CHAPTER 2 INTRODUCTION

2.1 Preamble

The Proterozoic Thompson Nickel Belt (TNB) of north-central Manitoba represents a highly prospective, but difficult exploration target. It contains several world-class Fe-Ni-Cu-(PGE) sulfide deposits (e.g., Zurbrigg, 1963; Coats et al., 1972; Peredery, 1979; Peredery et al., 1982; Paktunç, 1984a and b; Bleeker, 1990) and exhibits both of the fundamental elements that define major magmatic sulfide districts: ultramafic cumulate host rocks (serpentinized peridotites and dunites) that represent a dynamic magmatic plumbing system and an abundant sulfur source (sulfide facies iron-formation). However, the rocks in the TNB are complexly deformed and metamorphosed to upper amphibolite facies, which has complicated the geological and stratigraphic relationships, dismembered and separated ores and host rocks, and modified the geochemical and isotopic compositions of the ores and host rocks. To complicate matters further, the rocks in the northern part are poorly exposed and those in the southern part are covered by Paleozoic carbonates. For this reason, relatively little detailed work had been done on these deposits. Although it was known that they occurred at specific levels in the stratigraphic sequence (e.g., Bleeker, 1990) and that they appeared to represent intrusive equivalents of extrusive deposits such as those at Raglan, Kambalda, and Perseverance, much more work was needed to establish the genesis of the host units and the metallogenesis of the sulfide ores.

Previous work by J. Macek and W. Bleeker had established the general stratigraphy of the Ospwagan Group, shown that the ores in the TNB were located in specific stratigraphic positions in the sequence, and that the ores had experience most, if not all of the deformational and metamorphic history of the belt. However, there were still considerable uncertainties regarding the stratigraphic, structural, and tectonic setting of the TNB. Work by O.M. Burnham, L. Hulbert, R.R. Keays, and C.M. Lesher in CAMIRO Project 94-E04 had shown that there appeared to be systematic geochemical, mineralogical, and isotopic differences in the compositions of mineralized and non-mineralized ultramafic intrusions in the TNB. However, none of the sampled intrusions were unequivocally non-mineralized and analogous geochemical/isotopic signatures in similar environments had been attributed to metasomatic processes (e.g., Menard et al., 1996). Recent drilling by Cominco Ltd. had also identified a sequence of extremely well-preserved microspinifex-textured komatiitic basalts in the southeastern extension of the TNB, where it was covered by Paleozoic carbonate rocks (Hulbert et al., 1994). Their presence raised the possibility that Kambalda-type Fe-Ni-Cu-(PGE) mineralization might occur in the southern extension of the TNB. Thus, much more information was required to assess the influences of metamorphism and metamorphism on the geochemical, mineralogical, and isotopic compositions of the ores, host rocks, and country rocks in the TNB.

2.2 Objectives

The overall objectives of the project were to: 1) define the geology, stratigraphy, petrogenesis, and metallogenesis of the ores and host rocks in the TNB, 2) refine geological and geochemical exploration tools applicable to the TNB and other terranes, and 3) aid in the identification of new exploration targets.

Specific objectives were to:

1) Compile existing geological, geochronological, and geochemical data on the TNB and its southern extension,
2) Produce (in collaboration with MGS and GSC colleagues) updated stratigraphic columns and geological maps of the northern, central, and southern parts of the TNB, particularly the various lithofacies of the Ospwagan Group and the occurrences of ultramafic rocks within that sequence,
3) Define the stratigraphic/geochemical/petrogenetic relationships between the various types of ultramafic sills and mafic-ultramafic volcanic rocks and dikes in the TNB,
4) Develop geological and geochemical tools to discriminate between mineralized and non-mineralized ultramafic bodies,
5) Investigate elemental behaviour (chalcophile and lithophile) in the ores and host rocks during magmatic, metamorphic, and tectonic processes as they relate to contamination, metasomatism, and ore redistribution, and
6) Refine regional tectonic and metallogenetic models.

The results of this research were anticipated to be applicable to exploration in the TNB, in particular, and to exploration for ultramafic-hosted Ni-Cu-(PGE) sulfide deposits in complexly deformed and metamorphosed terrains worldwide.

2.3 Research Team

In order to capitalize on available expertise and to ensure that as many objectives as possible could be achieved, the work was done by a multidisciplinary team of researchers:

Laurentian University: Dr. O.M. Burnham (Research Scientist), D. Layton-Matthews (MSc student), Prof. C.M. Lesher, and Prof. R.R. Keays

University of Manitoba: J. Liwanag (MSc student), Prof. N. Halden, D. Michalak (MSc student), and C. Wegleitner (BSc student)

Université de Rennes: Prof. D. Gapais

Université du Québec à Montréal: Dr. N. Machado and Dr. A. Potrel (Post-Doctoral Fellow)

University of Alberta: Prof. L. Heaman and K. Toope (MSc student)

University of Saskatchewan: Dr. K. Ansdell

Brandon University: C. Chandler, E. Ducharme, and C. Freund (BSc Honours students)

Manitoba Geological Survey: T. Corkery, P. Lenton, M. Pacey, Dr. D. Peck[1], Dr. P. Theyer, and Dr. H. Zwanzig

Geological Survey of Canada: Drs. J. Broome, L. Hulbert, J. Kraus (Post-Doctoral Fellow), and W. Bleeker

The researchers were assisted by many company geologists, especially:

Cominco Ltd.: J. Pearson

[1] Currently employed by Anglo-American Ltd.

Falconbridge Ltd.: J. Robertson, P. Tirschmann, and K. Wells

Inco Ltd.: Dr. P. Golightly[2], L. Larson, K. Lutz, H. Mahoney, S. Mooney, D. Owens, R. Somerville, G. Sorensen, and R. Stewart

Hudson Bay Exploration & Development Ltd.: J. Pickell

The involvement of university, provincial, and federal governmental researchers ensured the highest degree of technical expertise.

2.4 Sponsors

The initial sponsors were Cominco Ltd., Falconbridge Ltd., Hudson Bay Exploration & Development Co. Ltd., Inco Ltd., and Teck Ltd., WMC Ltd., and NSERC. Following changes in exploration priorities, Cominco withdrew from the project in 1998, but kept their commitment to donate drill core and geochemical data. For similar reasons Teck withdrew from the project in 1999, but not before arranging for Billiton International Metals B.V. to take their place. We are grateful to John Pearson of Cominco, John Thompson of Teck, James Macdonald of Billiton for coordinating these changes in sponsorship, and to the remainder of the sponsors for increasing their levels of support to allow us to maintain the original budget.

The Natural Sciences and Engineering Research Council of Canada – Collaborative Research and Development Program (NSERC-CRD) generously matched almost all of the industry funding.

2.5 Methodology

The project built on several other recent or concurrent investigations in the TNB: 1) previous and ongoing work by L. Heaman and N. Machado in the region, 2) a recently completed Lithoprobe Trans-Hudson Orogen Transect, 3) a recently completed CAMIRO Project (94E-04: *Application of PGE Geochemistry to Exploration for Ni Sulfide Deposits*), and 4) a concurrent Manitoba Geological Survey TNB compilation mapping program. Integration of the results from these investigations provided an unparalleled knowledge base onto which this project was built.

The project was subdivided into two subprojects: a ***Geology Subproject*** led by N. Halden, and a ***Geochemistry Subproject*** led by C.M. Lesher. For logistical and financial reasons related to the timing of NSERC funding, the Geochemistry Subproject commenced in July 1997, whereas the Geology Subproject commenced in July 1998. D. Peck served as Project Coordinator for the first 3 years of the project; this role was shared by N. Halden and C.M. Lesher for the last year of the project.

Cominco, Falconbridge, Inco, and Hudson Bay provided access to their exploration properties, mines, diamond drill cores, geophysical data[3], and geological data. Cominco, Falconbridge, and Hudson Bay provided geochemical data.

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[2] Retired, now an independent geological consultant in Sudbury.

[3] Indirectly, through the contribution of J. Macek to the compilation maps produced by the TNB Working Group

2.5.1 Geology Subproject

The Geology Subproject involved regional mapping, geochronology, tectonics, geophysics, and GIS data management and analysis. Data acquisition, organization, visualization, analysis, and presentation utilised state-of-the-art GIS methods.

Field mapping and drill core logging was done by the TNB Geology Working Group (Macek, Peck, Theyer, and Zwanzig) and Kraus, with assistance from Chandler, Ducharme, and Freund. Structural work was done by Potrel, Gapais, Kraus, and Zwanzig with assistance from Wegleitner. The geochronological work was done by Machado, Potrel, Heaman, and Toope. The GIS work was done by Michalak, Lenton, Pacey, with assistance from Broome and Halden.

2.5.2 Geochemistry Subproject

The Geochemistry Subproject involved surface and underground mapping, drill core logging, sampling, and mineralogical/geochemical/isotopic analysis of mineralized and non-mineralized peridotites, Ospwagan Group metasedimentary and mafic volcanic rocks, mafic dikes, and Fe-Ni-Cu-(PGE) sulfide mineralization. Existing samples and data were utilised as much as possible, but the most important goal was to generate a high-quality, internally consistent database. Analytical methods are described in **Appendix 1**. The drill core studies and sampling were done by Burnham, Keays, Layton-Matthews, Lesher, Liwanag, and Theyer. The mineralogical, geochemical, and petrological studies were done primarily by Burnham, Layton-Matthews, and Liwanag, with assistance from Halden and Lesher.