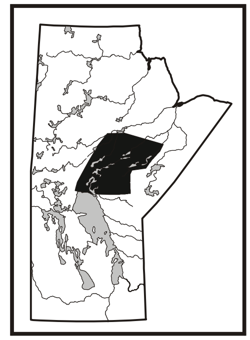
GS-21 SUMMARY OF METALLOGENETIC AND PETROGENETIC FEATURES OF ARCHEAN ANORTHOSITES AND ASSOCIATED MAFIC AND ULTRAMAFIC ROCKS IN THE SUPERIOR PROVINCE, MANITOBA (PARTS OF NTS 63I, 63J, 63P AND 64A)



**by D.C. Peck, N.M. Halden[1], S. Jobin-Bevans[2], H.D.M. Cameron and P. Theyer**

Peck, D.C., Halden, N.M., Jobin-Bevans, S., Cameron, H.D.M., and Theyer, P. 1999: Summary of metallogenetic and petrogenetic features of Archean anorthosites and associated mafic and ultramafic rocks in the Superior Province, Manitoba (parts of NTS 63I, 63J, 63P and 64A); *in* Report of Activities, 1999, Manitoba Industry, Trade and Mines, Geological Services, p. 94-96

## SUMMARY

A metallogenetic and petrogenetic investigation of several Archean anorthositic intrusions occurring in the Superior Province of Manitoba (Fig. GS-21-1) has been completed. A comprehensive report containing the results from this study is in preparation. The most important findings are described below.

(1) Economically important stratiform, magmatic ilmenite-magnetite mineralization is developed in the Pipestone Lake anorthosite complex. Similar oxide mineralization occurs in the adjacent Kiskitto Lake intrusion (Fig. GS-21-2);

(2) Magmatic Cu-Ni-PGE sulphide mineralization is present in anorthositic intrusions in the Bird River greenstone belt (see Peck et al., GS-22, this volume). The disseminated sulphide mineralization developed in the Mayville intrusion of the Bird River belt is very similar, in a lithostratigraphic context, to contact-type PGE-rich disseminated sulphide deposits in layered anorthositic intrusions in central Ontario (Peck et al., 1993);

(3) The anorthositic rocks investigated are distinguished from other Archean mafic rock suites by the common presence of plagioclase megacrysts (Fig. GS-21-3). In the study area, plagioclase megacrysts occur in a wide variety of mafic and ultramafic rock types including small to large mafic dykes, pillow basalt, massive basaltic komatiite, layered ultramafic-mafic intrusions and, most commonly, layered gabbro-anorthosite intrusions;

(4) In many cases, the plagioclase megacrysts are xenocrysts. They typically show evidence of partial resorption by enclosing gabbroic to pyroxenitic matrix and display more calcic compositions than adjacent, finer-grained matrix plagioclase (Jobin-Bevans et al., 1997). Field and geochemical data obtained during the current study suggest that the megacrysts crystallized in the upper parts of large, slowly-cooled, shallow-level ultramafic-mafic stratiform intrusions;

(5) The trace element geochemistry of the anorthositic rocks is extremely variable (Fig. GS-21-4). Regional geochemical variations may have arisen from slight differences in the chemistry of the mantle sources or from variable degrees of crustal assimilation. Sm-Nd isotopic investigations are planned in order to test these alternative hypotheses. Geochemical variations within individual plutons can be demonstrated to have resulted from effective fractional crystallization. In the Pipestone Lake anorthosite complex, fractional crystallization involved efficient gravity and/or flow-driven sorting of buoyant, large plagioclase

[1] Department of Geological Sciences, University of Manitoba, 125 Dysart Road, Winnipeg, Manitoba R3T 2N2

[2] Department of Earth Sciences and Mineral Exploration Research Centre, Laurentian University, Ramsey Lake Road, Sudbury, Ontario P3E 2C6

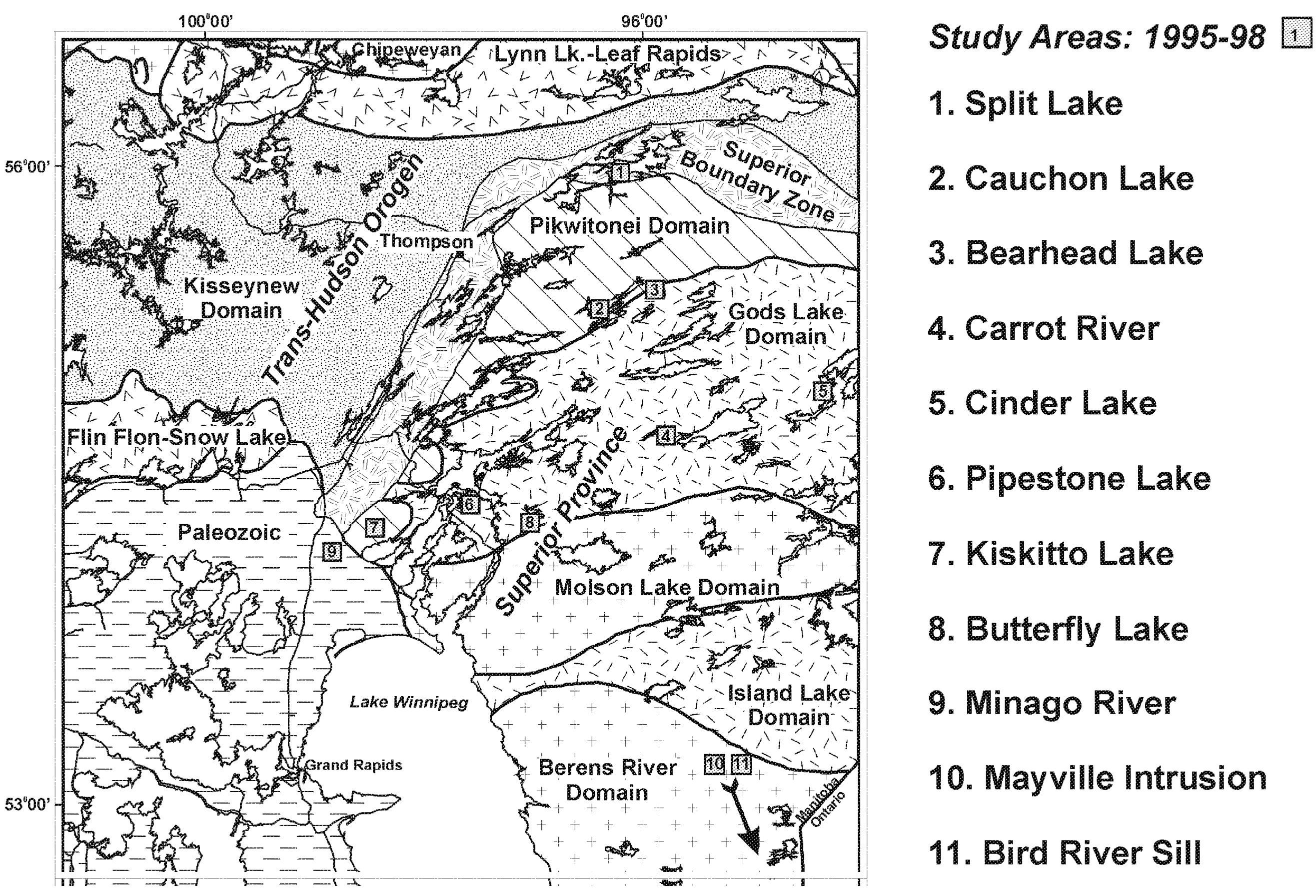



*Figure GS-21-1: Location of study areas in the Superior Province, Manitoba.*

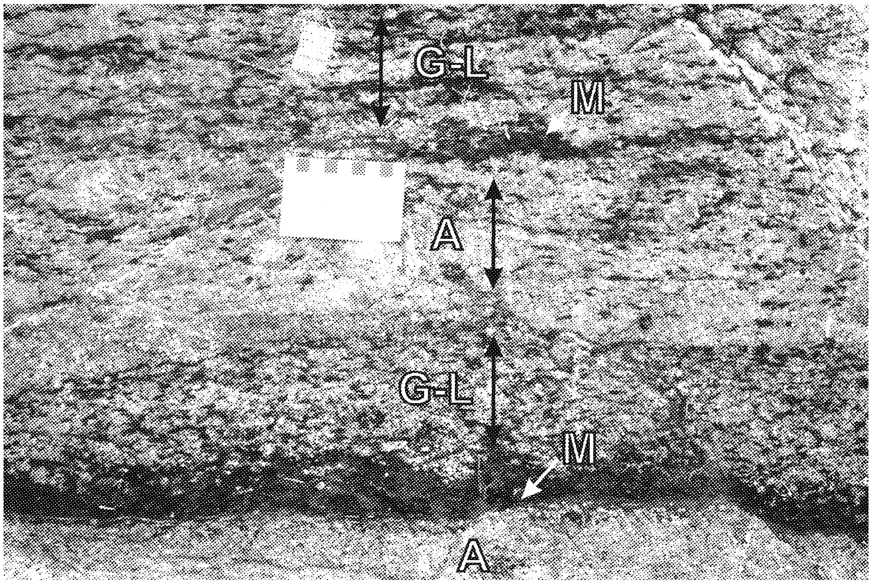



*Figure GS-21-2: Typical cyclic modal layering in the Pipestone Lake anorthosite complex. Ilmenite- and magnetite-rich melagabbro layers (M) grade sharply upward into poikilitic gabbro and leucogabbro (G-L) and massive to megacrystic anorthosite (A). The younging direction, based on the observed layering, is to the top of the photograph (north).*

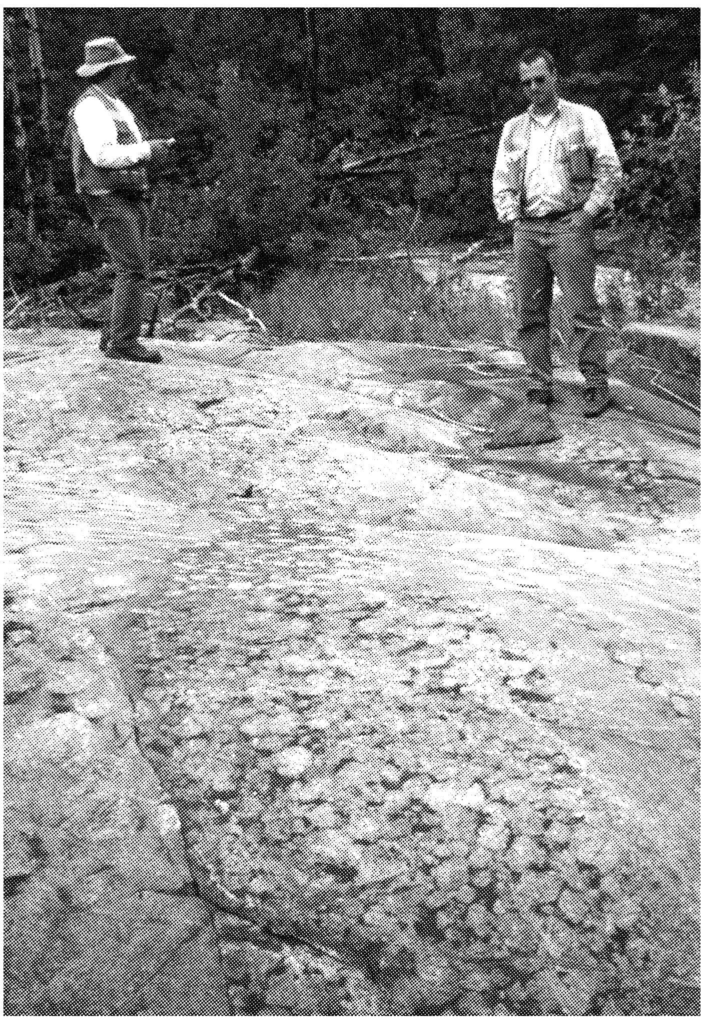


*Fig. GS-21-3: Modal and grain size layering produced by sorting of plagioclase megacrysts, Pipestone Lake anorthosite complex.*

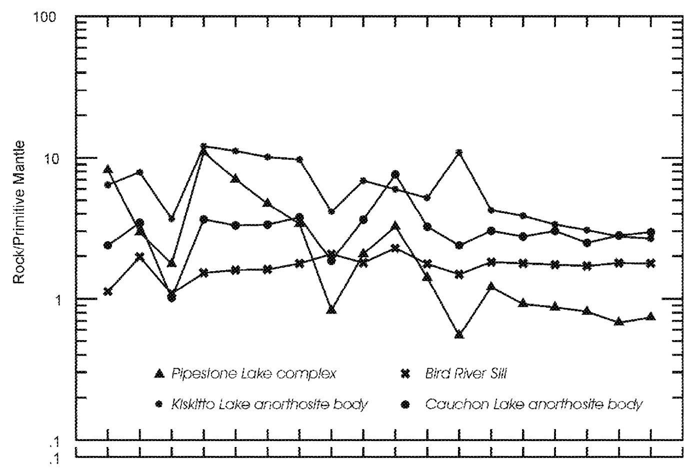



*Figure GS-21-4: Mantle-normalized multielement plots for representative samples of leucogabbro from the Cauchon Lake anorthosite body, the Kiskitto Lake anorthosite body, the Pipestone Lake anorthosite complex and the Bird River Sill. See Fig. GS-21-1 for the locations. Mantle normalizing values are from McDonough and Sun (1995). Data are unpublished. Note: (1) the variable Nb, Zr, Eu and Ti abundances, which can be controlled by fractional crystallization of minor phases such as magnetite and zircon and, (2) the variable slopes of the profiles, which likely reflect differences in mantle source composition or degree of crustal contamination of the parental magmas. For example, rocks from the Pipestone Lake complex and the Bird River Sill commonly have primitive-mantle-like trace element ratios whereas samples from both the Cauchon and Kiskitto Lake anorthosite bodies are typically enriched in the highly incompatible elements (left side of diagram) relative to less incompatible trace elements (right side of diagram).*

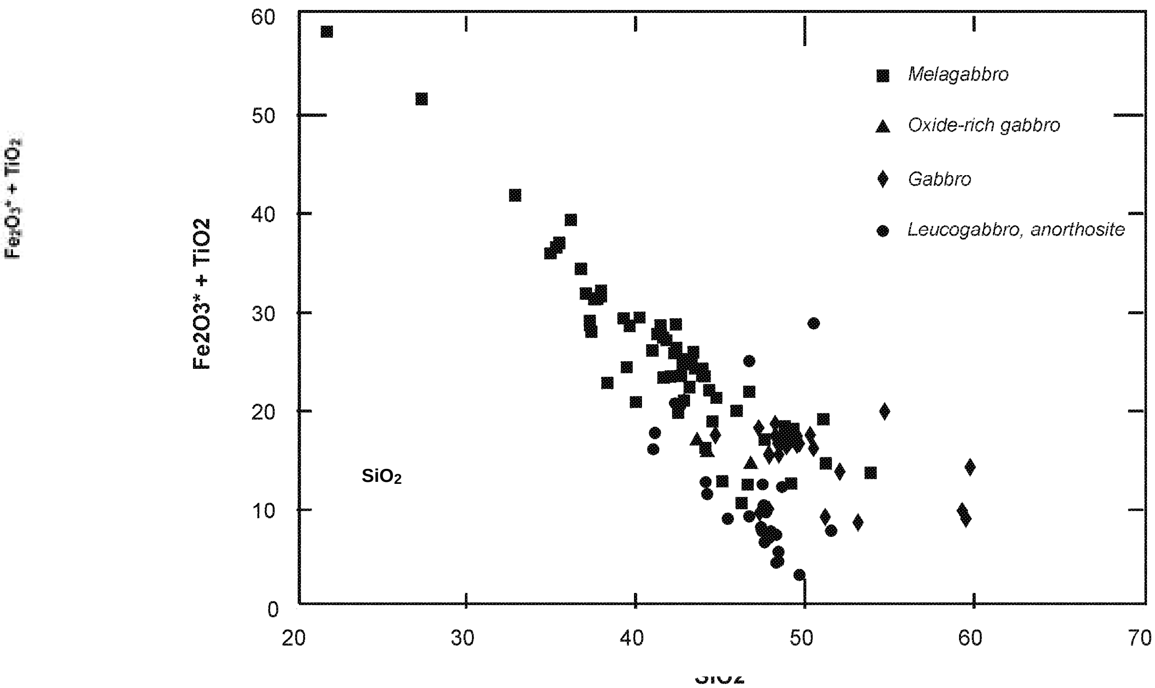



*Figure GS-21-5: Plot of whole-rock abundances, in weight percent, of $Fe_2O_3$* + TiO2 ($Fe_2O_3$* = total iron reported as $Fe_2O_3$) against $SiO_2$ for the principal rock types from the Pipestone Lake anorthosite complex. Data are unpublished.*

megacrysts from high temperature Al-basalt parent magma and denser, cooler, ferrogabbroic residual liquid (Fig. GS-21-2);

(6) The stratigraphic setting of the anorthositic intrusions is remarkably similar. Most of them occur at the base of juvenile mafic volcanic sequences of tholeiitic or komatiitic affinity containing little or no interflow sedimentary rocks. The anorthositic rocks, as in the Bird River Sill, are interpreted to represent the products of fractional crystallization of ultramafic or high Mg-basalt magmas emplaced at shallow crustal levels. In several areas, the anorthositic intrusions are chemically similar to and may have fed overlying plagioclase phyric mafic dykes and flows.

(7) The anorthositic intrusions appear to have developed in continental rift environments and, despite the occurrence of ilmenite deposits in some of the host intrusions, are interpreted to have been derived from low-Ti tholeiitic basalt or komatiitic basalt magmas originating from a depleted mantle source. At low pressures and following an early stage of pyroxene and olivine crystallization, the anorthositic intrusions crystallized only plagioclase, leading to an Fe-enrichment trend (e.g., Fig. GS-21-5) that locally produced cumulate oxide layers in ferrogabbroic residual liquids.

## ACKNOWLEDGEMENTS

This research is supported by an NSERC Collaborative Research and Development Grant awarded to N. Halden and D. Peck. Financial and technical support was provided by Gossan Resources Ltd., Cross Lake Mineral Exploration Inc. and Exploratus Elementis Diversis. Doug Berk and his staff are thanked for their efforts.

## REFERENCES

Jobin-Bevans, L.S., Halden, N.M., Peck, D.C., and Cameron, H.D.M. 1997: Geology and oxide mineralization of the Pipestone Lake anorthosite complex; Journal of Exploration and Mining Geology, v. 6, p. 35-61.

McDonough, W.F. and Sun, S.S. 1995: The composition of the earth; Chemical Geology, v. 120, p. 223-253.

Peck, D.C., James, R.S., and Chubb, P.T. 1993: Geological environments for PGE-Cu-Ni mineralization in the East Bull Lake gabbro-anorthosite intrusion, Ontario; Journal of Exploration and Mining Geology, v. 2, p. 85-104.