weak chloritic alteration, a transitional zone of decreasing alteration, and the first appearance in an eastward direction of unconsolidated sediments.

In detail, the distribution of alteration types is complex. The eastern argillic zone interfingers with the silicified zone and pockets of argillic alteration occur within the silicified zone and vice versa. The cross-section (Figure 2-9-1) shows an apparent mushrooming of silicification toward the surface, which is partly blocked beneath the lower mud-flow breccia. The mud-flow breccia may have been an aquiclude during initial silicification but an aquifer during later argillic alteration, as alteration changed the permeability contrast with the underlying sediments.

Some overprinting of earlier stages of alteration has occurred, for example, between silicic and argillic alteration of the conglomerates, as exhibited by the occurrence of silicified clasts in a clayey matrix and vice versa. The presence of cellular, cavernous and spongy rock textures in parts of the silicified zone records an earlier stage of acid leaching. Champigny and Sinclair (1982) noted that illite in the argillic alteration may be a remnant of earlier phyllitic alteration (quartz, illite and pyrite?).

The intensity of alteration is influenced by primary and secondary (structural) permeability. The effects of primary permeability are most marked near the periphery of the main alteration zone, where the conglomerates are hydrothermally altered but adjacent interbedded siltstones and mudstones exhibit little alteration. Within the central part of the deposit, the large number of fractures and veins has allowed the hydrothermal fluids to penetrate and intensely alter all lithologies.

Pyrite and marcasite are ubiquitous constituents of the altered rocks. They occur disseminated or concentrated in clots, bands, cores of clasts, and in veins. Their distribution is variable in the conglomerates. In low and intermediate intensity alteration, the sulphides occur scattered in the matrix and as rims around clasts. With increasing intensity, sulphide concentrations occur in zones and cores within the

clasts. Adjacent clasts may have sulphides concentrated in the core of one clast and as zones in the other. The concentration is probably related to the permeability of the original clast lithology. Much of the silicified conglomerate is strongly pyritized, and pyrite and marcasite are pervasive in the matrix and clasts.

The hydrothermal alteration was dated by Champigny and Sinclair (1982) at 14 Ma, based on two potassium-argon ages for altered rhyolite.

MINERALIZATION

Gold and silver occur disseminated in silicified wallrocks and in quartz veins and hydrothermal breccias. The ore zone is about 800 metres long and parallels the Specogna fault. It is wedge-shaped in cross-section, being approximately 200 metres wide at surface but thinning to a width of about 50 metres at 200 metres below surface (Figure 2-9-1). Ore grading more than 1 gram of gold per tonne is hosted as follows: 55 per cent in Skonun sediments, 30 per cent in hydrothermal breccia, 13 per cent in rhyolite and 2 per cent in Haida mudstone (City Resources, 1988b).

DISSEMINATED MINERALIZATION

Most of the silicified rocks within the deposit contain gold and silver, however, without associated quartz veining or brecciation precious metals are generally present in low concentrations.

VEINS

The veins and their crosscutting relationships are best exposed in the underground workings. The descriptions given here are based mainly on observations made underground. A wide variety of vein types and stages are present but most can be assigned to one of the five groups listed below. A notable feature of the larger veins is the repetitive invasion of pre-existing veins by later veins.

Dark grey chalcedonic silica veins and stockworks are a characteristic feature of the deposit. They are common in the rhyolite and hydrothermal breccia units described below but decrease in intensity west and east of these units. The stockworks are usually spatially associated with the large dark grey silica veins and have mutual and crosscutting relationships, indicating that both are the result of multiple injections. The density of stockworking varies between sub-parallel vertical veins and crackle breccias (*see* separate section below). The veins vary from 1 or 2 millimetres to a metre wide, stockwork veins being generally less than 1 centimetre thick.

Multibanded (crustified) veins range in thickness from 15 centimetres to 2 metres but are typically 30 to 50 centimetres wide. In the adit, they are widest and most numerous in the Skonun sediments near the contact between the sediments and the hydrothermal breccia unit. The veins decrease in number and width eastward from about 75 metres east of the contact. They are steeply dipping and generally strike at 030 degrees. Other attitudes occur causing some vein crosscutting. Some of the veins also bifurcate and later re-join, enclosing horses of country rock. The veins contain multiple bands of brown and white chalcedonic silica 3 to 15

millimetres thick, thicker bands of silica-cemented bladed quartz (quartz pseudomorphs after calcite), and less commonly bands of vein breccia cemented with chalcedonic silica. The banded veins are invaded by coarse pinkish brown and white quartz veins which generally parallel the banding of the primary veins but exhibit crosscutting relationships with them in some places. The primary bands themselves are asymmetrically banded, indicating that the veins were not filled in a simple manner from the margins inwards. Addition of new bands, singularly, in pairs, or in sets, appears to have occurred in various parts of the vein. Although the veins observed have a similar overall appearance, the sequence of bands within the veins differs from vein to vein.

Coarse pinkish brown and white quartz veins, typically 20 centimetres wide, occur as isolated veins or veins crosscutting and invading the previous vein types. The veins are usually symmetrically banded with individual bands being 15 to 40 millimetres thick. A typical sequence from wallrock to the centre of the vein is: white quartz, pinkish brown quartz, white quartz, and clear dog-tooth quartz with occasional drusy vugs. Variations of this sequence include the addition of one or more white quartz bands, one or two thin, dark grey to black (sulphide-bearing?) bands, brown or dark grey silica margins and/or a late central stage of white flinty chalcedonic silica. These veins have a wide distribution, but are most numerous in the northern part of the main drift where they commonly contain vein breccias.

White to translucent banded and massive quartz veins, typically 3 to 5 centimetres wide, generally occur as isolated veins. Some crosscut the previously described veins.

Calcite veins are typically 10 centimetres wide and contain banded white calcite, which is generally fine grained near the margins and coarsely crystalline near the centre. They are uncommon, but occur in most rock types and are late in the vein sequence.

The central cavities of some banded veins are lined with late, finely banded white and/or grey chalcedony which develops a vertical fluted texture on cavity surfaces. Most cavities are partly filled with a brownish grey clay.

Many of the veins have a late brecciation stage which may disturb individual bands or all of the vein. The breccias are usually cemented by white to translucent quartz, but breccias consisting of dark grey chalcedonic silica cementing white quartz fragments also occur. These breccias are correlated with the coarse pinkish brown and white quartz vein and the white banded to massive quartz vein stages.

Generally, in any individual vein, chalcedonic silica precedes translucent to clear crystalline quartz, and the grey and brown phases of chalcedonic silica are earlier than the white phases. The brown colour was previously attributed to the presence of hematite (Champigny and Sinclair, 1982), however recent examination of similar material at the McLaughlin mine in California indicates it may result from the inclusion of hydrocarbons (N. Lehrman, geologist, McLaughlin mine, personal communication, 1988). Some of the grey chalcedonic veins are granular, resulting in silty to fine pebbly textures, indicating the presence of entrained particles and a breccia style of origin.

HYDROTHERMAL BRECCIAS

Hydrothermal breccias are important features with respect to the genesis and economics of the Cinola deposit. Their occurrence was noted by Cruson *et al.* (1983) and later, City Resources mapped and logged the breccias as distinct lithological units. They recognized three groups of breccias; brecciated Haida shale, brecciated rhyolite and a heteromictic breccia.

Brecciated Haida shale occurs near the Specogna fault zone. The shale has been silicified and subsequently brecciated and cemented by white quartz.

Brecciated rhyolite occurs on the margins of the rhyolite intrusion and as large blocks within the hydrothermal breccia unit described below. The degree of brecciation ranges from crackle and mosaic breccias, to matrix-supported rubble breccias with floating rhyolite clasts a few centimetres to about 0.5 metre in size. The breccias are cemented by dark grey silica and, in some places, further brecciated and cemented by white quartz.

Heteromictic breccia was mapped by City Resources as a tabular body 800 metres long, oriented parallel to the Specogna fault and dipping steeply westward. Near surface it is up to 100 metres wide but narrows to a width of 10 metres at a depth of about 200 metres. The breccia unit contains gold grades consistently greater than 1.7 grams per tonne.

Observations made during this study indicate that the breccia body, as mapped by City Resources, includes several different generations of breccia intermixed with large sections of undisturbed rhyolite and sediments. Two types of early breccia are recognized:

- (1) Fine-grained breccia with pale grey to white fragments in a pale grey to pale blue flow-textured silica matrix. The fragments are mostly angular to subrounded rhyolite, typically 2 to 15 millimetres in diameter and matrix supported. The flow texture is similar in appearance to that seen in flow-banded rhyolite.
- (2) Coarse to finely comminuted heteromictic hydrothermal breccia, cemented by white, brownish or dark grey chalcedonic silica. Fragments of chalcedonic silica (white, grey and black), rhyolite and sediment are present. The fragments are angular to subrounded, mostly between 2 and 30 millimetres in diameter, and predominantly matrix supported. The matrix commonly has a flow-like texture. Parts of the unit exhibit a transition from a silica-flooded matrix-supported conglomerate to a fluidized conglomerate, whereas most of the unit has more angular clasts, many being fragments of rhyolite and chalcedonic silica and quartz veins.

Parts of these early breccias are rebrecciated (one or more times), transported and mixed with wallrock and vein clasts, and then cemented by grey or white chalcedonic silica. The breccias are later invaded by veins and stockworks of grey and/or white chalcedonic silica and white quartz (*see* vein section above). This results in parts of the breccia body having very complex textures. Fragments of breccia within breccia (representing two generations of brecciation) occur frequently but fragments of breccia within fragments of breccia (representing three generations) are rare.

PARAGENESIS OF THE VEINS AND BRECCIAS

Crosscutting relationships suggest the following sequence of veins and breccias:

- (1) Flow-textured hydrothermal breccia in rhyolite.
- (2) Crackle and mosaic brecciation of rhyolite and heteromictic hydrothermal breccia (several phases).
- (3) Grey silica veins and stockworks (several phases continuing intermittently during events listed below).
- (4) Multibanded veins (several phases).
- (5) Pinkish brown and white (clear) quartz veins and vein breccias.
- (6) White (clear) quartz veins and vein breccias.
- (7) Calcite veins.

ORE MINERALOGY

Pyrite and marcasite are the dominant metallic minerals. Rutile, magnetite, hematite and pyrrhotite are less common (Champigny and Sinclair, 1982). Gold occurs as native gold and electrum which are rarely visible. Silver is alloyed with gold. No silver minerals other than gold-silver alloys have been identified in the deposit. Champigny and Sinclair (1982) noted "rare" and "very rare" sphalerite, chalcocopyrite, galena, cinnabar and tiemannite in quartz veins. City Resources identified needles of stibnite in cavities at a depth of 57 metres in diamond-drill hole 80-104.

DISCUSSION

The hydrothermal alteration, veins and breccias are believed to postdate the intrusion of the rhyolite stock. A possible exception is the flow-banded breccia with abundant rhyolite clasts, which may represent a marginal phase of the rhyolite dyke. The localization of the deposit along the Specogna/Sandspit fault system indicates that these structures were fundamental loci for the ascent of deep hydrothermal fluid. The initial high primary permeability of the Skonun sediments allowed the fluid to flow laterally near the surface. This lateral flow caused widespread silicification and prepared the ground for later brittle-fracture episodes. Subsequent events (characteristic of epithermal hot-spring deposits (Berger and Eimon, 1983) consisted of several phases of brecciation and vein formation associated with cycles of pressure build-up, then failure and pressure release, superimposed on the pattern of local faulting. Evidence for multiple events includes: multiple stages of veining; banding within the veins; breccias within the veins; several episodes of hydrothermal breccias; and crosscutting relationships between the veins and hydrothermal breccias. The generally fine-grained nature of the heteromictic breccias suggests efficient comminution and vertical movement of the fragments.

By analogy with modern geothermal systems, silicification was the dominant form of alteration caused by the deep hydrothermal fluid, whereas argillic alteration formed in a peripheral zone of mixing between groundwater and recirculating steam-heated, near-surface waters. Acid leaching textures within the silicified zone and overprinting relationships between argillic, phyllic (Champigny and Sinclair, 1982) and silicic alteration, indicate that the boundary be-

tween the different hydrothermal fluid types was complex and moved in response to changing hydrologic conditions. Local changes in primary (rock) permeability and secondary permeability (fracture and fault fissures), as well as widespread changes in fluid type (gas content and pH) would have occurred during the evolution of the hydrothermal system.

Hydrothermal activity was partly contemporaneous with sedimentation. This is indicated by the presence of fragments of quartz-vein material and hydrothermally altered conglomerates in the silicified upper mud-flow breccia. The type of quartz in the vein fragments correlates with the later stages of veining exposed in the adit. The silicification, brecciation and veining in the upper mud-flow unit and overlying conglomerate may correlate with the late white (clear) quartz veins in the adit.

ACKNOWLEDGMENTS

This research was carried out while on sabbatical from the New Zealand Geological Survey, hosted by the Geological Survey of Canada and in affiliation with the Department of Geological Sciences, The University of British Columbia. These organizations are thanked for their support. Dr. K.M. Dawson of the Geological Survey of Canada suggested the topic and together with Dr. A. Panteleyev of the British Columbia Ministry of Energy, Mines and Petroleum Resources, assisted with grant applications. Fieldwork was funded by a British Columbia Ministry of Energy, Mines and Petroleum Resources Geoscience Research Grant and support from City Resources (Canada) Limited.

Confidential proprietary data, generated by many geologists, particularly R.S. Tolbert, N.V. Froc, C. Baldys and T.A. Watkins, was supplied by City Resources (Canada) Limited. Many City Resources staff and contractors provided assistance during the study, and special thanks are due to Mr. N.V. Froc and Mr. P.H. Cowdery (Project Manager).

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