BASE METAL DISTRIBUTION IN GOSSANS OF THE KAKAGI LAKE ARCHEAN VOLCANIC ROCKS, NORTHWESTERN ONTARIO

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Abstract

One hundred and thirteen samples were collected from gossans of the Snake Bay-Kakagi Lake metavolcanic sequence in the Lake of the Woods area, northwestern Ontario. The sequence is more than 15 km thick and consists of a Lower Mafic unit 2.5 km thick, a Middle Mafic unit 7.5 km thick, a Middle Felsic unit 4.8 km thick and an Upper Cyclic unit more than 0.2 km thick.

The gossans are rusty-weathering, sulphide-bearing, concordant to locally discordant zones that range in width from 1 to 50 m and are traceable laterally for more than 60 m. They represent sheared alteration zones in mafic and felsic flows and tuff, and in felsic sills and dykes. Gossan composition varies with composition of the host rocks with gossans in mafic flows being more mafic than in felsic rocks. The gossans are metamorphosed and their alteration is probably the result of volcanic gases. Gossan composition may be a useful guide to ore bodies that were formed by the same volcanic emanations.

The gossans were analysed for Ni, Co, Cu, Zn, Pb and S. The values are widely scattered. The distribution trends show that Ni, Co, Cu and Pb are highest in the Lower Mafic units and decrease in the higher units. Zn values are highest in the boundary area between the Middle Mafic

and Middle Felsic units. S values are highly variable.

Ni and Zn trends in gossans are generally similar to those in unaltered metavolcanic rocks of Kakagi Lake, but Cu trends are different. Median values are generally different in gossans and unaltered volcanic rocks. For example Ni, Co, Cu, Zn and Pb medians in gossans and (in the Kakagi Lake unaltered metavolcanic rocks) are: Ni 42.5 (73.5); Co 33.0 (41.5); Cu 78.5 (63.5); Zn 78.0 (68.0) and Pb 2.0 (0.0) ppm respectively.

Lack of correlation between S and Ni, Co, Cu and Zn is probably due to the fact that Ni, Co, Cu and Zn are primary while S is of later introduction. A few gossans have high Cu, Zn and S concentrations, and these may represent actual base metal mineralization.

CHAPTER I

INTRODUCTION

The Kakagi Lake metavolcanic sequence in the Lake of the Woods area, northwestern Ontario is more than 15 km thick. It consists of a Lower Mafic unit 2.5 km thick, a Middle Mafic unit 7.5 km thick, a Middle Felsic unit 4.8 km thick and an Upper Cyclic unit of which only 0.2 km were measured (Figure 3.1). The Lower Mafic unit is characterized by basalt flows and minor gabbro sills while the Middle Mafic unit is characterized by thick basalt-andesite flows and gabbro sills. The Middle Felsic unit is dominantly dacite pyroclastic breccia intruded by large differentiated gabbro-pyroxenite-peridotite sills (Wilson, 1973). The Upper Cyclic unit is characterized by felsic to mafic flows and tuffs.

STATEMENT OF THE PROBLEM

This meta-volcanic sequence contains numerous, relatively thin and generally concordant, sheared alteration zones that are characterized by higher than normal content of sulphide minerals and a reddish-brown weathered surface. These zones are herein referred to as gossans. The zones occur throughout the meta-volcanic sequence but are variable in composition: in the lower and middle mafic units they have replaced mafic flows but in the middle felsic and

and upper cyclic units they have replaced dacite-rhyolite flows and tuffaceous rocks. Sheared felsic sills and dykes throughout the sequence also locally form gossans.

Samples were collected from weathered surfaces of the gossans along four traverses through the Kakagi Lake metavolcanic sequence (Figure 1.1) and one hundred and thirteen samples were analysed for Co, Ni, Cu, Zn, Pb and S.

The gossans were studied to:

a) determine their content of Co, Ni, Cu, Zn, Pb and S as a function of stratigraphic position and host rock lithology;

b) compare this elemental content with that in unaltered metavolcanic rocks of the same sequence;

c) determine the relationship between the various base metal elements and between the base metal elements and sulphur;

d) compare and contrast, where possible, these relationships with similar relationships in sulphide ores and in igneous rocks;

e) investigate the possibility that base metal content of gossans in Archean metavolcanic sequences could be a guide to the presence of base metal ore bodies and to the most favourable stratigraphic units for such ore deposition.

The possible use of gossans as an exploration guide is based on the assumption that gossans represent widespread, low grade mineralization that is genetically similar to the more mineralized, higher grade mineralized zones that can be mined. Gossans near ore bodies should thus contain anomalous base metal contents when compared with the standard distribution curves for gossans of the same sequence. The first objective of this research is to determine standard distribution curves for the Kakagi Lake sequence.

As far as the author has been able to determine there has not been a similar study of the distribution of base metals in gossans of a volcanic sequence, particularly in the Archean. However, the same elements have been studied in sulphide ores of North America by Kilburn (Unpublished Ph. D. Thesis, 1960, and paper in Economic Geology, 1960). Govett, (1972) studied ore-bearing gossans in the Troodos volcanic sequences of Cyprus.

LOCATION AND ACCESS

The thesis area is located between Lake of the Woods and Kakagi Lake in the District of Kenora, Northwestern Ontario (Figure 1.1 in envelope).

Access to the area is good. Highway 71 passes through the area and several gravel roads lead from the highway to various parts of Lake of the Woods and Kakagi

Lake. The lakes themselves offer good access by boat to various outcrops.

LOCATION OF SAMPLING TRAVERSES

Material for this study was collected during the field season of 1973 from four traverses that extend across the regional strike of the Kakagi Lake metavolcanic belt (Figure 1.1 in envelope).

The first pair of traverses extends from the Aulneau batholith/metavolcanic belt contact in Snake Bay, Lake of the Woods, passing through Wapus and Cedartree Lakes and ending near Steven Lake. The second pair starts near the Pipestone dome/metavolcanic belt contact south of Kakagi Lake and passes through Kakagi Lake and Wicks Lake ending near Little Steven Lake (Figure 1.1 in envelope).

The traverses from each pair are about 1.6 km apart. The two pairs almost converge in the upper part of the sequence near Steven Lake, but, in the lower part they are about 40 km apart.

The traverses of the Snake Bay pair are numbered 1 and 2; while those originating near the Pipestone dome are numbered 3 and 4. Stratigraphic sections along traverses 1 and 2 have been measured by the Centre for Precambrian Studies, University of Manitoba (Figure 3.1).

Samples of partially oxidized material were collected from all gossan zones encountered along the traverses with one sample being collected from each gossan. Fresh material underlying the gossans was not sampled as this was impractical without a drill or similar equipment. The sample interval was determined by the frequency with which gossan zones occurred. A total of 113 samples were collected, representing 113 gossans throughout the meta-volcanic sequence, 89 from traverses 1 and 2, and 24 from traverses 3 and 4.

ANALYTICAL METHODS

Chemical analysis for Ni, Co, Cu, Zn, Pb and S were made by the Chemical Laboratory of the Earth Sciences Department, University of Manitoba.

Co, Ni, Cu, Zn and Pb were determined by Atomic Absorption Spectrometry using a Perkin Elmer 303 Atomic Absorption Spectrophotometer. The samples were dissolved with HF, H_2SO4 and HNO_3 in platinum crucibles. The concentration used was 1 gm/100 ml.

Sulphur was determined by heating samples in an induction furnace with oxygen flowing through the combustion chamber. The evolved SO_2 was titrated. The equipment consisted of a Leco induction furnace and automatic titrator.

The precision and accuracy of the analyses are reported in Table 1.1.

Table 1.1 Precision and Accuracy of Analyses

Constituent	Concentration	Instrument Precision	Accuracy of Replicates
		Standard Deviation	Standard Deviation
Co	53 ppm	1.0	2.0
Ni	77 ppm	1.0	3.0
Cu	40 ppm	1.0	2.0
Zn	108 ppm	1.0	2.0
Pb	34 ppm	2.0	3.0
S	0.185%	0.003	0.005

PRESENTATION OF DATA

Data are presented in the form of tables, histograms, graphs, scatter diagrams and triangular compositional diagrams.

Histograms

Relative frequency (or percent frequency) distribution of the six elements has been studied using histograms. From these the range and mode of a given element can be readily obtained.

Graphs

Graphs have been used to study the distribution of the elements as a function of stratigraphic position.

Scatter Diagrams

Relationships between base metal elements and between base metals and sulphur have been studied by means of scatter diagrams which show the degree of correlation between elements.

Triangular Compositional Diagrams

Triangular compositional diagrams have been used to study three compositional systems, namely:

Co; Cu; Zn

Ni; Co; Cu and

Ni; Cu; Zn

It is important to know whether plots of this nature indicate the dominant kind of base metal concentration occurring in gossans of a meta-volcanic belt.

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Finally, I am grateful to Mr. H. Ambach for preparing computor plots of the chemical data.

CHAPTER II

FIELD OCCURRENCE AND PETRAGRAPHY

The gossans occur as concordant to locally discordant sheared zones in metavolcanic rocks. Most concordant zones have gradational contacts with the enclosing rocks and appear to be the result of alteration along shear zones in mafic to felsic metavolcanic flows and pyroclastic rocks. A few of the concordant and most of the discordant zones have sharp intrusive contacts and are altered, sheared, felsic sills and dykes.

The gossans usually range in thickness from a few cm to 20 m and in places are as much as 50 m thick. Laterally the gossans can be traced for as much as 60 m depending on quality of exposure.

Petrographic Description

Twenty-six thin sections of gossans were examined but these are restricted to the Lower Mafic unit in Snake Bay. Samples from higher parts of traverses 1 and 2 and from both traverses 3 and 4 were not collected until late in the field season, and no thin sections were prepared from these samples.

For comparative purposes, seven thin sections were also examined from unaltered metabasaltic flows in the Snake Bay area. Both the unaltered flows and the gossans are metamorphosed to green schist facies. The available thin sections, although stratigraphically restricted, allow the source rock of the gossans to be determined.

In the Snake Bay area 21 of the 26 gossans examined in thin section were derived from mafic flows, the remaining 5 were derived from felsic sills and dykes.

The gossans can thus be subdivided into two types: mafic and felsic.

Mafic gossans

Mafic gossans predominate in the Lower and Middle Mafic units. They contain approximately 60% actinolite, 10% chlorite, 5% epidote, 10% carbonate, 13% albite and 2% pyrite and other opaque minerals. Quartz is rare. Grain size ranges from 0.5 mm to 2 mm and averages 1 mm. Relict volcanic textures are largely destroyed but the shape of the original tabular plagioclase is locally preserved by cloudy pseudomorphs. The mafic gossans are poorly foliated and fractured with the fractures being filled by quartz and carbonate veins that locally contain pyrite cubes.

Generally equigranular carbonate and rare quartz occur as fine-grained interstitial aggregates between coarser-grained mafic minerals and as coarser crystals in veins.

The unaltered metabasalt flows from Snake Bay contain approximately 50% actinolite, 40% plagioclase, 6.5% epidote, 3% carbonate, 0.5% pyrite and other opaque minerals and minor fine-grained stubby crystals of rutile. Quartz is rare. Generally grain size ranges from less than 0.5 mm to 1 mm. The primary volcanic texture in these rocks is well preserved and is intergranular to subophitic. Plagioclase is partly replaced by fine-grained carbonate. The unaltered basalts are massive to poorly foliated and are only rarely fractured.

Unaltered metabasalt flows differ from the gossans in that they have a lower content of mafic minerals and are more poorly foliated, less fractured, and less recrystallized.

Felsic gossans

The felsic gossans form concordant to discordant sills and dykes in the Lower and Middle Mafic units and concordant zones in metavolcanic rocks of the Middle Felsic and Upper Cyclic units. The sills and dykes contain approximately 60% quartz, 38% carbonate, 2% pyrite and other opaque minerals. Minor sericite is present. Carbonates have formed mainly as a result of alteration of plagioclase. Primary textures have been obliterated by alteration and metamorphism.

Felsic gossans are moderately to strongly foliated and the minerals are oriented parallel to shear planes.

Fractures are common and are mainly parallel to foliation. These are filled with quartz and/or carbonate veins.

Petrographic and field data indicate that most gossans are concordant alteration zones within the dominant lithology of the host metavolcanic unit. Thus mafic gossans occur largely in the mafic lower part of the sequence and felsic gossans in the upper felsic part. Felsic dykes and sills in the mafic flows are also locally altered to gossans. Such features as preferred orientation of minerals, planar fissility of some gossans and to a certain extent preferred orientation of veins suggest that alteration was aided by shearing. The major chemical effects of alteration were the addition of H_2O, CO_2, SiO_2, S and loss of Na and K.

Sulphide Mineralogy

Polished section studies showed that the gossans contain pyrite, chalcopyrite and minor pyrrhotite, galena and sphalerite. Only pyrite, and in places chalcopyrite are visible in hand specimen.

Pyrite

Pyrite is the main sulphide mineral in the gossans and occurs as isolated cubes (0.5 mm - 3 mm in diameter) and as finer-grained disseminations. Abundance ranges from 1% to 2%.

Chalcopyrite

Fine-grained anhedral chalcopyrite crystals occur as fracture fillings and as interstitial aggregates between silicate minerals. Chalcopyrite also occurs in pyrite and in places replaces sphalerite. Chalcopyrite abundance ranges from trace to 0.5%

Pyrrhotite, sphalerite and galena

These are present in trace amounts. Ni and Co sulphides were not observed. Therefore, these elements probably occur in pyrrhotite or in silicate minerals.