GEOLOGY OF THE SENECA PROPERTY SOUTHWESTERN BRITISH COLUMBIA (92H/5W)

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INTRODUCTION

The Seneca property in southwestern British Columbia is located approximately 120 kilometres east of Vancouver (Figure 1). The property is accessible from the Lougheed Highway at Harrison Mills by the Morris Valley Road and the Chehalis-Fleetwood logging road.

The property has been described as a zinc-copper-lead-barite volcanogenic massive sulphide environment similar in many aspects to the Kuroko-type deposits (Urabe *et al.*, 1983). Current geological reserves are estimated at 1.5 million tonnes grading 3.57% zinc, 0.60% copper and 0.14% lead. Mineralization occurs as replacement sulphides associated with volcaniclastic sediments and as stockwork-style stringer sulphides hosted in a sequence of felsic to intermediate volcanic rocks of the Harrison Lake Formation.

The objective of this study is to better constrain the spatial, temporal, and geochemical relationships of the various rock units and the accompanying alteration and mineralization. Fieldwork in the 1993 season involved logging of diamond-drill cores as well as some outcrop examination.

EXPLORATION HISTORY

The Seneca Prospect, formerly known as the Lucky Jim property, was discovered in 1951 as an indirect result of logging operations and was optioned by Noranda Exploration Company at that time (Thompson, 1972). The sulphide mineralization was believed to be part of a steeply dipping vein or shear system. In 1961 stripping, trenching, and some underground work were carried out, but the results were not encouraging. The property was held by Noland Mines, Ltd. from 1964 to 1965 and was bought by Zenith Mining Corporation, Ltd. in 1969. Cominco Ltd. optioned the property in 1971 and carried out further exploration based on the concept that the zone represented Kuroko-style conformable mineralization. The property was acquired by Chevron Standard Ltd. in 1977 and further diamond drilling was completed over the next ten years in joint ventures with International Curator Resources Ltd. and B.P. Canada Inc. Further logging in the area indirectly led to the discovery in 1986 of the Vent zone stockwork mineralization 1.75 kilometres to the west of the original discovery. In 1991 drilling by Minnova, Inc., 1 kilometre to the west of the Vent zone, led to the discovery of the Fleetwood zone. The property is currently held by International Curator Resources Ltd. and is under option to Metall Mining Corporation.

REGIONAL GEOLOGY

The Harrison Terrane on the west side of Harrison Lake is a sequence of Triassic to Cretaceous volcanic and sedimentary rocks that are adjacent to Upper Jurassic quartz diorite batholiths that lie to the east of the property. The Harrison Formation is a Lower to Middle Jurassic succession that strikes north-northwest, with gentle to moderate easterly dips, and which may be up to 2500 metres thick. Although not fully constrained, the Seneca property is interpreted to lie within the Weaver Lake Member of the Harrison Lake Formation. Regionally, the Weaver Lake Member, which is dominated by intermediate to felsic volcanic rocks and related intrusions, is overlain by the Echo Island Member which comprises mostly volcaniclastic sediments (B. Mahoney; personal communication, 1993). Metamorphic grade is zeolite facies around the property. The regional geology is described in more detail by Monger (1970).

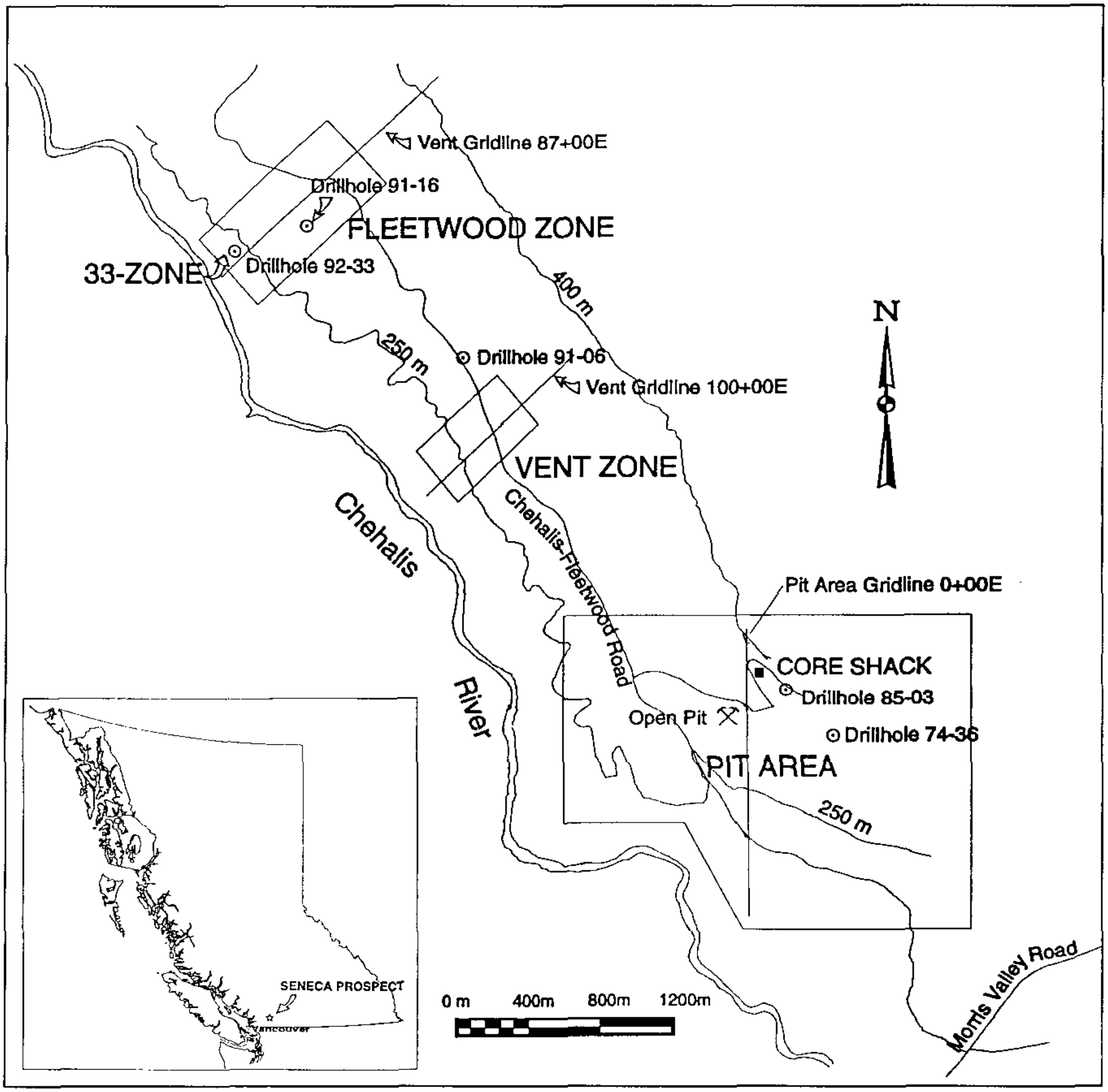

Figure 1. Location of the Seneca prospect showing location of zones of mineralization and selected drill holes.

GEOLOGY OF THE SENECA PROPERTY

The geological setting of the Seneca property will be discussed using the volcanological models and terminology of Easton and Johns (1986) and McPhie and Allen (1992). The rock units at Seneca are subdivided into three principal volcanic facies as follows:

- dacite and andesite lavas and associated autoclastic breccias;
- juvenile to reworked volcaniclastic rocks;
- rhyolitic to andesitic synvolcanic intrusions.

A possible fourth facies consists of an argillite that often contains flattened feldspar-phyric pumice clasts(fiamme). However, it is only observed in drillholes in the vicinity of the Pit Area and is usually a relatively thin layer. The three principal facies are generally observed in all drillholes, but their relative abundances vary greatly from hole to hole. The spatial and textural relationships of the facies in four representative drillholes are schematically depicted in Figure 2. Variations in the characteristics and abundances of each facies provide a means of interpreting the primary volcanic environment.

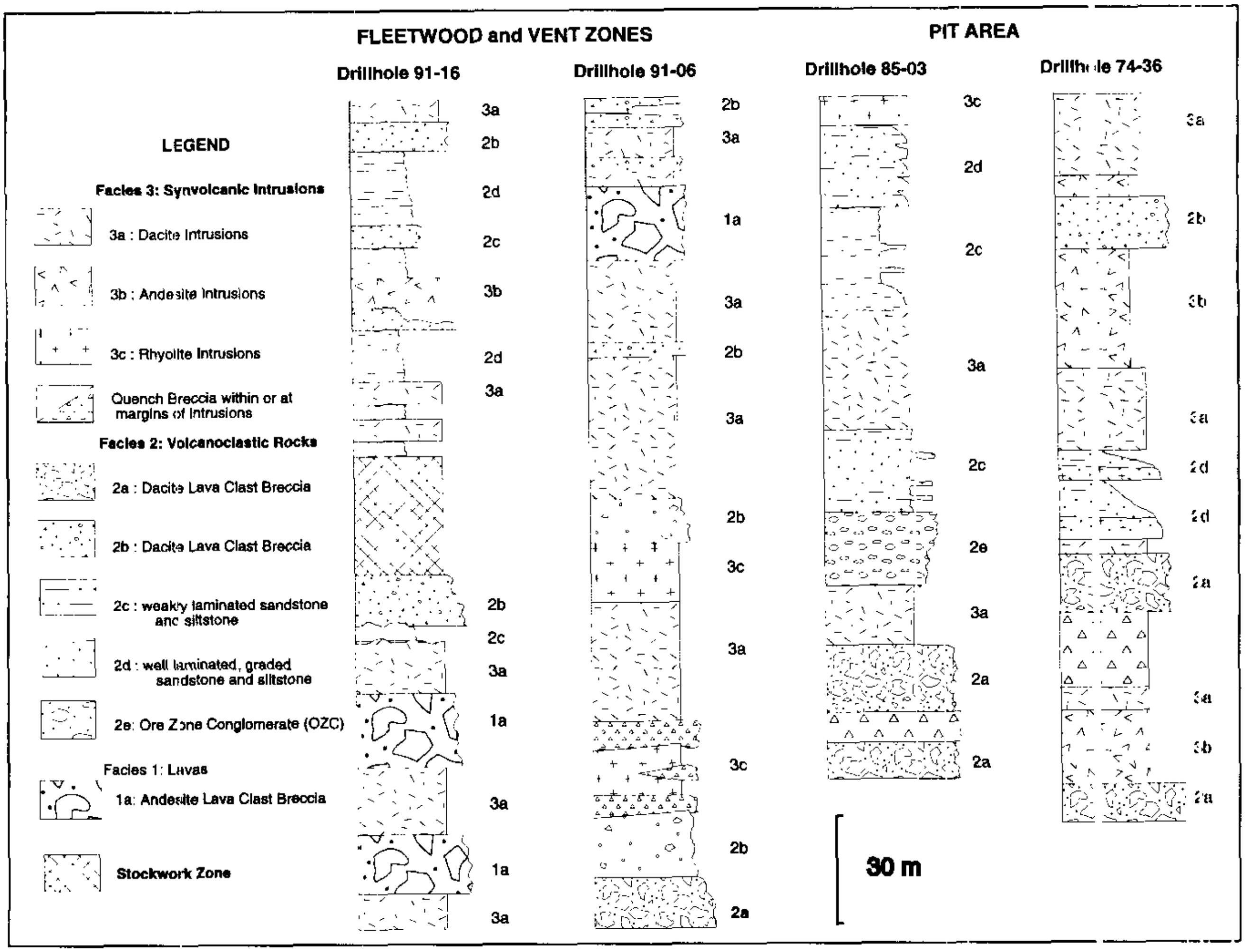

Figure 2. Stratigraphic logs for selected drill holes on the Seneca property.

FACIES 1: LAVAS

Lava flows are defined by the presence of contact relationships, flow textures, and autobrecciation. The dacite lavas contain 5 to 15% subhedral to euhedral plagioclase phenocrysts that are typically 1 to 2 millimetres long. Quartz phenocrysts are much less common, but may comprise up to 5% of the rock. They are usually less than 5 millimetres in diameter and are subrounded. Chloritized hornblende laths are also usually present (up to 5%) and average 1 to 2 millimetres in size. Flow brecciation tends to be restricted to the upper part of flows whereas lower parts tend to be chilled and/or slightly brecciated. The upper brecciated zones range in thickness from 0.5 to 3 metres with subangular to angular lava clasts generally less than 10 centimetres across. The cores of the thicker flows are typically massive and greyish green in colour.

The occurrence of extrusive mafic flows at Seneca has not been confirmed as pillows were not observed and the unbrecciated andesites tend to be featureless. However, a unit that consists of subrounded to amoeboid fragments of vesicular andesite surrounded by angular andesite clasts and hyaloclastite was logged in most holes in the vicinity of the Fleetwood and Vent zones (Unit 1a, Figure 2). These fragments are typically 1 to 10 centimetres in size, are light green or purplish grey in colour and consist of a core of massive andesite and chilled or cracked rims. The textures of the fragments, together with their elongate shape and tail-like ends, suggests that they were ejected as molten material either subaqueously or subaerially, but landed in water while still semi-molten. In either case, this unit must have formed close to a vent as the surrounding angular hyaloclastite does not appear to have been reworked. This facies is termed 'fire fountain debris' and is only seen in lower parts of the drillholes.

FACIES 2: VOLCANICLASTIC SEDIMENTS

There are a variety of volcanically derived sediments and breccias on the Seneca property, which range from mud size to block size (< 10 cm). These units probably represent the reworking of volcanic debris derived from lava flows and eruptions with the probable addition of fine sediments of a more distal origin.

One of the more economically important volcaniclastic units is seen in drillholes in the Pit Area and is referred to as the 'ore zone conglomerate' (OZC ; unit 2e). This unit, which varies from 1 to 15 metres in thickness, hosts some of the strongest mineralization on the property. It consists of moderately silicified, mostly subrounded dacite lava clasts ranging from sand size up to 3 centimetres in diameter in a sandy or silty matrix. The unit can be matrix or clast supported, and also contains clasts and matrix that have been replaced by sulphides.

A dacite lava clast breccia (units 2a and 2b) is present stratigraphically below the ore zone conglomerate in the Pit area and generally above the major andesitic units in the Fleetwood and Vent zones. Typically the unit is clast supported (up to 90% clasts up to 10 centimetres in diameter) and consists dominantly of subangular dense fragments of feldspar-phyric dacite lava, significant amounts of dark green vitric or pumiceous material, andesitic fragments and occasional silty rip-up clasts. The dacite clasts vary in colour from light grey to reddish tan, possibly representing subaerial deposition and later reworking. The unit is moderately to poorly sorted, suggesting deposition by debris flows. The drillholes in the Pit area usually terminate in this unit.

The Fleetwood and Vent zones show an increased abundance of reworked andesitic lava clast breccias consisting of centimetre-size, subangular, amygdaloidal andesite fragments and hyaloclastite, compared to the Pit area. It is not unusual to find up to 30% dacite lava clasts within this unit. The true thickness of the unit is difficult to determine due to synvolcanic intrusions, but individual intersections are in the order of 5 to 10 metres thick. Andesite lava clast breccias are less common at higher levels, and where they do occur, they have smaller clasts that are more rounded.

Fine-grained volcaniclastic sediments are common throughout the area, particularly in the upper part of the stratigraphy intersected by drilling (units 2c and 2d). The sediments form light to dark grey beds of mud to coarse sand-sized material. Individual beds range in thickness from a few centimetres to 5 metres, and vary from massive to well laminated and graded. The bases of normal graded beds are most often in sharp contact with the underlying beds, and are characterized by coarse sand to gravel-sized material, often with a component of dacite pumice fragments. These beds grade upward through massive or weakly laminated sands to well-laminated and occasionally cross bedded fine sand, silt and mud. These beds may represent individual turbidite layers. Graded beds become more common higher in the stratigraphy.

FACIES 3: SYNVOLCANIC INTRUSIONS

Synvolcanic intrusions were distinguished from flows by their contact relationships. Commonly, the contacts, where they are well preserved, are parallel to the local bedding. These units lack flow banding and autobreccia and are interpreted to be sills. Chilled margins and contacts at high angles to stratigraphy provide simple criteria for the recognition of dikes.

The most common intrusions are feldspar-phyric dacite porphyry sills (unit 3a). The sills range in thickness from 1 metre to more than 50 metres, and are columnar jointed in some outcrops. Mineralogically, and often texturally, these rocks are identical to the dacite flows described earlier and are only distinguishable by their contact relationships. Dacite sills commonly cut other intrusions with contacts that are chilled over widths of 10 centimetres to more than 1 metre, and are very slightly brecciated. Where sills intrude the volcaniclastic sediments and breccias, the contacts tend to be quenched and brecciated into angular to cuspate hyaloclastic fragments less than 1 centimetre to 20 centimetres in size that are mixed with a matrix of the sediment. These zones of mixing, which reach thicknesses of several metres, are usually at the top of the sills. The textures suggest that the sills have intruded into wet, unconsolidated sediments as described by McPhie and Allen (1992).

Andesitic intrusions (unit 3b) are less common and are restricted to the lower part of the stratigraphy. Similar to the dacite porphyries, they have both crosscutting and bedding-parallel contacts with chilled margins. The andesites are generally massive and dark green with chlorite-filled amygdules 0.5 to 1 millimetre in diameter. Where they intrude sediments, they exhibit quenching, brecciation, and mixing similar to that described above, except that brecciated zones tend to be more extensive (in the range of several metres). In many of the drillholes in the Pit area, these andesitic sills are intimately associated with the ore zone conglomerate, intruding into it and into units immediately above and below it.

The third type of intrusions are quartz-feldspar-phyric rhyolite porphyry bodies (unit 3c). These are less common than the other two types (at least in the drill-cores studied) and their mode of emplacement is less clear. They occur at higher levels in the stratigraphy and their upper contacts are rarely seen. Their size and massive nature suggest they too may be synvolcanic sills, but they may also represent emergent domes. The rhyolite porphyries are easily distinguishable from the dacite porphyries by their greyish brown groundmass and by the presence of up to 10% subrounded quartz phenocrysts 2 to 5 millimetres in diameter. There are also 5 to 15% plagioclase phenocrysts 1 to 2 millimetres in size, as well as minor hornblende. The rhyolite porphyry bodies range in thickness from a few metres to more than 30 metres. They have not been observed to exhibit the same intrusion-sediment relationships as the dacites and andesites.

MINERALIZED ZONES

Three types of mineralized zones are present at Seneca:

- conformable massive sulphide lenses;
- semi massive and disseminated sulphides associated with volcaniclastics;
- stockwork and stringer mineralized zones.

Conformable, stratabound lenses of semi-massive sphalerite, pyrite, and chalcopyrite with lesser galena are exposed in the pit at the discovery site, and to a lesser degree in drillhole 92-33 which intersects the recently discovered "33-zone" in the Fleetwood area. The sulphides in both locations are hosted by fragmental rocks and occur as discontinuous pods. In the 33-zone, 2 metres of massive sulphides are underlain by a quartz-carbonate-chlorite zone and are sharply overlain by a cherty sulphide layer and a zone of strongly chloritized fragmental material. This zone is not correlatable to any other drillholes. Unlike the 33-zone, the massive sulphides in the pit are underlain by siliceous stringer mineralization. Blades of barite are seen together with the sulphides in both locations. In the 33-zone, the drilholes studied do not intersect mineralization of the type seen in the pit.

Semi massive to disseminated sulphides are associated with the volcaniclastic ore zone conglomerate. It should be noted that the term ore zone conglomerate refers to the entire unit which hosts this particular type of mineralization and that much of the unit does not contain sulphides. The sulphides, where present, tend to be restricted to upper parts of the conglomerate. The best such intersection is 0.5 metres of massive pyrite, sphalerite and barite with lesser chalcopyrite underlain by 3.5 metres of mostly semi massive pyrite in drillhole 85-03. More often the mineralization in the conglomerate consists of clasts and matrix that have been replaced by pyrite, and occasionally sphalerite. Some of the clasts are rimmed by a later pyrite.

Stockwork and stringer quartz-sulphide mineralization can be seen in outcrop and in drillcore from the Vent zone and in drillhole 91-16 from the Fleetwood zone (Figure 2). The Vent zone consists of veinlets up to 1 centimetre wide of sphalerite, pyrite, and quartz ($\pm$ chalcopyrite) in altered dacite. The mineralization below the stockwork consists of occasional sphalerite-pyrite-chalcopyrite veinlets and disseminated sulphides in a moderately altered andesite lava clast breccia. Drillhole 91-16 in the Fleetwood zone intersects 1.1 metres of massive sphalerite, pyrite and chalcopyrite immediately above about 30 metres of stockwork sphalerite-pyrite-chalcopyrite-anhydrite-quartz veinlets in altered dacite similar to the Vent zone. Mineralization at Fleetwood ends fairly abruptly below the altered stockwork.

ALTERATION

Typically most of the rocks at the Seneca property are unaltered with pristine volcanic textures preserved. Significant alteration is restricted to the Vent and Fleetwood zones where it is characterized by intense silicification and sericitization associated with a hydrothermally brecciated dacite porphyry (not necessarily the same porphyry in both areas). The brecciation is restricted to the dacites but alteration extends 10 to 20 metres into the surrounding fragmental rocks, obliterating the original textures. The dacites were identified on the basis of the relict feldspar "ghosts" left by the alteration. Petrography and lithogeochemistry will be used to confirm this and to further examine the alteration.

DISCUSSION

The stratigraphy hosting the Seneca Prospect consists of massive to normal-graded dacitic and andesitic volcaniclastic sediments and lava flows that were intruded before consolidation by massive rhyolitic to andesitic synvolcanic sills and dikes. This succession comprises part of the Lower to Middle Jurassic Weaver Lake Member of the Harrison Lake Formation. The volcaniclastic rocks represent volcanically derived material that has been deposited by mass flows in the case of the coaser grained, poorly sorted units, and by turbidites in the case of the finer grained, graded units. These units become progressively finer grained and better graded upwards in the succession. Typically, andesitic units are restricted to the lower part of the examined stratigraphy. Rhyolite porphyry sills and dikes are generally restricted to the upper part of the stratigraphy. Dacite porphyries intrude at all levels of stratigraphy including the andesitic intrusives lower in the stratigraphy. Mineralization consists of conformable lenses of massive, semi massive and disseminated sulphides in the Pit area and the 33-zone, and stockwork-style sphalerite-pyrite-chalcopyrite-quartz veinlets and stringers in the Vent and Fleetwood zones. Major zones of silicification and sericitization are associated with the stockwork zones. Major and trace element lithogeochemical data and petrographic samples will be examined to determine the relationships between the intrusive units and the volcaniclastic rocks and lavas, and to determine to nature of alteration in the mineralized zones. Additional drill cores will be examined to better constrain the volcanic stratigraphy, lateral facies relationships, and paleotopography, and to delineate potential horizons that would be favourable for the deposition of volcanogenic massive sulphide mineralization.

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