PROPERTY DESCRIPTIONS

Ultramafic nickel-bearing magmas of the Nadaleen River map area (106C/3) and associated listwaenites: New exploration targets in the Mayo Mining District, Yukon

Jean-Pierre Jutras, P. Geol.
Manson Creek Resources Ltd.[1]

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ABSTRACT

Pentlandite-bearing serpentinized ultramafic flows with a komatiitic composition have been identified within volcano-sedimentary stratigraphy in the Nadaleen Range. Associated listwaenites or silica-carbonate-fuchsite-altered serpentinites carry locally significant gold, copper, nickel and cobalt values. The occurrence of laterally extensive ultramafic units at the northern edge of the Selwyn Basin remains difficult to explain within the current scope of geological knowledge in the area. However, it represents a new style of exploration target for copper-nickel-bearing massive sulphide deposits, as well as listwaenite-associated gold.

RÉSUMÉ

Des coulées de lave ultramafiques de composition komatiitique contenant de la pentlandite ont été reconnues au sein de la séquence volcano-sédimentaire des Monts Nadaleen. Des roches listwanitiques à dominance de silica-carbonate-fuchsite associées aux coulées représentent une forte altération des unitées ultramafiques et contiennent localement des teneurs importantes en or, cuivre, nickel et cobalt. La présence d'unitées ultramafiques d'étendue importante en bordure nord du Bassin de Selwyn demeure énigmatique dans l'état actuel des connaissances de la géologie du district. Par-contre, leur présence souligne de nouvelles cibles d'exploration dont l'objectif serait la découverte de dépots de sulphures massifs contenant du nickel et du cuivre ainsi que des dépots aurifères associés aux listwaenites.

[1]*Manson Creek Resources Ltd., Suite 500, 926-5th Avenue S.W., Calgary, Alberta, Canada T2P 0N7, jp@gold.ca*

INTRODUCTION

Strongly serpentinized ultramafic units and associated zones of quartz-carbonate rocks have been described in the literature for the Nadaleen Range since at least 1977. Recent work in the area by Manson Creek Resources Ltd. has revealed that these units are contributors to nickel stream geochemical anomalies documented for this area (Hart et al., 2001). Short field mapping programs in 1998 and 2001 have established that the ultramafic units are locally conformable with the underlying volcano-sedimentary stratigraphy. Geochemical data suggests that the rocks are komatiites. Locally significant (tens of metres), resistant quartz-carbonate-fuchsite units are developed as listwaenites, an altered phase of the ultramafic units. The ultramafic flows themselves contain high background nickel values (up to 2080 ppm nickel), and local occurrences of massive sulphide mineralization within the listwaenite units have assayed as high as 20.37 g/t Au, 6.85% Cu, 0.56% Ni and 0.16% Co.

HISTORY

The area of known ultramafic occurrences in the Nadaleen Range lies on NTS Map Sheet 106C/3 (Fig. 1). This area has seen comparatively little work as it has only been mapped once as part of a 1:250 000-scale program (Blusson, 1974). One wave of grassroots exploration in the late 1970s, aimed at discovering Mississippi Valley Type (MVT) carbonate-hosted silver-lead-zinc deposits, provides the bulk of available information in the Nadaleen Range area, although on a property by property basis. No airborne geophysical surveys have been flown over the area as part of regional coverage by government agencies.

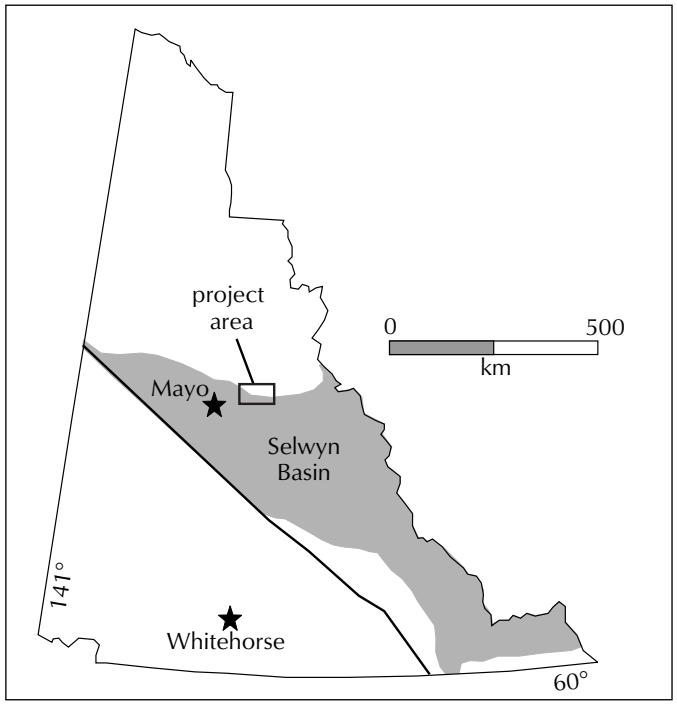

Figure 1. *Location sketch map of study area (Fig. 2).*

Exploration work in the 1970s resulted in the publication of an initial property evaluation and summary report by Tempelman-Kluit (1980). At that time, it was recognized that the "serpentinites," "quartz-carbonate rocks" and volcanic strata from the Nadaleen Range were genetically related, although the ultramafic parent to the serpentinites was not observed.

Work by Manson Creek Resources Ltd. since 1997, including regional mapping programs in the Nadaleen Range, has led to more detailed data being available within the area. Specifically, it has been determined that the ultramafic units were, at least locally, emplaced as flows, as evidenced by the presence in outcrop of serpentinite-filled, well preserved megascopic pillow structures in a basalt flow.

REGIONAL GEOLOGY

The geology of the Nadaleen Range is characterized by a large-scale anticlinal closure exposing a sequence which, from bottom to top, includes 1) a basaltic/andesitic-dominated volcanic sequence overlain by 2) ultramafic, serpentinized units, locally altered to quartz-carbonate-fuchsite facies overlain by 3) transitional shales grading into sandstones, polymictic to chert-pebble conglomerates, and thinly bedded to massive limestone units (Fig. 2).

Within the known regional geological context and in light of the work recently performed on the adjoining Mount Westman and Tiny Island map sheets (Abbott, 1990; Gordey, 1990), the intermediate volcanic units and associated ultramafic flows are tentatively assigned to the Devono-Mississippian Earn Group.

Structure in the area is dominated by large-scale isoclinal folding (F_1) with development of a pronounced schistosity (S_1) within the finer grained or more plastic units. Local folding of the S_1 schistosity subparallel to the east-trending F_1 axial planes suggests a second phase of tectonic stress or a reactivation of the first folding event at a minor scale. A third event of regional-scale folding with a north-trending axial plane is also present over the area. These structural observations are, on a regional scale, in

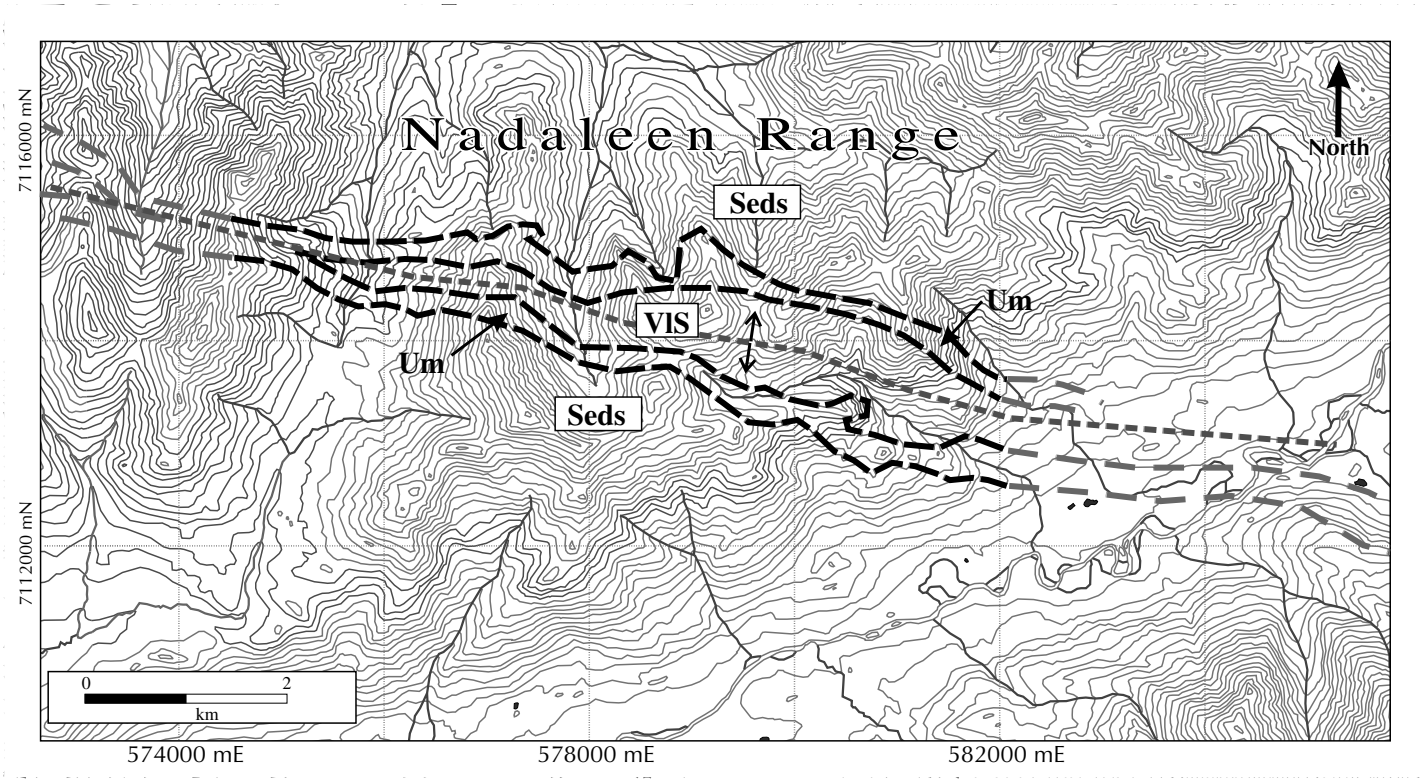

Figure 2. *Regional geology of the Nadaleen Range. Centre of area of interest is characterized by a broad, regional-scale anticlinal axis exposing volcano-sedimentary stratigraphy (VlS) dominated by pillow basalts, andesite flows and minor quartz-eye dacites. The ultramafic unit (Um) and its altered equivalents (listwaenites) are exposed in both limbs of the fold and appear to close to the west. Overlying the ultramafic units is a sedimentary sequence (Seds) volumetrically dominated by shales, sandstones and conglomerates. Resistant limestone units within the sedimentary sequence form prominent hilltops and thus locally appear much more significant than their true extent.*

accordance with the observations presented by Gordey (1990) on the Tiny Island Lake map sheet located to the southwest of the Nadaleen Range.

ULTRAMAFIC UNITS

The presence of ultramafic units in the Nadaleen Range was documented as far back as 1997 during a property visit and mapping exercise conducted by MacIntyre Mines Ltd. during regional exploration of carbonate units of the Nadaleen Range aimed at the discovery of Mississippi Valley Type silver-lead-zinc mineralization.

Upon reactivation of exploration in the area in 1997, the serpentinite units were mapped in greater detail in order to unravel their relationship with the surrounding country rocks as well as obtain information about the parent material. Whole rock and trace element geochemistry was also conducted in 1999-2000. The discovery in 1998 of significantly elevated nickel background values within the serpentinites, as well as the presence of copper and gold mineralization in the associated silica-rich carbonate units, provided the main impetus for further work, which included an airborne magnetic/electromagnetic survey and further mapping in 2001.

The serpentinite units typically weather to a fine greenish black talus and consist predominantly of talc, serpentine and few preserved mafic phases such as magnetite. They vary in thickness from a few metres to over 50-60 m where well exposed. In most cases, primary textures have been obliterated by the serpentinization process and only relict textures can be observed. These generally include fine-grained and porphyritic facies, but suspect cumulate textures are also present in outcrop. No flow tops or spinifex textures have been conclusively identified in the field to date. This could be a function of either insufficient mapping or pervasive alteration. The units are laterally extensive, with a strike length of over 10 km known by exposure of both limbs of a regional-scale anticline (Fig. 2). Original thickness of the units is difficult to determine as the serpentinites have absorbed a large

amount of regional strain during deformation due to their ductile nature. Numerous sliding/shear planes, highlighted by the development of slickensides and fibrous antigorite, are present at all scales, even where small-scale faulting/rotation within the units occurred. However, shearing does not extend into the lithological units above and below the serpentinites.

In one outcrop, the relationship between the ultramafic unit and the underlying pillow basalt is well preserved (Fig. 3). At this location, the serpentinized material is seen infilling well preserved megascopic pillows. The implications of the textural relationship are that the ultramafic magmas were extruded slightly after formation of the basaltic flows, and that the two magmas are therefore coeval.

Analysis of whole rock geochemistry results shows that the rocks are classified as komatiites as they contain greater than at least 18% MgO on an anhydrous basis (S. Ebert, pers. comm., 2001) and have low TiO_2 (Le Maitre, 1989, Fig. 4). The ultramafic rocks also plot in the komatiitic field of Jensen (1976, Fig. 5).

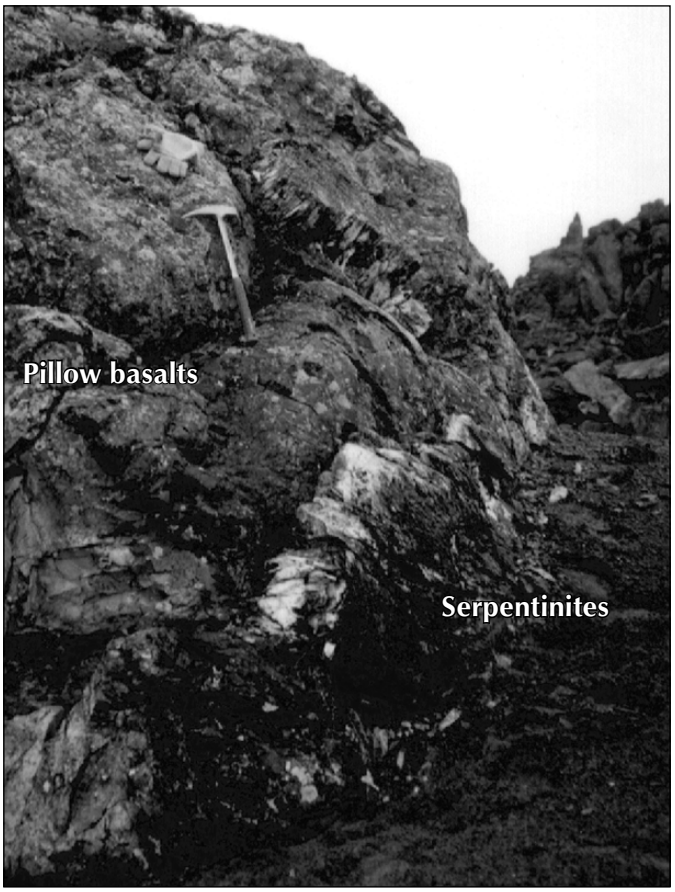

Figure 3. *Well preserved megascopic pillows in a basaltic flow stratigraphically overturned by serpentinized rocks (weathering to fine-grained talus). The field relationship suggests emplacement of the ultramafic magma as coeval with the rest of the volcanic sequence. Hammer for scale.*

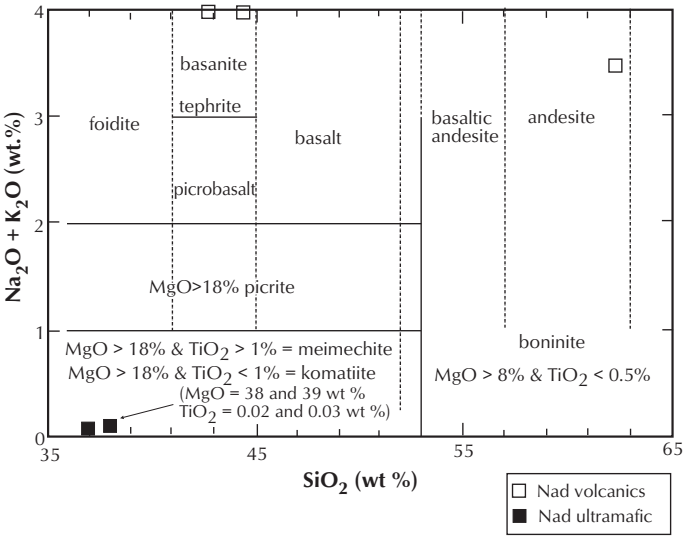

Figure 4. *Alkalies versus silica diagram for mafic volcanic rocks from Le Maitre (1989). Geochemistry shows distinct compositions for the ultramafic and mafic to intermediate flows of the Nadaleen Range. The Nad ultramafic rocks are high Mg and low Ti, consistent with komatiite geochemistry.*

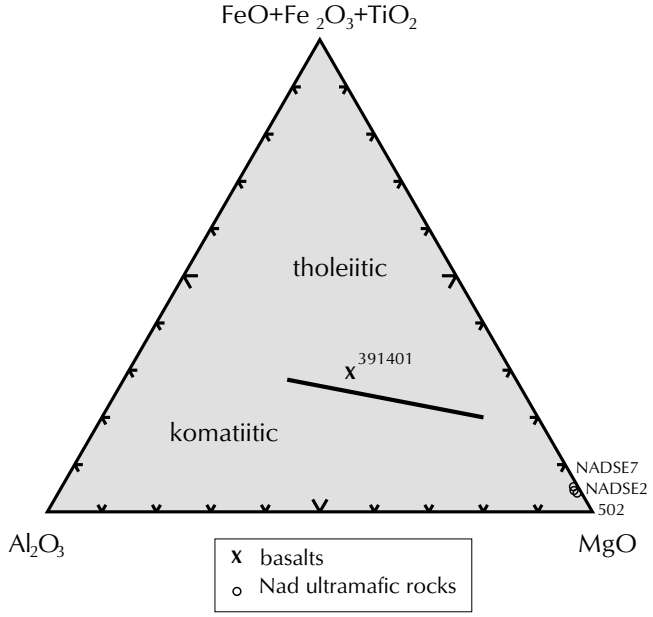

Figure 5. *Komatiite versus tholeiite ternary diagram (Jensen, 1976). The serpentinized ultramafic rocks plot within the komatiitic field, while one of the basalt sample from the Nadaleen Range plots within the tholeitiic field.*

A suite of grab samples highlighted a high nickel background associated with the serpentinized units. A total of 19 grab samples at numerous sites along the unit averaged 1580 ppm Ni, with a range of 720 to 2080 ppm. Scanning electron microscopy allowed for the determination that pentlandite, a nickel-bearing sulphide phase, is present within the samples examined (Fig. 6). A suite of rocks with high nickel values was also sent for assay for platinum group elements (PGEs), but results for 11 samples were consistently at or near the lower detection limit for both platinum and palladium.

ALTERED ULTRAMAFIC FACIES

Units consisting predominantly of quartz-carbonate-fuchsite with locally minor disseminated pyrite have been mapped in association with the serpentinites. These units can range to over 70 m in thickness and are systematically found stratigraphically above the ultramafic flows. Mapping has shown them to form a progressive alteration front into the ultramafic units. The intensity of alteration locally ranges from minor quartz-carbonate veining and stockwork, to a massively replaced phase that is resistant to weathering and forms orange bluffs. Because field relationships indicate these units are a quartz-carbonate alteration product of serpentinites, they are tentatively being termed listwaenites in the broad sense of the term; this is with reference to descriptions of similar units in British Columbia (Ash and Arksey, 1990).

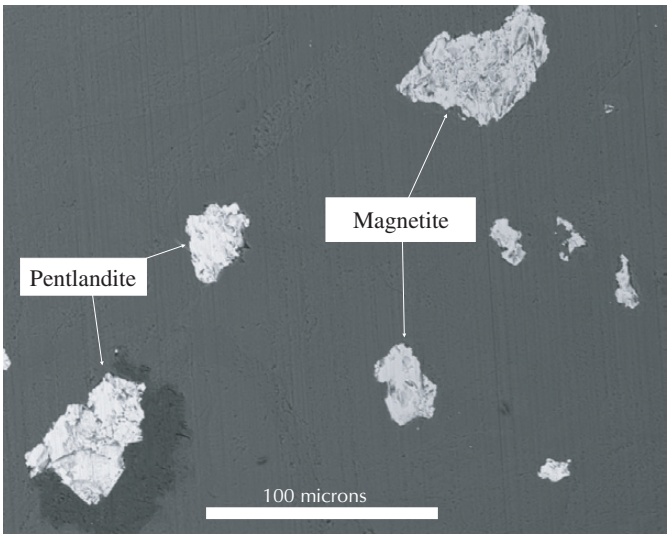

Figure 6. *Scanning electron backscattered image. Aphanitic altered matrix (light gray) with disseminated grains of pentlandite and magnetite.*

Mineralization within the listwaenite units is associated with disseminated to massive pyrite-dominated sulphide pods and veins. One such occurrence consists of an irregular lens of pyrite-chalcopyrite mineralization with minor malachite and azurite staining. The lens is located at the base of a listwaenite unit and is roughly 1 m thick and 3-4 m long. Grab samples from this outcrop have returned values of up to 20.37 g/t Au, 6.8 g/t Ag, 6.85% Cu, 0.56% Ni and 0.16% Co. Grab samples of another sulphide-rich showing some 3 km to the west of this showing, returned values of up to 5.27% Cu. The listwaenites also have a high nickel background, with 17 samples averaging 1997 ppm Ni and having a range of 14 to 5680 ppm. This data also supports the interpretation that listwaenites are an alteration phase of the serpentinites, as nickel has not been identified in any other rock type within the volcano-sedimentary sequence in the Nadaleen Range.

DISCUSSION

The presence of ultramafic units with a komatiitic geochemistry within the Selwyn Basin is not consistent with current knowledge of the area. More work is required before a mechanism can be suggested for the emplacement of these units within the Devono-Mississippian volcano-sedimentary package of the Nadaleen Range. However, in terms of mineral exploration, the units outline the possibility that deep crustal features may be present in the area. This is an important factor in terms of introducing base and precious metals into the existing sequence, as well as potentially outlining the presence of regional-scale heat sources that could have driven paleo-hydrothermal systems. Heat sources are important in both sedimentary-exhalative and volcanogenic massive sulphide style ore deposit models.

Earn Group stratigraphy locally contains abundant sulphur in the form of diagenetic as well as exhalative pyrite and barite (Yukon MINFILE, 2002). Following this, the presence of nickel-rich ultramafic magmas intruding Earn Group outlines potential for copper-nickel-bearing ultramafic-associated massive sulphide deposits, such as those found in the Proterozoic Raglan belt of northern Quebec.

Extensive associated belts of listwaenites could also be a target for lode gold deposits such as those associated with similar alteration of ultramafic units in California, the Urals, British Columbia and Alaska.

ACKNOWLEDGEMENTS

Geological descriptions in this paper are based on field work conducted on behalf of Manson Creek Resources Ltd. Whole rock analytical work and scanning electron microscopy was performed by Dr. Shane Ebert of the Mineral Deposit Research Unit. This paper summarizes the findings to date on the Nadaleen ultramafic occurrences and is a result of dedicated work from the field to the laboratory from an excellent team including all the geoscientists who worked on the project to date. The process of generating and interpreting this data was helped tremendously by Yukon exploration incentive programs such as Yukon Mineral Exploration Tax Credit, as well as discussions with Grant Abbott, Mike Burke, Craig Hart and Ken Galambos.

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