ASSEAN LAKE ANCIENT CRUST: AN UPDATE

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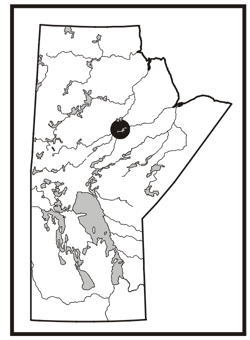

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SUMMARY

In 1997, the first hints of ancient crust were discovered at Assean Lake in northern Manitoba. This surprising discovery has led to extensive research in the Assean Lake area and the adjacent crustal domains of the Superior Boundary Zone. The Assean Lake ancient crust represents an Archean assembly of crustal segments that trend approximately 090 to 110º and are overprinted by Neoarchean and Paleoproterozoic deformation and metamorphism trending 060°. The Assean Lake crustal complex can be subdivided into 1) a southern, migmatitic, supracrustal series of quartz arenite, arkose and metagreywacke gneiss, containing amphibolite and silicate-facies iron-formation, and 2) a central, orthogneiss-dominated crustal segment that intrudes 3) a northern package of supracrustal rocks dominated by mafic to intermediate metavolcanic rocks and greywacke gneiss.

Combined Sm-Nd isotopic and U-Pb (by thermal-ionization mass spectometry [TIMS] and sensitive high-resolution ion microprobe [SHRIMP]) geochronological results indicate that Assean Lake preserves Paleoarchean to Mesoarchean crust that underwent a complex and prolonged history spanning more than two billion years.

INTRODUCTION

This program began in 1995 with the collection of samples in the Split Lake and Nelson River areas for U-Pb geochronology (Heaman and Corkery, 1996). It led to a detailed (1:50 000 scale) mapping project in 1997 at Assean Lake to better understand the Assean Lake deformation zone and the geological nature, kinematics and changes across this presumed Archean–Paleoproterozoic boundary (Böhm, 1997). Since 1997, Sm-Nd isotopic studies have been applied in conjunction with integrated mapping and reconnaissance programs on a regional scale. The Sm-Nd isotopic tool has proven to be ideal for discriminating between ancient (i.e. Paleoarchean to Mesoarchean), Neoarchean (i.e. typical Superior Province) and Paleoproterozoic (Trans-Hudson Orogen) crust. Based on the Nd isotope information, key samples were then analyzed by U-Pb dating methods in order to get primary and metamorphic ages. The combination of Nd isotope and U-Pb geochronological data has been instrumental in leading us to propose a new geological configuration of the craton margin, as indicated in Figure GS-25-1 and discussed in Böhm et al. (2000b). One of the most exciting results from this project so far is the identification of an assemblage of rocks in the Assean Lake area, previously mapped as Proterozoic, that is now known to be Mesoarchean (Böhm et al., 2000a). Evidence for ancient (pre-3.5 Ga) crust has provided enormous excitement for the possible preservation of some of the oldest rocks on Earth at Assean Lake. In addition, the re-interpretation of these rocks opens up potential for new mineral-exploration targets in this region.

The aim of this report is to focus on recent field work that provides an update on the component rock types, structural relationships and mineral potential of the ancient crust at Assean Lake. Together with

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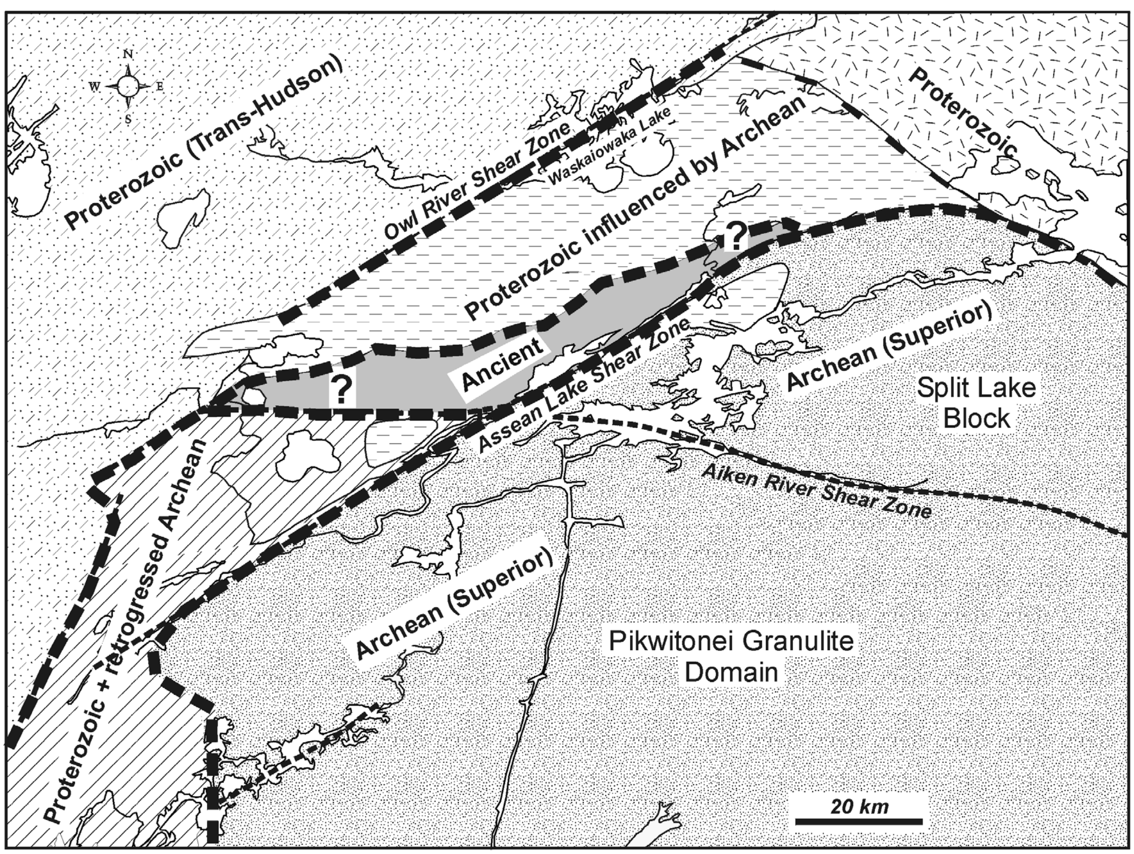


Figure GS-25-1: General geology and domain subdivisions in northwestern Superior Province.

geochemical, isotope and geochronological results, these new field observations should contribute to a better understanding of the nature and evolution of the Assean Lake ancient crust, and thus provide new insights into the early crustal evolution of the Earth.

GEOLOGY OF THE ASSEAN LAKE AREA

The more than 120 km^2 of ancient crust exposed at Assean Lake represents an Archean assembly of crustal segments that trend approximately 090 to 110º and are overprinted by Neoarchean and Paleoproterozoic deformation and metamorphism trending 060º (Fig. GS-25-2). The Assean Lake crustal complex can be subdivided into 1) the Clay River paragneiss, a southern, migmatitic, supracrustal series of quartz arenite, arkose and metagreywacke gneiss, containing amphibolite and silicate-facies iron-formation, and 2) a central orthogneiss-dominated crustal segment intruding 3) the Lindal Bay paragneiss, a northern package of supracrustal rocks dominated by mafic to intermediate metavolcanic rocks and greywacke gneiss.

Clay River Paragneiss and Related Intrusive Rocks

At the west end of Assean Lake, north of the main Assean Lake deformation zone, outcrop is dominated by paragneiss with subordinate orthogneiss (Fig. GS-25-2). Two colour varieties of paragneiss occur in this region (pink and grey). The high degree of recrystallization, mobilization and melt injection in the pink gneiss generally masks its probable sedimentary origin (i.e. derived from arkosic sedimentary rocks). Only the garnetiferous, greywacke-derived, grey gneiss is recognized as having a sedimentary origin. In addition, the paucity of outcrop and strong east-northeast-trending structural overprint associated with the Assean Lake Shear Zone preclude definition of mappable stratigraphy. Nevertheless, four distinct units can be described from this southern, migmatitic, supracrustal series.

The core of the Clay River paragneiss is a cordierite-sillimanite-garnet–bearing biotite metatexite (Fig. GS-25-3a). This migmatitic greywacke gneiss is interpreted to represent a sequence of thickly bedded, psammitic to semipelitic greywacke, most likely formed by density flows. Outcrops show 5 to 15% in situ mobilizate and minor associated garnetiferous pegmatitic injection. The Clay River metagreywacke is associated, on both the north and south sides, with a 5 to 10 m thick sequence of amphibolite. Decametre-scale layered amphibolite varies from massive, coarse–grained, salt-and-pepper–textured, hornblende-plagioclase amphibolite (Fig. GS-25-3b) to layered hornblende-diopside amphibolite interlayered with pelitic greywacke gneiss.

To the north and south of the amphibolite is a K-feldspar- and magnetite-bearing arkosic metatexite (Fig. GS-25-3c) that is strongly recrystallized and contains up to 25% mobilizate and injected granodioritic *lits*. This arkosic gneiss has previously been mapped as Sickle Formation (Lenton and Corkery, 1981). The compositional layering and interlayering with amphibolite of the Clay River paragneiss series are interpreted as being the result of primary sedimentary layering, migmatization and injection phases.

White-weathering, feldspathic biotite gneiss forms the southern and northern unit of the Clay River paragneiss (one outcrop displays a vague hint of trough cross-bedding). These gneissic units are highly variable in quartz content and probably represent quartz arenite composition in some layers (Fig. GS-25-3d).

Central Orthogneiss-Dominated Segment

The area north of the Clay River paragneiss series is dominated by a sequence of mainly 3.2 Ga tonalite to granodiorite intrusions and derived gneissic rocks. Similar to the Clay River paragneiss, the central orthogneiss underwent migmatization and was injected by later pegmatitic melt phases, resulting in variably layered orthogneiss (Fig.

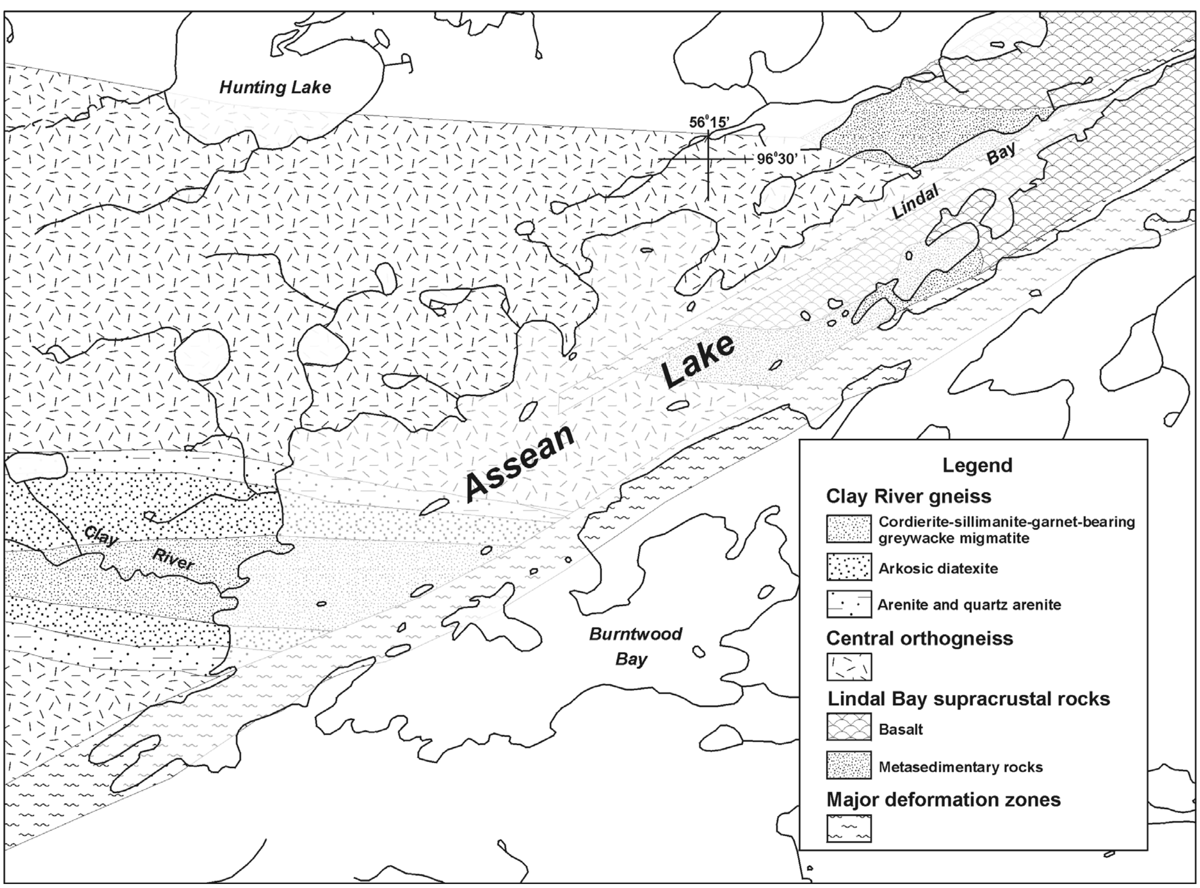


Figure GS-25-2: General geology of the Assean Lake area.

a)

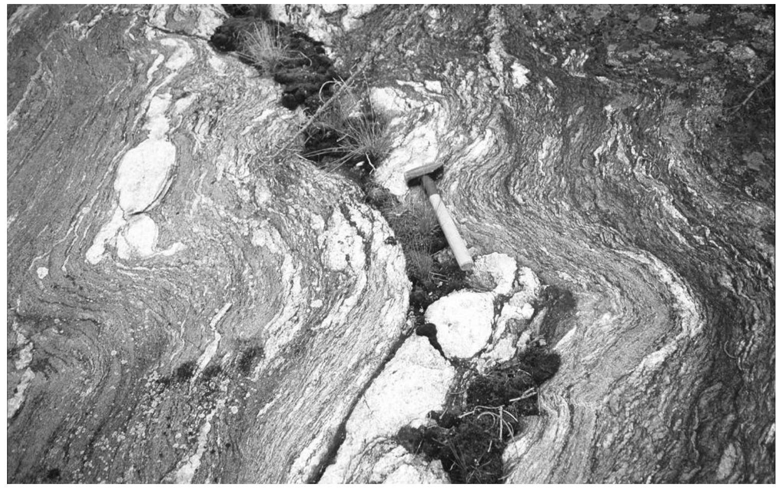
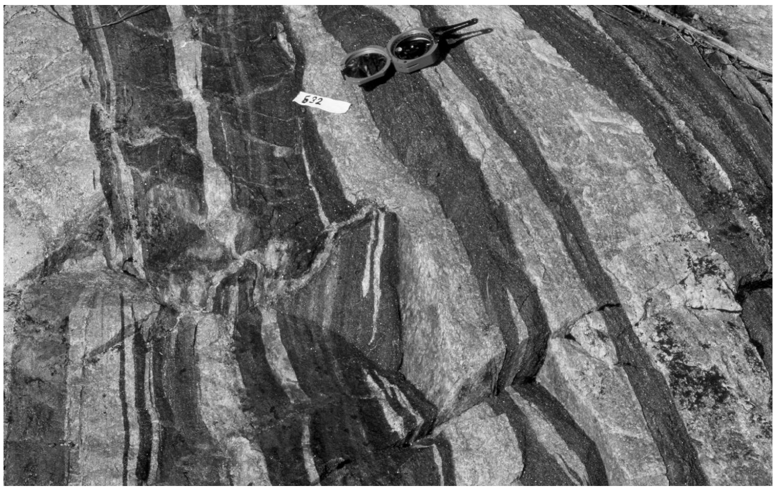
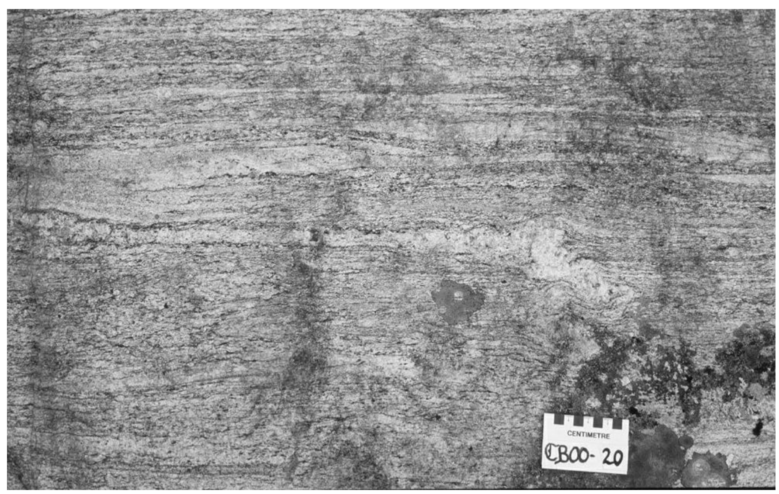


Figure GS-25-3: Clay River metasedimentary rocks: a) cordierite-sillimanite-garnet–bearing greywacke migmatite, b) amphibolite, c) arkosic diatexite, d) arenite and quartz arenite.



b)

c)



d)

GS-25-4a, -4b). Larger, metre-scale, homogeneous pegmatite bodies seem to be directly related to pegmatite injection in the migmatitic orthogneiss. Relict lenses of paragneiss and minor interlayered amphibolite indicate that the central orthogneiss intruded an older supracrustal sequence. Centimetre- to decimetre-scale paragneiss lenses are generally fine-grained, garnet-bearing biotite gneiss. Detailed geochemical analysis of amphibolite samples is in progress and should address the question of whether these mafic lenses and layers represent relicts of early mafic dykes or form part of a supracrustal sequence that includes the above biotite gneiss.

Lindal Bay Supracrustal Sequence and Younger Intrusive Rocks

In the Lindal Bay area of northeastern Assean Lake, a package of supracrustal rocks dominated by mafic to intermediate metavolcanic rocks and subordinate metasedimentary rocks has been identified (Fig. GS-25-2). As in the Clay River area, a number of rock units can be defined, but stratigraphic relationships are difficult to determine due to the complex structural overprints and lack of continuous outcrop.

On the north shore of Lindal Bay, a sequence of rock units trending 090 to 110° is dominated by amphibolite, derived from mafic volcanic rocks, and associated gabbro sills with subordinate greywacke sedimentary rocks (Fig. GS-25-2). Near the contact with the central orthogneiss sequence to the southwest, granodiorite gneiss forms discrete layers in the supracrustal rocks, but contact relationships are overprinted. On the south shore of Lindal Bay, metasedimentary rocks dominate, with subordinate amphibolite, derived from mafic and ultramafic volcanic rocks, along the northwest margin. Rock units in this area are strongly re-oriented by the east-northeast-trending deformation zones.

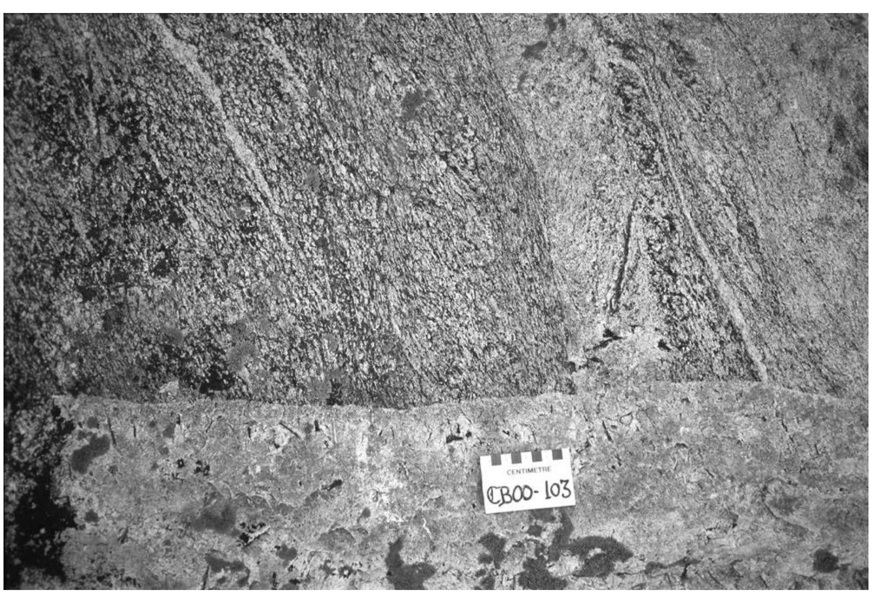
The mafic volcanic rocks are generally highly deformed and vary from fine- to medium-grained, massive to centimetre-scale layered, hornblende-plagioclase amphibolite. In several locations, however, the layering can be recognized as remnants of pillow selvages (Fig. GS-25-5a). These rocks are predominantly basaltic in composition, with subordinate andesitic and ultramafic rocks. The ultramafic rocks occur as isolated outcrops with intrusive textures, and their age relationship to the paragneiss sequence is uncertain.

Metasedimentary units are generally thinly bedded and include quartz arenite, silicate-facies iron-formation, layered amphibolite, and mafic lithic and psammitic greywacke (Fig. GS-25-5b). Outcrops are generally small and most are dominated by one rock type. Stratigraphic relationships can only be observed in a few locations. At one location, quartz arenite grades into a garnetiferous plagioclase gneiss and then into thinly bedded, chert-anthophyllite-silicate iron-formation (Fig. GS-25-5c). The amphibole-rich layers become more abundant and the chert layers decrease, over a distance of 30 cm, into staurolite- and amphibole-bearing mafic pelite. This sequence then grades into thinly

a)

Figure GS-25-4: Central orthogneiss from the north shore of Assean Lake: a) hornblende-biotite granodiorite gneiss with pegmatitic melt injection, b) hornblende tonalite intruded by straight-walled pegmatite.

b)

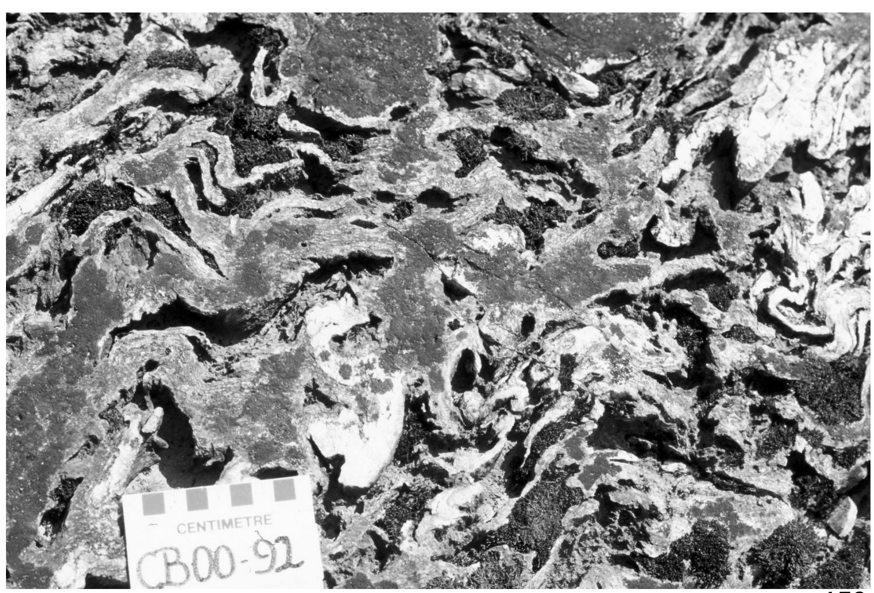


a)

Figure GS-25-5: Lindal Bay supracrustal rocks: a) highly strained pillowed basalt, b) staurolite-bearing pelitic metagreywacke, c) silicate-facies iron-formation.

b)

c)



layered staurolite- and biotite-bearing pelitic greywacke. Segments of this stratigraphy are observed on numerous outcrops on the peninsula between Lindal Bay and southeastern Assean Lake, but a sedimentary stratigraphy has not been determined. The contact relationships between the volcanic and sedimentary sequences are also unclear. However, both rock units seem to be intruded by later granodiorite to granite and pegmatite.

ECONOMIC CONSIDERATIONS

The Assean Lake area was found to have gold potential in the late 1930s (Lindal and Dunbrak veins), and a massive sulphide body was drilled in the 1960s. Lead has been known on Galena island since the early 1960s as well. Geological findings of this study may both explain and enhance the economic potential of the area. The Mesoarchean assemblage has the elements of a rift sequence, not unlike the Thompson Nickel Belt except in age. The recognition of zinc-lead showings in highly strained orthogneiss has until now been at most a curiosity. However, the recognition that the gneiss represents a paragneiss sequence may indicate that SEDEX-type deposits could occur in the area, as well as shear-hosted gold and nickel deposits.

The occurrence of thick ancient crust in this region may also provide a potential area for diamond-bearing kimberlite pipes.

DISCUSSION

Integrated mapping and geochemical, Sm-Nd isotopic and U-Pb geochronological studies across the northwestern Superior craton margin over the past five years have resulted in a re-interpretation of the location and nature of the boundary zone between Archean rocks of the Superior Province and Paleoproterozoic rocks of the Trans-Hudson Orogen in the region northeast of Thompson. Based on the discovery of ancient (pre-3.5 Ga) crust at Assean Lake, our research in this area has been intensified and continues to reveal surprising results. The mapping and sampling program during the 2000 field season was designed to document and better define the nature of the rock types that form part of the Assean Lake ancient crustal complex. The 2000 fieldwork identified three crustal assemblages as described above. Samples were collected from all major rock units for further geochemical, isotopic and geochronological studies. Highlights of the 2000 field program include the identification of two distinct supracrustal packages, separated by an orthogneiss-dominated central sequence. Within the supracrustal sequences, silicate-facies iron-formation and metabasalt flows provide critical stratigraphic horizons with which to trace the structurally complex and incomplete stratigraphic assemblies.

Unravelling the nature and history of a complex high-grade terrain such as the Assean Lake ancient crust requires a combination of detailed mapping, and isotope and geochronological tools. In addition to the continuous fruitful collaboration between researchers at the University of Alberta and the Manitoba Geological Survey, this project will benefit from collaboration with R. Stern, who is in charge of the sensitive high-resolution ion microprobe (SHRIMP) laboratory at the Geological Survey of Canada in Ottawa. For example, the first ion microprobe U-Pb age results from the Assean Lake ancient crust confirm the existence of crustal components as old as 3.9 Ga preserved in meta-greywacke detritus. Considering the size, complexity and heterogeneity of the Assean Lake ancient crust, this area clearly holds enormous potential for providing clues to the nature and evolution of Earth's earliest crust.

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