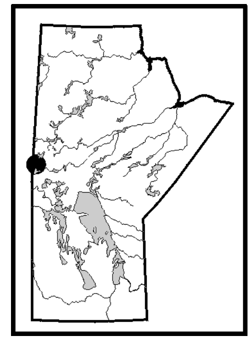
GS-3

ALTERATION OF THE PALEOPROTEROZOIC FELSIC VOLCANIC BAKER PATTON COMPLEX (NTS 63K12NE AND 13SE), FLIN FLON, MANITOBA

by D.E. Mitchinson[1], H.L. Gibson[1] and A.G. Galley[2]



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INTRODUCTION

Studies by Hannington et al. (in press a, b) on the regional-scale hydrothermal systems of the Noranda (Quebec) and Kristineberg (Sweden) VMS districts have demonstrated the importance of using metamorphosed hydrothermal mineral assemblages in detecting centres for robust, subseafloor hydrothermal activity. Furthermore, these studies illustrated the usefulness of the X-ray diffraction method for the efficient identification of key alteration minerals and their semi-quantitative abundances. The felsic Baker Patton Complex is one of three study areas chosen, during the Flin Flon Targeted Geoscience Initiative (FFTGI), in which to further test this detection method, and compare its reliability against petrographic analysis and lithogeochemistry-generated modal mineralogy.

Volcanogenic massive sulphide (VMS) deposits of the Paleoproterozoic Flin Flon Belt of Saskatchewan and Manitoba are commonly associated with rhyolitic flows and volcaniclastic rocks within predominantly mafic terranes (Syme and Bailes, 1993). The dominantly felsic, approximately 50 km^2, Baker Patton Complex (BPC) is the largest domain of felsic rocks in the Flin Flon Belt and has been a target for much VMS exploration activity. Although the BPC does host a number of small, subeconomic VMS deposits and occurrences, and locally displays evidence of having undergone intense hydrothermal alteration, it is inexplicably devoid of significant VMS mineralization.

The BPC has been previously studied by both government (Gale et al., 1992, 1993; Gale and Dabek, 1995, 2002) and industry (Prior and Dabek, 1999) workers. The objective of this study is to evaluate the primary volcanological controls on alteration type and intensity, and to evaluate different methodologies, including lithogeochemistry and mineralogy derived from X-ray diffraction (XRD), with which hydrothermal alteration in the felsic complex can be quantified. This will assist in further evaluation of the VMS potential of the BPC.

This subproject is part of the Flin Flon Targeted Geoscience Initiative (FFTGI), the objective of which is to gain a better understanding of the hydrothermal systems associated with the various VMS deposits and prospects in the Flin Flon region, thereby assisting industry in developing new exploration criteria. The final product of this particular subproject will be an M.Sc. thesis in the form of a published paper. The map-based results are to be published, along with the results of the other FFTGI projects, in a geographic information system (GIS) format on a Geological Survey of Canada (GSC) CD-ROM release in the spring of 2003.

METHODOLOGY

This study is focused on felsic flows of the western half of the BPC, where four subeconomic VMS deposits are located (Fig. GS-3-1). The initial analysis of lithogeochemical data will be followed by an assessment of mineralogical variations derived from semiquantitative XRD analysis of BPC samples using the WinJade XRD software package. The effect of flow morphology on the distribution of alteration, as defined by lithogeochemistry and XRD-derived mineralogy, will also be examined. The effectiveness of each method in defining VMS-related hydrothermal alteration zones related to known deposits will be evaluated at the deposit scale and at the scale of the entire BPC.

REGIONAL GEOLOGY

The Flin Flon Belt (FFB) is a Paleoproterozoic greenstone belt located within the Reindeer Zone of the Trans-Hudson Orogen (*see* inset on Fig. GS-3-1). To the north, the FFB is bounded by the Kisseynew Gneiss Belt and, to the south, it extends beneath Paleozoic rocks of the Western Interior Platform. The FFB is composed of structurally amalgamated arc, ocean-floor and ocean-island volcanic assemblages, related turbidite deposits and rare Archean crustal fragments (Stern et al., 1995).

The study area occurs within the central FFB, an island arc–back arc assemblage that consists of a series of fault-bounded segments formed during collisional tectonics (Lucas et al., 1996). Stratigraphic units, which cannot be

[1] Mineral Exploration Research Centre, Department of Earth Sciences, Laurentian University, Sudbury, ON P3E 2C6

[2] Geological Survey of Canada, 601 Booth St., Ottawa, ON K1A 0E8

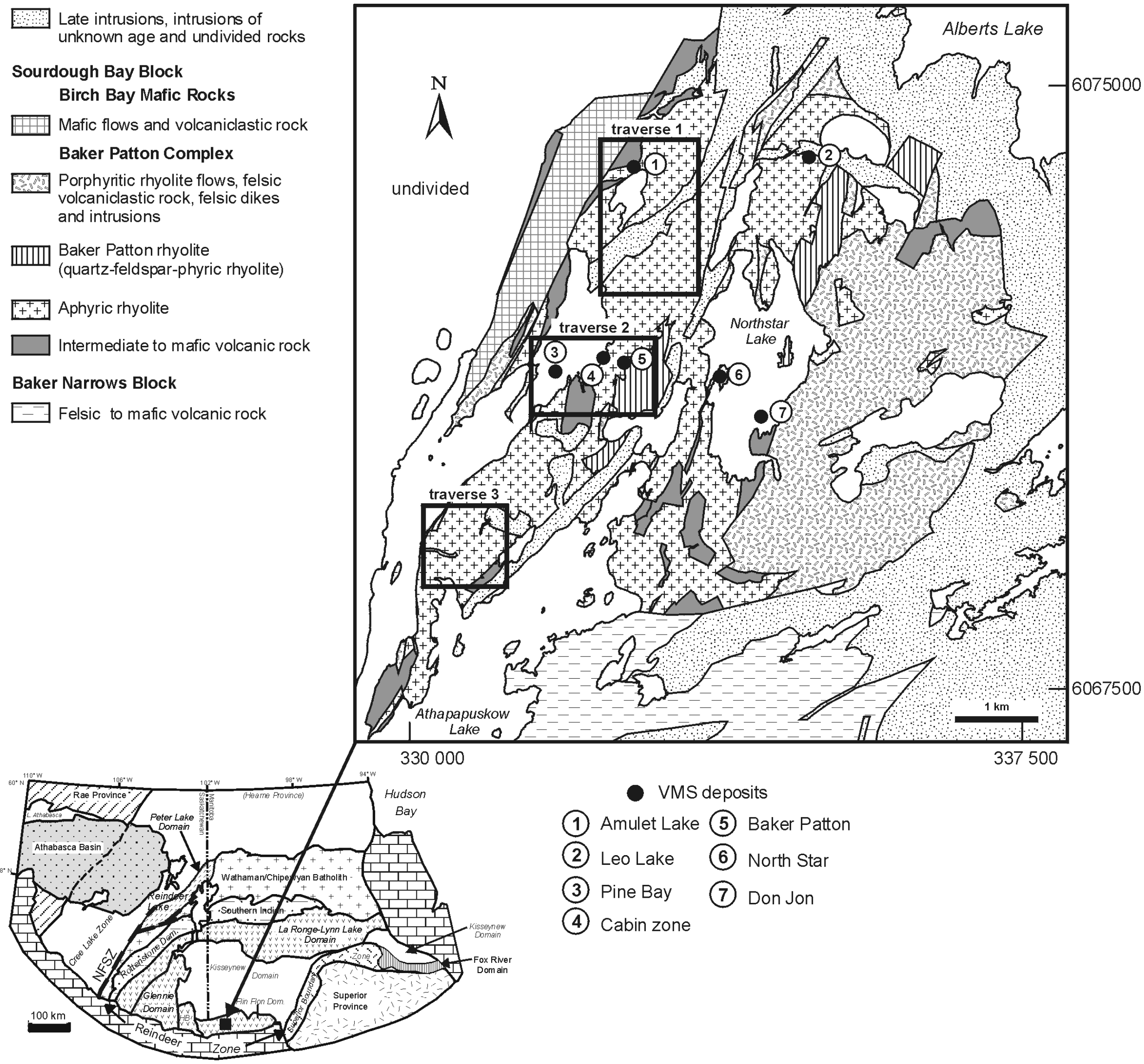

Figure GS-3-1: Baker Patton Complex (after Gale and Dabek, 2002), showing VMS deposits and 2001 field season traverse locations. The Baker Patton Complex is located within the Flin Flon Belt of the Trans-Hudson Orogen (inset).

correlated across block-bounding faults, are well preserved and contain mainly greenschist-facies mineral assemblages (Bailes and Syme, 1989; Lucas et al., 1996).

LOCAL GEOLOGY

The BPC (Fig. GS-3-1) is located approximately 16 km east of the town of Flin Flon and lies within the Sourdough Bay Block of the FFB (Bailes and Syme, 1989). The Sourdough Bay Block is the easternmost VMS-hosting structural domain in the Flin Flon arc assemblage and contains the largest volume of felsic volcanic rocks in the FFB.

Due to bounding regional faults and a lack of radiometric dating, the relative stratigraphic position of the BPC within the Flin Flon arc assemblage remains uncertain. The most recent and detailed mapping of the BPC is the work of George Gale and co-workers (Gale et al., 1992, 1993; Gale and Dabek, 1995, 2002). A number of exploration companies have also created detailed property maps of parts of the BPC. Despite this mapping, many of the relationships between units remain unresolved due to lack of outcrop exposure, especially in eastern areas of the BPC (Gale et al., 1993).

The volcanic rocks of the BPC are mainly rhyolite, although rhyodacite and dacite have been delineated using lithogeochemistry; andesite and basalt are volumetrically insignificant. The rhyolite units are generally differentiated by their phenocryst population as either quartz-feldspar–phyric, feldspar-phyric or aphyric. Lobe-breccia–hyaloclastite facies are common throughout most rhyolitic units, and pillows are frequently noted in mafic units. These features suggest a subaqueous environment of deposition for the volcanic rocks (Prior and Dabek, 1999). Units generally trend northeast, parallel to major faults and shear zones. The dip of the units is near vertical as a result of isoclinal folding (Gale and Dabek, 1995). The main foliation parallels major fault zones that are commonly defined by laterally extensive gabbro sills (Prior and Dabek, 1999).

The locations of VMS deposits within the BPC are illustrated in Figure GS-3-1. The largest is the Pine Bay deposit, which has been reported by the Cerro Mining Company of Canada to contain 1 340 000 tonnes at an average grade of 1.5% Cu (Gale and Eccles, 1988).

WORK COMPLETED AND IN PROGRESS

In order to establish the lithostratigraphy, chemostratigraphy, flow facies, alteration types and alteration distribution of the BPC, three traverses, each approximately 300 m wide and mapped at a scale of 1:3500, were conducted in the western portion of the BPC. The stratigraphy in this area is interpreted to be the structurally duplicated equivalent of stratigraphy to the east (Prior and Dabek, 1999). Figure GS-3-2 shows examples of western BPC rock types and flow morphologies, summarized in preliminary maps and accompanying stratigraphic sections for traverses 1 and 2. Representative samples were collected of all rock types, textures, morphologies, alteration types and alteration intensities on each traverse. Petrography was carried out on 87 samples to aid in subdividing rhyolitic flows and units, to examine the distribution of alteration minerals and to determine the extent of their alteration. The 87 samples were analyzed by ICP-MS to provide a lithogeochemical dataset. This dataset was combined with a larger lithogeochemical dataset of 220 samples collected by George Gale during previous Manitoba Geological Survey (MGS) projects. Gale's samples cover a larger area of the BPC than those collected during this study.

Initial analysis of the geochemical data, using ratios of immobile elements (specifically TiO_2 and Zr), indicates that the mapped aphyric and quartz-phyric rhyolite are compositionally similar and are likely to have been derived from the same source. Discrete aphyric rhyolite flows, established through mapping, show no compositional variation between them. Feldspar-phyric rhyolitic flows, encountered along traverse 3, differ slightly from the aphyric and quartz-phyric rhyolitic flows to the northeast, in that they have a higher TiO_2 /Zr ratio.

Petrography was used document and monitor mineralogical and chemical changes associated with hydrothermal alteration, with the realization that the present mineral assemblages represent metamorphosed equivalents of the original hydrothermal assemblages. The abundances of sericite and chlorite, in particular, vary significantly between traverses and with respect to rhyolite-flow morphology. These minerals are common products of VMS-related hydrothermal alteration (Franklin et al., 1981; Lydon, 1984). Spatial analysis of calculated abundances of sericite and chlorite was carried out, using sericite and chlorite indices (Saeki and Date, 1980). These indices were derived from lithogeochemical data using the formulas shown in Figure GS-3-3, which document increases in the abundance of sericite based on the addition of K and increases in the abundance of chlorite based on the addition of Mg and Fe. The breakdown of plagioclase, which often occurs within the cores of hydrothermal alteration pipes, is reflected in the loss of Na and Ca from the system.

Figure GS-3-3 illustrates the spatial distribution of calculated sericite and chlorite along traverses 1 and 2 using these alteration indices. The distributions of sericite and chlorite are controlled almost exclusively by flow morphology along traverse 1, where they are most abundant within flow breccia and hyaloclastite, which may represent the most 'permeable' areas of the lobe-hyaloclastite flows. Conversely, along traverse 2, sericite and chlorite are both abundant and pervasive throughout. In this case, their distributions are not controlled by primary features or flow morphology. The distribution of sericite and chlorite along traverse 2 is interpreted to define an intense, disconformable and through-going hydrothermal system that extends through the Baker Patton VMS deposit into rhyolitic flows in the footwall to the overlying Pine Bay VMS deposits (Fig. GS-3-3).

Mineralogy established by detailed petrography was also used to aid in qualitative XRD analysis, by providing an independent means to differentiate between different minerals with similar peak intensities at similar angles of analysis. Semiquantitative XRD analysis was carried out, using the WinJade program, on whole-rock powders from samples collected during the 2001 field season and from samples previously collected by George Gale of MGS. The results of this XRD work are currently being evaluated and interpreted.

FUTURE WORK

Lithogeochemical and semiquantitative XRD data will be plotted on traverse maps at 1:3500 scale, as well as on

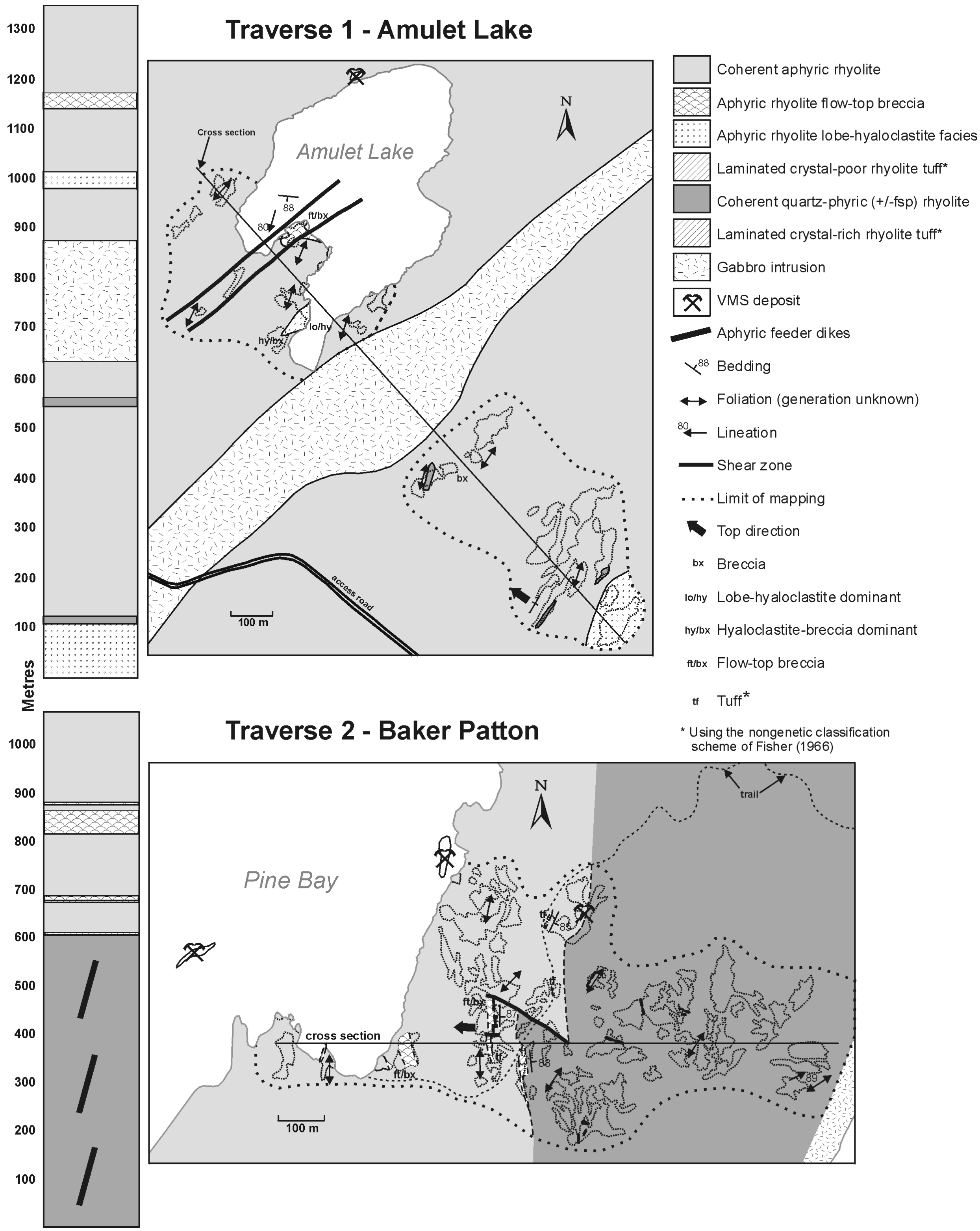

Figure GS-3-2: Maps and schematic cross-sections of traverses 1 and 2 from the Baker Patton Complex alteration study, showing rock types and flow facies. Maps and corresponding cross-sections are not of equal scale.

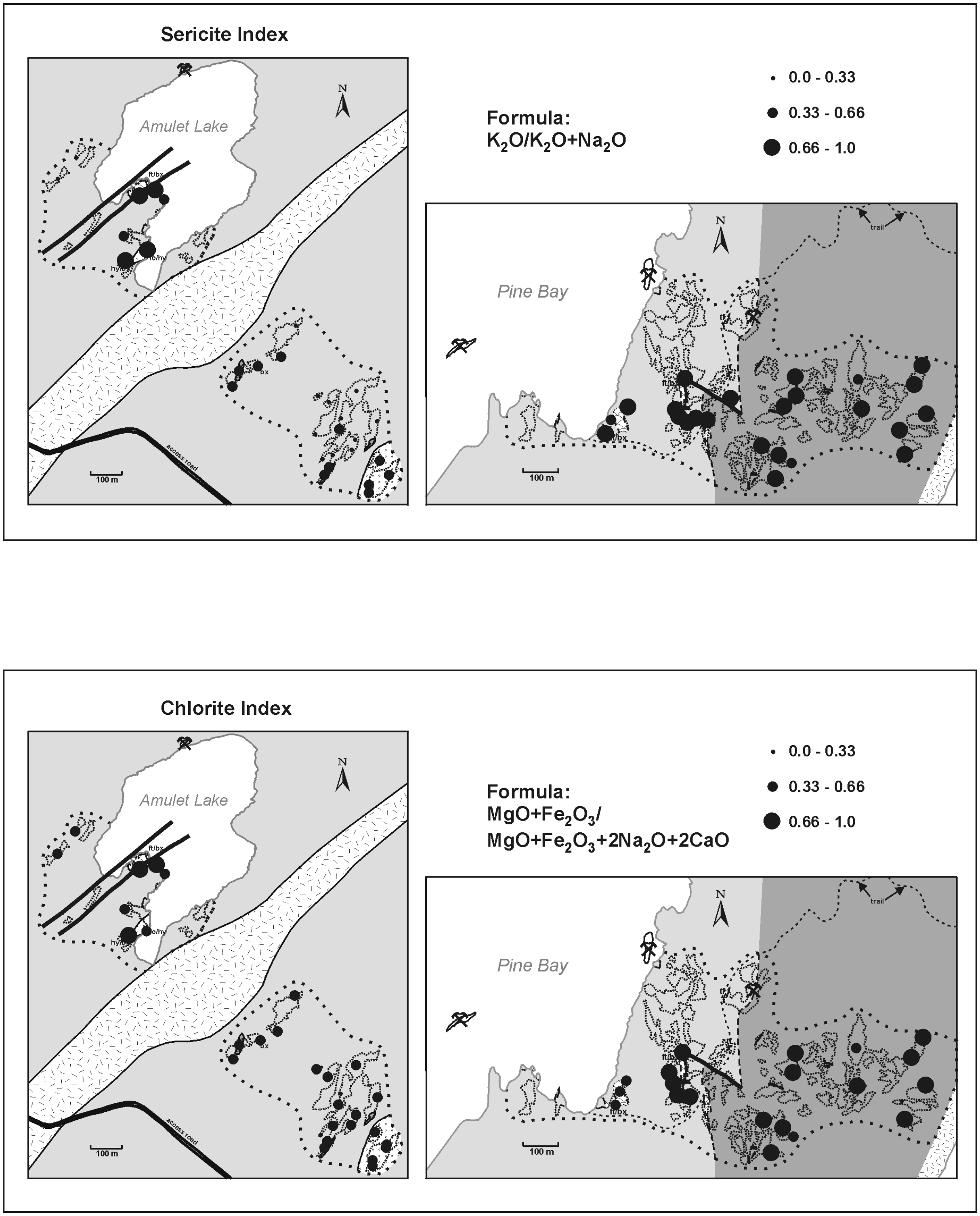

Figure GS-3-3: Chlorite and sericite alteration-index maps for traverses 1 and 2. Along traverse 1, high values are associated with lobe-hyaloclastite and breccia facies. Morphology appears to have no effect on the distribution and abundance of alteration minerals along traverse 2.

a larger 1:10 000-scale map of the entire BPC, and will be analyzed spatially to define and delineate areas of VMS-related hydrothermal alteration. The effectiveness of the two techniques will be compared with respect to varying scales of examination and their usefulness for delineating the known VMS deposits.

ACKNOWLEDGMENTS

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