The Wolf Discovery: A Kuroko-style volcanogenic massive sulphide deposit hosted by rift-related, alkaline felsic volcanic rocks

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ABSTRACT

The Wolf property is situated approximately 90 km south of Ross River, Yukon, within the St. Cyr Range of the Pelly Mountains. The Pelly Mountains are bounded to the northeast by the Tintina Fault, the northern extension of the Rocky Mountain Trench.

Mineralization consists of a tabular body of massive sulphide, commonly with subordinate amounts of ferro-dolomite, and more rarely, barite. Sulphide minerals consist of pyrite, sphalerite and galena. Textures vary from very fine-grained massive pyrite with bands of amber sphalerite and steely-gray galena (zebra ore), to medium-grained botryoidal sphalerite and galena within a gangue of buff-coloured Fe-Mg carbonate. Chalcopyrite is conspicuous by its absence. The deposit has been intersected by nine drill holes over a strike length of 500 metres and a down-dip length of 250 metres. Thickness of the sulphide deposit varies from 2, to more than 25 metres. The deposit and host stratigraphy strike northwesterly and dip at 45 degrees to the southwest.

The deposit is hosted by a sequence of high-K trachyte flows, lapilli and crystal tuffs with minor epivolcaniclastic rocks. Sulphide mineralization and/or massive barite occurs in at least three separate stratigraphic levels within a 300- to 1000-metre-thick pile of felsic volcanic rocks.

RÉSUMÉ

Le projet de Wolf est situé à environ 90 km au sud de Ross River, dans le chaînon Saint-Cyr des monts Pelly, au Yukon. Les monts Pelly sont limités au nord-est par la faille de Tintina, extension nord du sillon des Rocheuses.

La minéralisation consiste en un corps tabulaire de sulfures massifs renfermant fréquemment des quantités mineures de ferro-dolomite et, plus rarement, de barytine. Les minéraux sulfurés sont la pyrite, la sphalérite et la galène. La texture varie de celle d'une pyrite massive à grain très fin renfermant des bandes de sphalérite ambrée et de galène gris acier (minerai zébré) à celle d'une sphalérite botryoïde et d'une galène à grain moyen au sein d'une gangue de carbonate à Fe-Mg couleur chamois. La chalcopyrite brille par son absence. Le gisement a été sondé au moyen de neuf trous de forage sur une longueur de 500 m parallèlement à la direction et de 250 m en aval-pendage. L'épaisseur de ce gisement de sulfures varie de 2 à plus de 25 mètres. Le gisement et les roches encaissantes sont de direction nord-ouest et plongent à 45 degrés vers le sud-ouest.

Le gisement est inclus dans une séquence de coulées trachytiques très potassiques, de lapilli et de tufs cristallins, outre des roches épivolcanoclastiques peu abondantes. Des minéralisations sulfurées et/ou de la barytine massive sont présentes dans au moins trois niveaux stratigraphiques distincts, au sein d'un empilement de 300 à 1000 mètres d'épaisseur de roches volcaniques felsiques.

INTRODUCTION

The Wolf property is located approximately 90 km southeast of Ross River, Yukon, within the Watson Lake Mining District. The property includes the summit of Mt. Vermilion and lies within NTS map sheets 105G/ 5 & 6. Geodetic coordinates for the centre of the property are latitude 62° 20'N and longitude 131° 20'W. Access is by helicopter from Ross River or from the Hoole airstrip located on the Hoole River, 22 kilometres north of the property (Fig. 1).

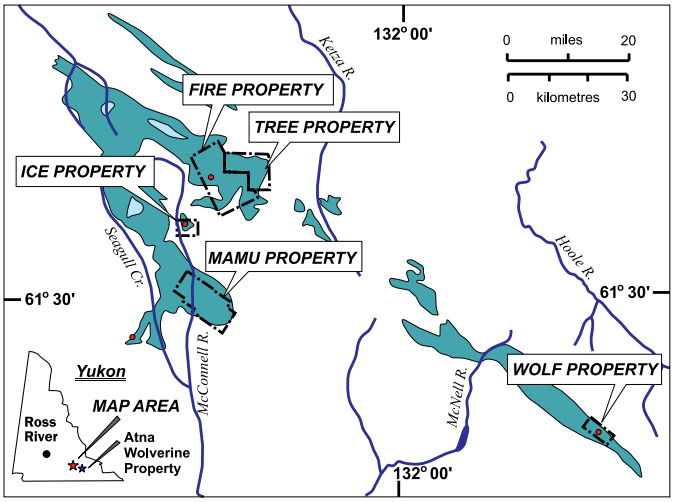


Figure 1. *Location of the Wolf (lower right) and other VMS occurrences in the Pelly Mountains of southeast Yukon. The shaded area is Devono-Mississippian volcanic and sedimentary rocks.*

The Wolf property consists of 18 contiguous mineral claims covering an area of 378 hectares (Fig. 2). Claims are owned by YGC Resources Ltd. and are under option to Atna Resources Ltd. The claims have been explored by Atna since 1995. The option agreement allows for Atna to earn a 65% interest in the claims for expenditures of $1.5 million over a five-year period.

The property is located within the moderately rugged St. Cyr Range of the Pelly Mountains, within the Yukon Plateau physiographic region of the northern Cordillera. The northeastern boundary of the Pelly Mountains is formed by the Tintina Trench, located just north of the property area. Elevations on the property range from 1400 to 1970 metres above sea level.

The Yukon Plateau was covered by McConnell glaciation from approximately 27 000 to 10 000 years before present time. This glaciation has produced rounded mountain peaks and broad valleys. Valley bottoms are typically underlain by glaciofluvial sediments, which are vegetated by grassy wetlands, "buckbrush" and stands of black spruce. The lower slopes of the valleys are commonly covered with aprons of colluvial sediments. Higher slopes are often talus covered, rising to exposed bedrock on cliff faces.

HISTORY

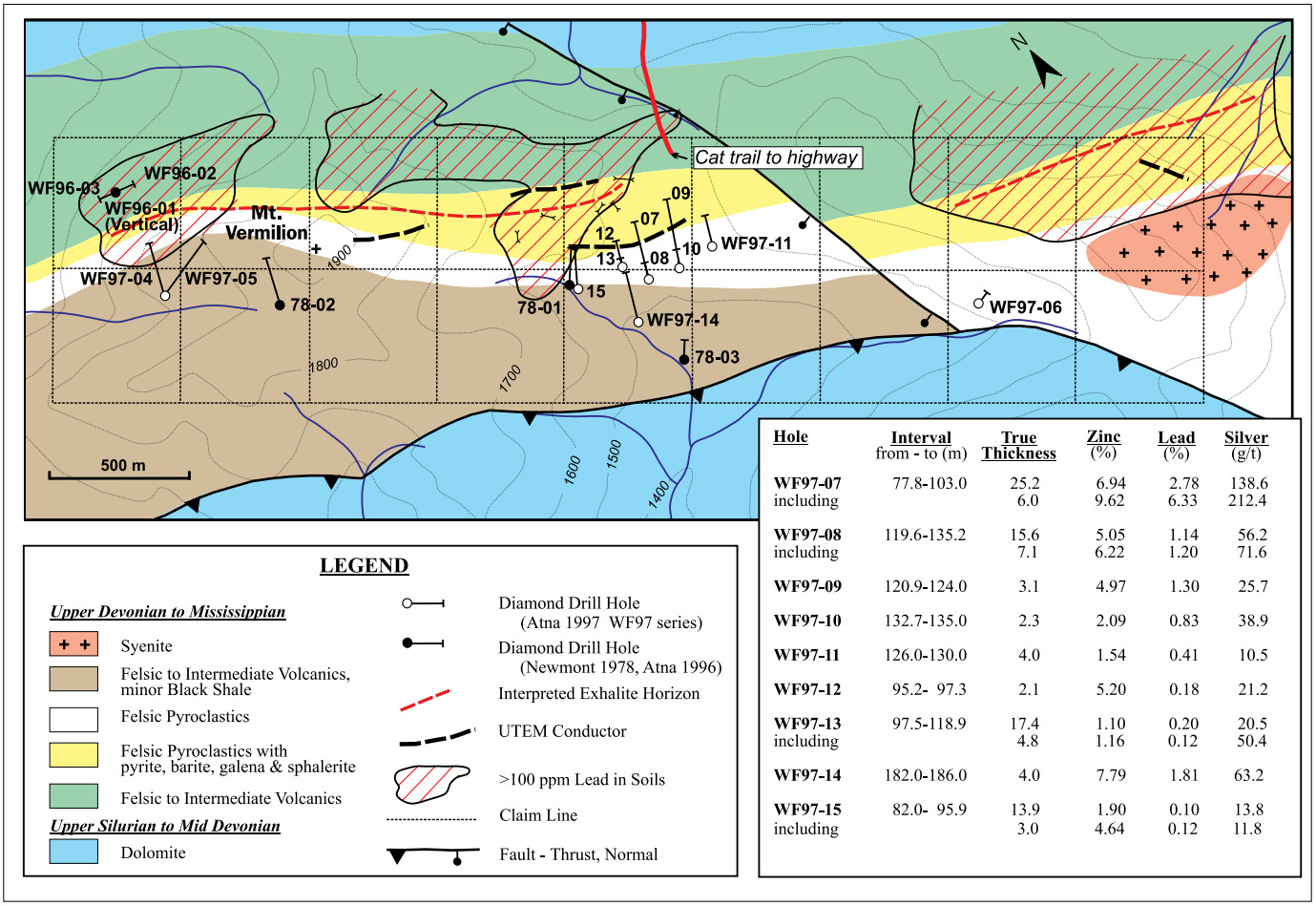
The area covered by the Wolf Claims has been explored intermittently for the last 40 years. The first recorded discovery of mineralization in the area was made by Newmont Mining Corp. in 1955 but claims were not staked until 1966. A tote road was pushed into the property area from the Robert Campbell Highway in 1967. The area was restaked in 1972 by Hesca Resources Ltd. who drilled two "x-ray" holes totalling 61 metres. These holes did not meet with the desired results and the claims were allowed to lapse. Newmont restaked the area in 1976 and conducted an exploration program consisting of a soil geochemical survey, EM and magnetometer geophysical surveys, bulldozer trenching, and three diamond drill holes totalling 528 metres. Newmont's first drill hole intersected 1.4 metres grading 5.6% zinc and 27.4 g/t silver, however, the claims were again allowed to lapse.

The area was next staked by Amax in 1982 and explored with a program of geological mapping and geochemical sampling (Harris, 1982). YGC Resources restaked the area in 1990 and conducted a geochemical survey (Carne, 1991). The property was optioned to Cominco who carried out more detailed studies than were done previously. This included rock and soil geochemistry, geological mapping, and UTEM geophysical surveys (MacRobbie, 1992; Holroyd, 1993). Cominco concluded that, although the area had all the earmarks of a productive VMS environment, the tonnage potential was limited and the location too remote and returned the property to YGC. Atna Resources Ltd. optioned the property in 1995 and conducted reconnaissance evaluation in 1995 (Kallock, 1995) and a program of soil sampling, hand trenching and diamond drilling in 1996 (Schmidt, 1997). Three holes were drilled in 1996 and intersected significant, but sub-economic zinc, lead and silver mineralization in a horizon below that which was previously explored. Following geological mapping by G. Belik in 1997, a drill program to geochemically evaluate the favourable volcanic stratigraphy was initiated. Significant massive sulphide mineralization was intersected during this program. The discovery hole (WF97-07) intersected a true thickness of 25.2 metres grading 6.94% Zn, 2.78% Pb and 138.6 g/t Ag.

GEOLOGY

REGIONAL SETTING

The region containing the Wolf property area is underlain by Early to Middle Paleozoic volcanic and sedimentary rocks of the Pelly-Cassiar Platform (Gordey, 1977), which is considered to be part of ancestral North America. Recent studies have suggested that the Pelly-Cassiar Platform contains strata which is similar, coeval, and possibly correlative to rocks within the Yukon-Tanana Terrane (Hunt, 1997).



Hole	Interval from - to (m)	True Thickness	Zinc (%)	Lead (%)	Silver (g/t)
WF97-07	77.8-103.0	25.2	6.94	2.78	138.6
including		6.0	9.62	6.33	212.4
WF97-08	119.6-135.2	15.6	5.05	1.14	56.2
including		7.1	6.22	1.20	71.6
WF97-09	120.9-124.0	3.1	4.97	1.30	25.7
WF97-10	132.7-135.0	2.3	2.09	0.83	38.9
WF97-11	126.0-130.0	4.0	1.54	0.41	10.5
WF97-12	95.2- 97.3	2.1	5.20	0.18	21.2
WF97-13	97.5-118.9	17.4	1.10	0.20	20.5
including		4.8	1.16	0.12	50.4
WF97-14	182.0-186.0	4.0	7.79	1.81	63.2
WF97-15	82.0- 95.9	13.9	1.90	0.10	13.8
including		3.0	4.64	0.12	11.8

Figure 2. *Simplified geological map of the Wolf Property, showing drill hole locations. The accompanying table gives significant intersections from the 1997 drilling,*

The Wolf property is underlain by Devonian to Mississippian volcanic rocks, including felsic tuffs, pyroclastic flows, trachyte flows, mudstones, and carbonates which form an arcuate belt nearly 5 km wide and 130 km long (Tempelman-Kluit, 1977). The felsic volcanic rocks are characterized by extremely high potassium geochemistry, bedded barite, and volcanogenic massive sulphide showings. The Wolf property is centered on one of the more prominent showings in the southern part of the belt. The MM property, located 60 km west of the Wolf claims, is underlain by similar strata and contains another prominent showing. The alkalic geochemistry of the volcanic rocks is compatible with formation in a continental rift-type setting (Mortensen, 1979); a setting not normally considered favourable for the formation of volcanogenic massive sulphide deposits (Mortensen and Godwin, 1982).

PROPERTY GEOLOGY

The mineralized volcanic-sedimentary rock sequence on the property occurs between two thrust faults which separates the sequence from underlying and overlying carbonate units (Fig. 3). Immediately to the northeast of the northeastern claim boundary, the favourable volcanic sequence is thrust onto, or possibly, disconformably overlies Upper Silurian to Devonian carbonates. Along the southwestern edge of the property Upper Cambrian to Ordovician dolomite is over-thrust upon the favourable stratigraphy (MacRobbie, 1992). This thrust appears to dip moderately to the southwest. Apparent thickness of the favourable stratigraphy within the claim area is approximately one kilometre.

It is not yet known whether the mineralized volcanic-sedimentary sequence is right-side-up or overturned and whether it contains fold, and/or thrust repetitions. Locally, a penetrative cleavage parallel to bedding is present and isoclinal minor folds are rarely observed, but no larger scale folds have been observed or delineated by mapping. For the sake of description here, the mineralized volcanic rock sequence will be assumed to be an upright monoclinal package.

The volcanic rock sequence is overlain, probably along a thrust fault, by a predominantly coarse clastic unit consisting of carbonate fragment conglomerate, chert pebble conglomerate, angular polymictic conglomerate (sharpstone breccia), dolomite,

argillite and interlayered basaltic flows or sills. The clastic units are unmetamorphosed, undeformed and remarkably fresh in appearance. The volcanic sequence consists of lapilli tuffs (pyroclastic flows), crystal and lithic ash tuffs, feldspar phyric trachyte flows, debris flows, greywacke and argillite/mudstone layers. In general, sedimentary units are thicker and more prevalent lower in the sequence. The trachyte flows are the most conspicuous units in the sequence due to 5 to 20% finely disseminated pyrite within the matrix which weathers to produce prominent gossans. The trachyte flows typically contain from 10 to 50% fine- to medium-grained euhedral feldspar phenocyrsts within an aphanitic light to dark gray matrix and are locally amygdaloidal. Trachyte flow units can attain a thickness of 120 metres, although they are commonly from 40 to 60 metres thick and laterally extensive. A single flow has been traced at least 8 kilometres to the northwest of the Wolf property. Locally, the trachyte flows are brecciated, and more rarely form crackle breccias with a fluorite matrix. Lapilli tuffs are volumetrically the most significant lithology within the sequence. The lapilli fragments are commonly from 10 to 20 mm in size, elongate and fairly well sorted. In the upper part of the sequence the lapilli tuffs tend to be well sorted and monomictic with white aphanitic lapilli fragments set in a feldspar-crystal, lithic ash matrix. Lower in the sequence the lapilli tuffs are more polymictic and poorly sorted becoming more like debris flows and volcanic conglomerates. A distinctive unit with lapilli-sized fragments of fine grained massive pyrite and wisps of barite, occurs at approximately the same stratigraphic position as the massive sulphide mineralization but is regionally extensive. Quartz crystals are rare within the volcanic rocks with the exception of a thin quartz crystal tuff unit which occurs in the proximal footwall of the massive sulphide mineralization. A coarse-grained syenite plug intrudes the upper part of the volcanic package on the eastern end of the claims.

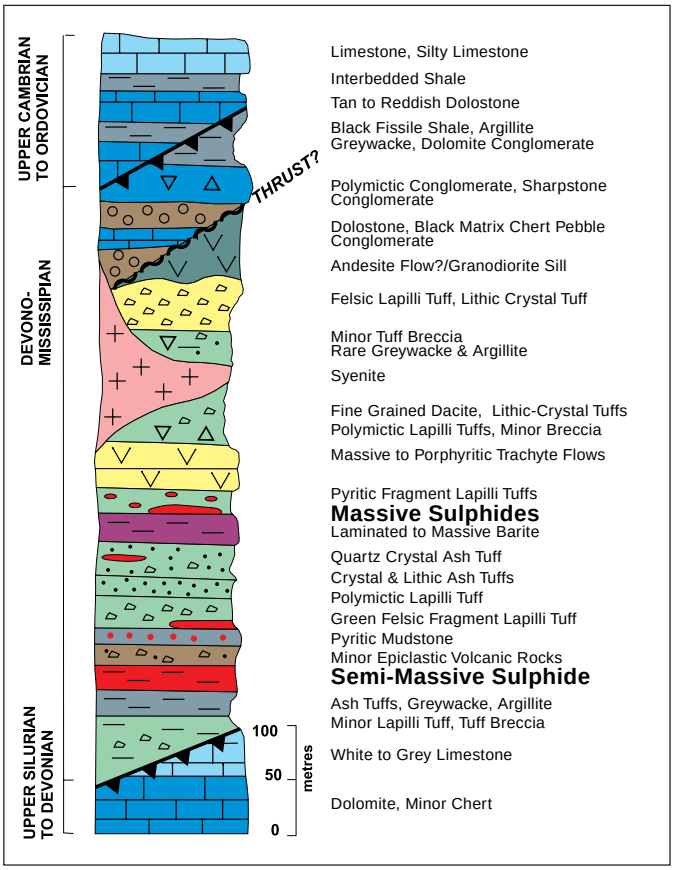


Figure 3. *Wolf property stratigraphic coloum.*

The felsic volcanic rocks and associated sediments are invariably pyritic, typically containing from 2 to 20% pyrite, which has resulted in extensive supergene alteration and formation of gossans. Drainage within the volcanic package is acidic which could have serious implications for exploration geochemistry. Alteration includes extensive pyritization, local but weak quartz-sericite alteration peripheral to the massive sulphide mineralization, and extensive ferro-magnesium carbonatization. A localized, black, chlorite-rich unit was observed during mapping but it is not known at this time if it is associated with sulphide mineralization.

MINERALIZATION

The Wolf deposit was discovered by the fourth drill hole of a four-hole program to determine to stratigraphy and lithogeochemistry of the property. The discovery hole (WF97-07) intersected a true thickness of 25.2 metres grading 6.94% Zn, 2.78% Pb and 138.6 g/t Ag. An additional 8 holes have defined a tabular massive sulphide deposit over a 500 metre strike length and approximately 250 metres in the down-dip direction. Drill hole intersections on the southeastern side of the deposit are narrow (2 metres) with sub-economic grades suggesting a southeastern boundary. The deposit, however, remains open to expansion in all other directions and is not exposed at surface.

The massive sulphides are primarily very fine grained pyrite with bands of amber colored sphalerite and fine grained, steely-grey galena. This form of mineralization has been termed zebra ore. Also present is medium grained botryoidal sphalerite and galena within a gangue of buff coloured Fe-Mg carbonate, and more rarely, barite. Chalcopyrite has only been observed within possible stringer mineralization intersected below the upper massive sulphide horizon in the most northwestern drill hole.

In general, the massive sulphides occur immediately below a feldspar phyric, locally amygdaloidal, trachyte flow, within a pyritic lapilli tuff unit (Fig. 4). The sulphides are underlain by a thin ash tuff containing quartz phenocrysts. Muscovite alteration is weakly developed in both the hangingwall and footwall. Carbonate alteration is distinctly more intense in both the hanging wall and footwall of the sulphide deposit but is also regional in extent. Three sulphide-bearing horizons have been intersected by drilling but potentially ore-grade mineralization

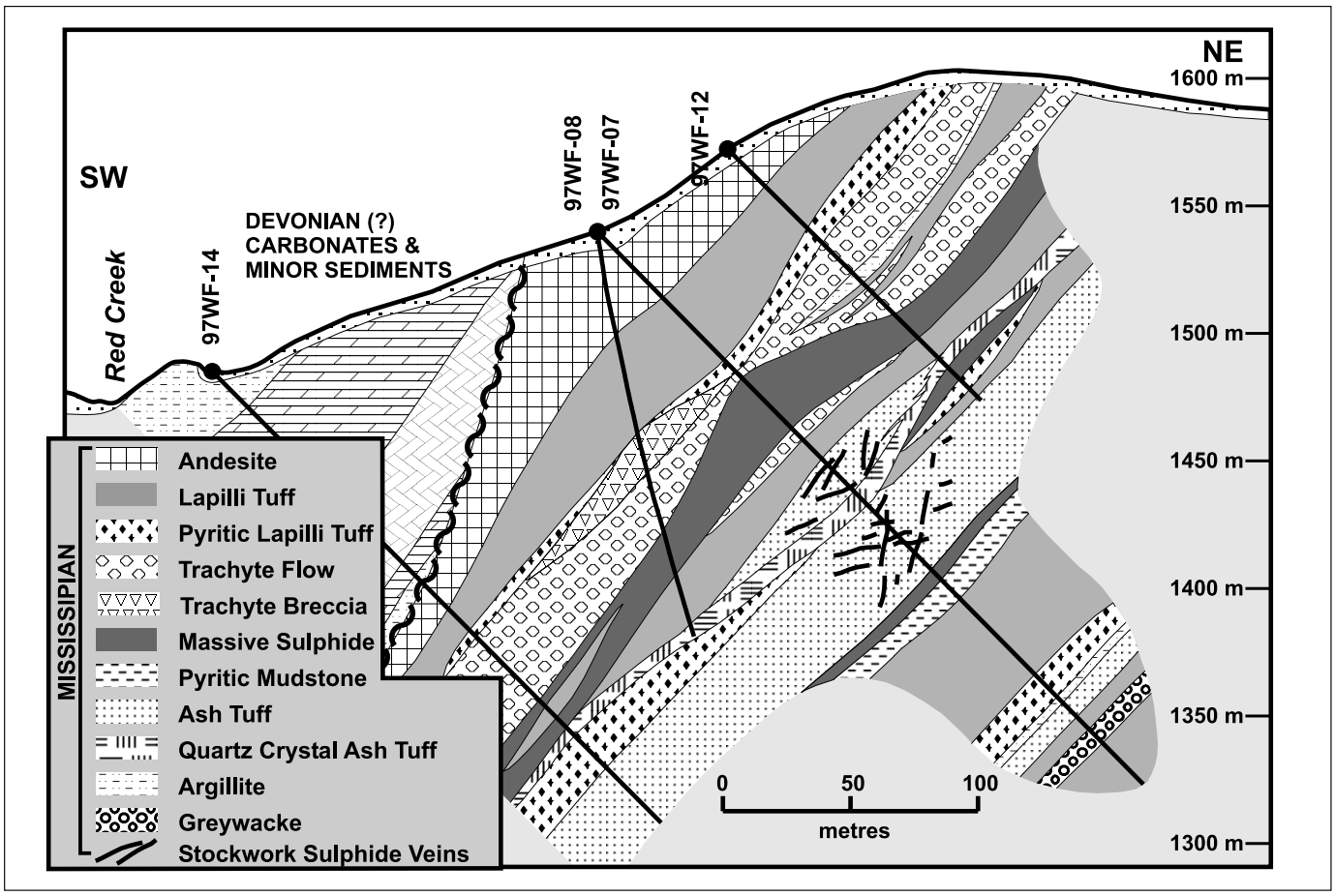


Figure 4. *Geologic cross-section of Wolf property, based upon the four drill holes and surface investigations.*

has only been intersected in the structurally uppermost horizon to date. The barite beds which Newmont trenched in 1978 correlate with the middle sulphide horizon and barite appears to occur laterally peripheral to sulphide mineralization.

WHOLE ROCK GEOCHEMISTRY

Representative core samples were collected from all diamond drill holes and analyzed by whole-rock geochemistry for major and trace elements. Preliminary interpretation of the results indicate that the rocks are of a trachyte composition and comparable to samples collected by Mortensen and Godwin (1982). Mortensen suggested, based upon whole rock geochemistry, that the Pelly Mountains Mississippian volcanic suite is the product of intracratonic rifting. The Wolf property is thus an example of a volcanogenic massive sulphide associated with highly alkaline rocks in an extensional tectonic setting.

CONCLUSIONS

Massive sulphide mineralization discovered on the Wolf property is stratabound and hosted by felsic volcanic rocks, probably of the Earn Group of the Pelly-Cassiar Platform but similar to, and possibly correlative with, strata of the Yukon-Tanana Terrane.

Whole-rock geochemistry indicating regionally extensive, anomalously high sodium content of the Devono-Mississippian volcanic stratigraphy of the Pelly-Cassiar Platform suggests that these rocks formed in an intercontinental rift setting. These types of rocks are relatively rare in the geological record and have not traditionally been considered a favourable location for VMS exploration. Work to date on the Wolf property and elsewhere in the belt clearly demonstrates that these rock are indeed favourable for hosting volcanogenic massive sulphide mineralization.

The Wolf deposit is open to expansion and the property has excellent potential to host an economic volcanogenic massive sulphide deposit.

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