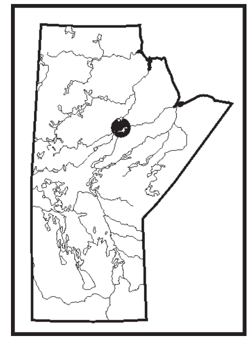
## GS-17 Structural geology of Assean Lake, Manitoba (NTS 64A1, 2 and 8)

by Y.D. Kuiper[1], S. Lin[1], C.O. Böhm and M.T. Corkery



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### Summary

This report summarizes new structural interpretations of the Assean Lake deformation zone and the Mesoarchean Assean Lake Crustal Complex to the north. The Assean Lake deformation zone shows dextral, southeast-side-up movement. It was probably active in the Paleoproterozoic, with possible earlier movement in the Neoarchean. Northwestern Assean Lake is structurally dominated by upright, moderately east-plunging folds. To the northeast, along Lindal Bay, these folds are strongly overprinted by dextral, southeast-side-up shear, which is probably related to movement on the Assean Lake deformation zone.

The discovery of gold, hosted within the Assean Lake deformation zone south of Lindal Bay (Assean Lake Hunt zone), has prompted a reevaluation of this area. The high-grade gold mineralization consists of gold-bearing quartz veins emplaced within tightly folded rocks of the Assean Lake Crustal Complex. Vein emplacement is associated with activity of the Assean Lake deformation zone under greenschist-facies metamorphic conditions. The timing of this deformation is presumed to be Paleoproterozoic, based on the low metamorphic grade and lack of significant structural and metamorphic overprint of the greenschist-facies shear fabric.

### Introduction

The Assean Lake deformation zone at Assean Lake separates the Neoarchean Split Lake Block to the southeast from the Mesoarchean Assean Lake Crustal Complex to the northwest (Böhm et al., 2000, 2003; Figure GS-17-1). Structural mapping was conducted during three weeks in 2003 and two weeks in 2004. Preliminary results were presented in Kuiper et al. (2003). A new contribution following this year's mapping is that rocks of northwestern Assean Lake are deformed by moderately east-plunging, open to isoclinal folds. These folds have not previously been recognized. In Lindal Bay (Figure GS-17-1), these folds may be present but they are obscured by overprinting dextral shear, probably related to movement on the Assean Lake deformation zone. This report is accompanied by preliminary map PMAP2004-2 (Kuiper et al., 2004).

### Structural geology of Assean Lake

Based on new structural data from this summer's mapping, the structural geology of the Assean Lake area is partly reinterpreted (cf. Kuiper et al., 2003) and structural domains are redefined as follows: 1) the Assean Lake deformation zone, 2) northwestern Assean Lake, 3) southern Lindal Bay, and 4) northern Lindal Bay (Figure GS-17-1).

Rocks of the Assean Lake Crustal Complex have been previously described by Corkery et al. (2000) and Böhm et al. (2003), and all rock types of Assean Lake have been described by Böhm (1997a; cf. Böhm, 1997b and Haugh, 1969). They reported that rocks of the Split Lake Block are variably retrogressed, granulite-grade granitic gneiss, hornblende-bearing granodioritic gneiss, lenses and dikes of deformed amphibolite, and aplite dikes. Rocks of the Assean Lake Crustal Complex consist of variably retrogressed, amphibolite-grade granitic and tonalitic gneiss, metasedimentary rocks, layered amphibolite and pegmatite. All rocks are deformed.

#### *Assean Lake deformation zone (domain 1)*

The Assean Lake deformation zone, which contains mylonite, protomylonite and some ultramylonite (Figure GS-17-1; Kuiper et al., 2004), dips steeply to the southeast (see foliations in Figure GS-17-2a). Fold axes and lineations lie within the plane of the shear zone (Figure GS-17-2a–c). Southeast-side-up, dextral movement is indicated by sheath folds. One generation of commonly asymmetric folds was recognized in the shear zone. These folds may be related to sheath folding. S- and Z-folds are plotted in Figure GS-17-2b. The S- and Z- fold axes meet at a moderately to steeply northeast plunge, which may approximate the shear direction. Lineations form clusters plunging moderately to the northeast and moderately to the southwest (Figure GS-17-2a). Northeast-plunging lineations are either stretching

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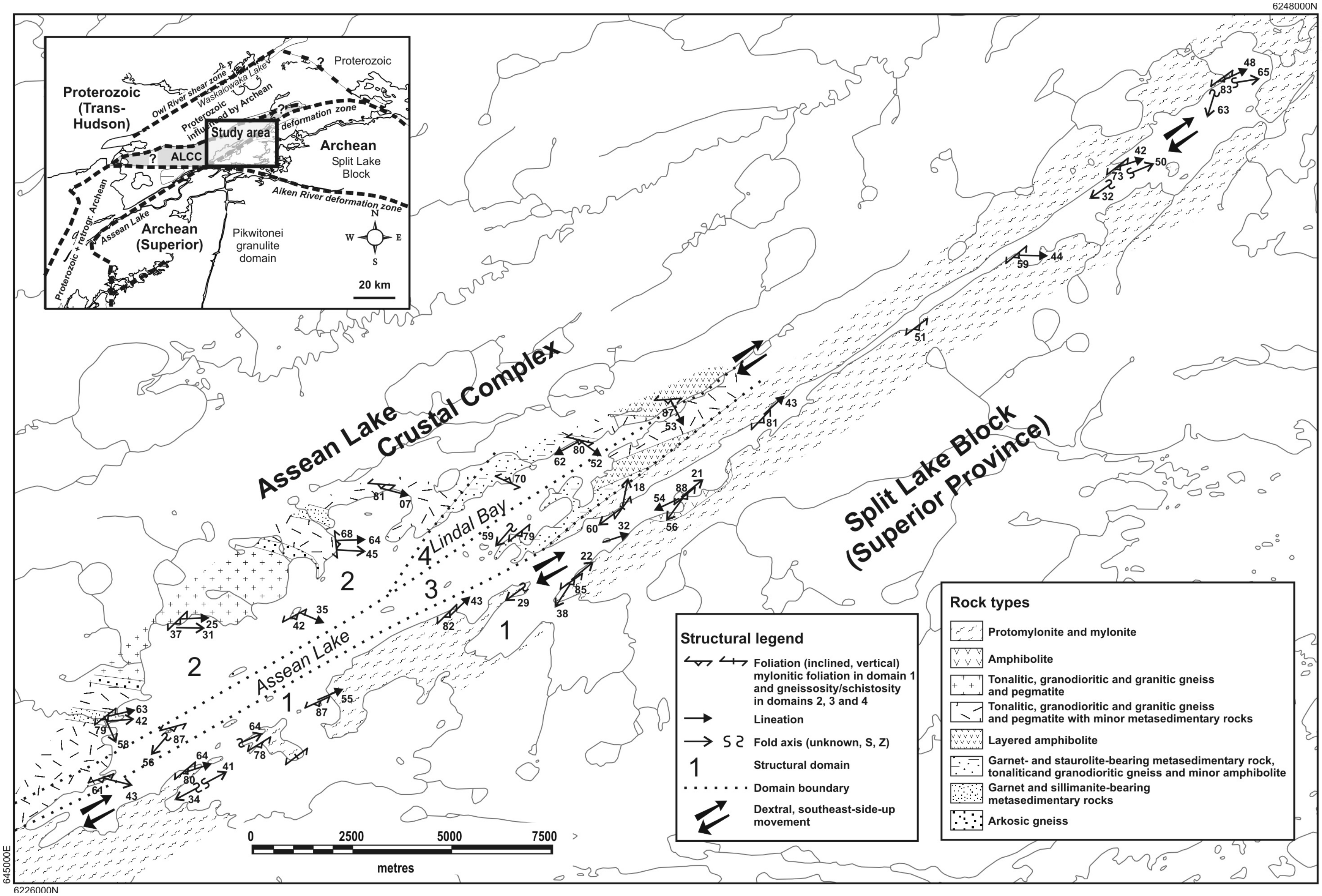


***Figure GS-17-1:*** *Simplified geology of the Assean Lake area. Inset map shows location. Abbreviation: ALCC, Assean Lake Crustal Complex.*

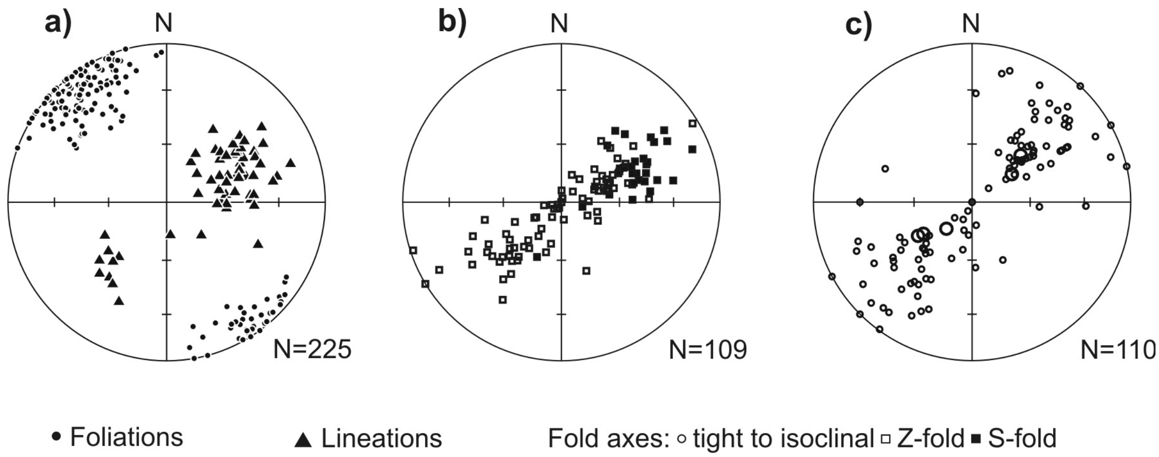


***Figure GS-17-2:** Equal-area lower-hemisphere projections of structural data from the Assean Lake deformation zone (domain 1): **a)** foliations and lineations; **b)** Z- and S-fold axes; and **c)** fold axes of M-folds and folds of unknown asymmetry.*

lineations or striations, or they are rods parallel to fold axes. Southwest-plunging lineations are mostly parallel to fold axes, but the relationship is not always clear because fold axes are not always visible. They may be partly a result of folding of the northeast-plunging lineations. At locations where sheath folds are present, there are no lineations plunging southwest. If only southwest-plunging lineations are present, no sheath folds are observed. This suggests a relationship between northeast-plunging lineations and sheath folds, both being a result of the same transpressive shear. Southeast-plunging lineations are near the top of sheath fold axes or they are outliers. They are not considered meaningful.

Dextral, southeast-side-up movement is indicated by shear bands, millimetre- to centimetre-scale shears, faults, asymmetric clasts and Z-folds (cf. Kuiper et al., 2003). Some Z-folds deform the northeast-plunging lineations (Figure GS-17-3). Development of Z-folds must therefore have continued during late simple shear. The presence of shear bands and the fact that sheath-fold axes and related fold axes lie within the plane of the shear indicate that the shear zone is thinning, or transpressional (Williams and Price, 1990; Jiang and Williams, 1999). In a transtensional zone, kinks would form instead of shear bands and fold axes would be at an angle with the shear zone (Williams and Price, 1990; Jiang and Williams, 1999).

All rocks within the shear zone are deformed. Undeformed mafic dikes (e.g., the 1883 Ma Molson dike suite; Heaman et al., 1986), which are present in the Split Lake Block and possibly the Assean Lake Crustal Complex, are absent or unrecognizable in domain 1. Layers of dextrally sheared chloritic schist may represent deformed equivalents of these dikes. Aplite dikes within the deformation zone are deformed by tight to isoclinal folds, which are probably

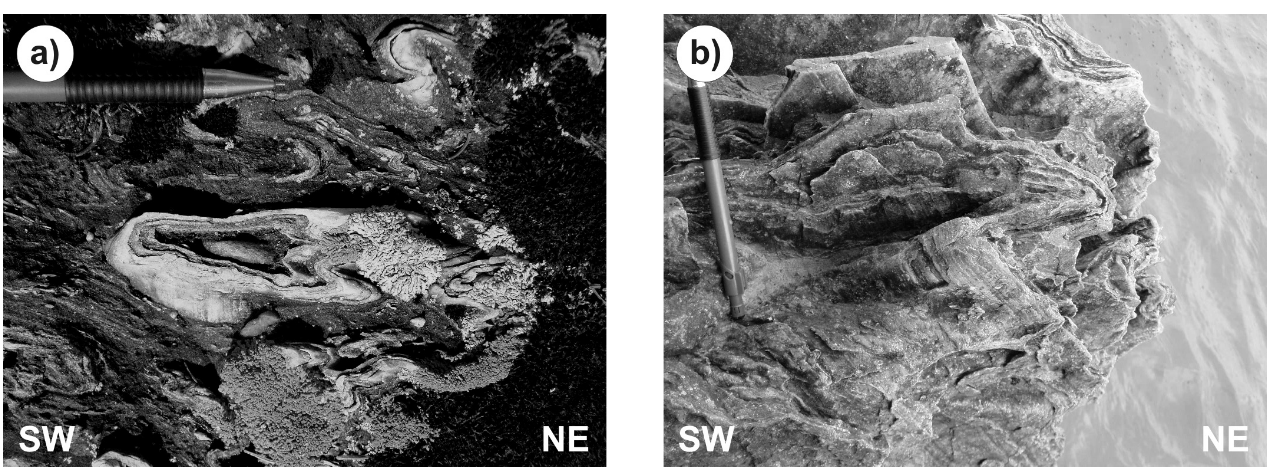


***Figure GS-17-3:** Outcrop photographs from the southwestern part of the Assean Lake deformation zone (domain 1): **a)** sheath fold with lineation on the surface; and **b)** Z-fold folding northeast-plunging lineation. Pencil for scale.*

related to sheath folding. In one location, a fold hinge curves through horizontal, which may indicate the top of a sheath fold. If this aplite is related to the nearby 1825 Ma Fox Lake granite (Heaman and Corkery, 1996), then at least one phase of deformation on the shear zone occurred after 1825 Ma. A sample of the aplite dike is currently being dated by SHRIMP (sensitive high-resolution ion microprobe) U-Pb methods at the Geological Survey of Canada in Ottawa to test this hypothesis.

Undeformed mafic dikes are present within the Aiken River deformation zone. If these are part of the Molson dike suite, and the above speculation is correct, then movement on the Assean Lake deformation zone was later than, or outlasted, movement on the Aiken River deformation zone. This is consistent with the interpretation by Kuiper et al. (GS-18, this volume) that the Aiken River deformation zone is deformed by the Assean Lake deformation zone.

### *Northwestern Assean Lake (domain 2)*

Northwestern Assean Lake is structurally dominated by moderately east-plunging, open to isoclinal folds (Figures GS-17-4a, -5a). Fold axes and intersection lineations (Figure GS-17-4b) are parallel and consistently plunge moderately to the east (Figure GS-17-5a). The lineations are intersections between the gneissosity and the axial-planar foliation to

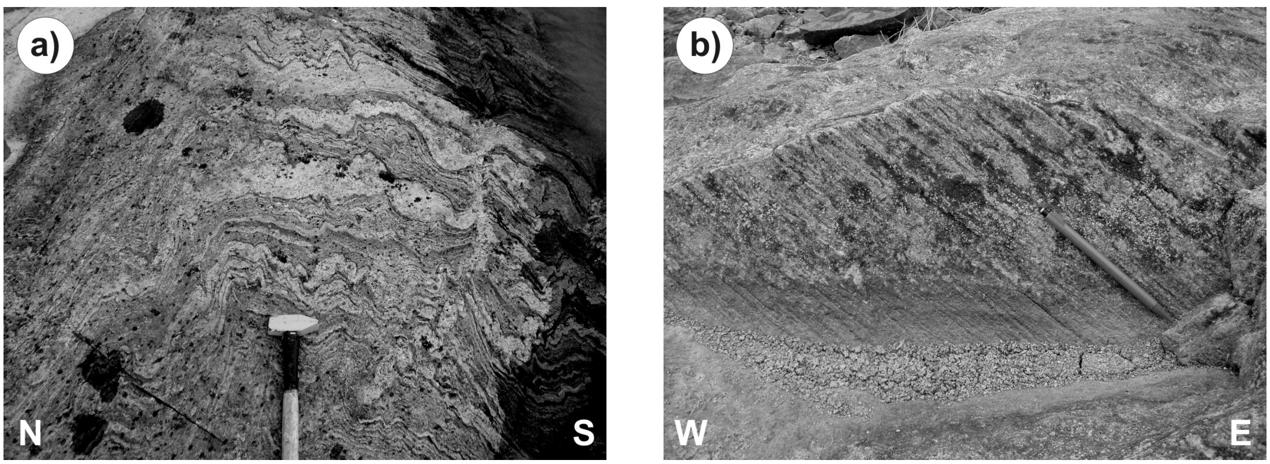


***Figure GS-17-4:*** *Outcrop photographs from northwestern Assean Lake:* ***a)*** *east-plunging fold (hammer for scale); and* ***b)*** *east-plunging intersection lineations between the gneissosity and the axial-planar foliation of the east-plunging folds (pencil for scale).*

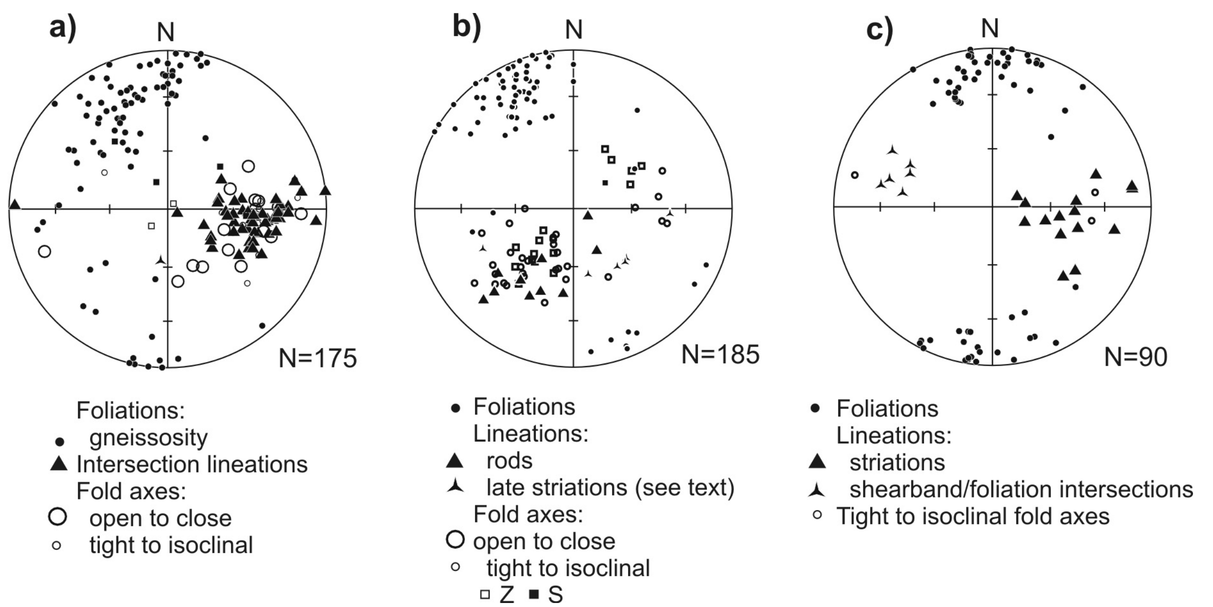


***Figure GS-17-5:*** *Equal-area lower-hemisphere projections of structural data from the Assean Lake Crustal Complex:* ***a)*** *northwestern Assean Lake (domain 2);* ***b)*** *southern Lindal Bay (domain 3); and* ***c)*** *northern Lindal Bay (domain 4).*

the folds. The folds may be the same as moderately to steeply southeast-plunging folds in the Split Lake Block (Kuiper et al., GS-18, this volume). If this is true, then the Assean Lake Crustal Complex was juxtaposed with the Superior Province before this folding event occurred.

### *Southern Lindal Bay (domain 3)*

Foliations in domain 3 are parallel to those in the Assean Lake deformation zone (cf. domains 1 and 3 in Figures GS-17-2a, -5b). Rocks are affected by dextral, southeast-side-up shear, but mylonite is absent. Fold axes fan within the plane of the foliation. Southwest-plunging lineations are parallel to fold axes, which are partly Z-fold axes (Figure GS-17-5b). They may be related to the southwest-plunging lineations within the Assean Lake deformation zone. Perhaps domain 3 represents a less deformed margin of the Assean Lake deformation zone of domain 1, in which dextral, southeast-side-up structures formed but strong shear fabrics such as sheath folds and the northeast-plunging lineations did not develop. Southeast-plunging lineations, which include striations on late local shears, chlorite and muscovite lineations on the margin of pegmatite, and a lineation on a locally rotated foliation, are not considered to be of regional importance.

### *Northern Lindal Bay (domain 4)*

The foliations in this domain are subvertical and trend east (Figure GS-17-5c). The west-plunging lineations (Figure GS-17-5c) are intersection lineations between shear bands and foliation, and indicate dextral, south-side-up shear. This movement may be related to that on the Assean Lake deformation zone (domain 1). East-plunging lineations (Figure GS-17-5c) are striations on amphibolite, metasedimentary rocks and a quartz vein. The obvious interpretation is that they are a result of dextral, southeast-side-up movement related to movement on the Assean Lake deformation zone, but their regional significance is unclear. No asymmetric folds were recognized. The westerly trend of the foliation is different from the rocks to the south (domains 1 and 3), perhaps because the foliation here is not rotated into the shear zone.

## Structures in the Assean Lake Crustal Complex

This report summarizes new interpretations following a detailed structural study in the Assean Lake Crustal Complex. The pervasive, moderately east-plunging folds in northwestern Assean Lake were previously not recognized.

The Lindal Bay area was previously interpreted as being a sinistral fault zone (Böhm, 1997a, b). In this study, dextral, southeast-side-up structures were recognized on both shores of Lindal Bay (domains 3 and 4). A fault or shear zone may be present between domains 3 and 4. This would explain the difference in rock types and foliation orientation across the bay. Alternatively, the variation in rock types could be explained by folding and the change in foliation orientation by rotation (*see* above).

Local, sinistral centimetre-scale shears, S-C fabric and shear bands in domains 3 and 4 (Kuiper et al., 2003) are probably mostly local late shears. Similar dextral and sinistral fabrics exist throughout the region (Kuiper et al., 2003). Part of the sinistral (and dextral) fabric (e.g., S-C fabric) may be a result of shear on fold limbs. East-plunging folds, as in domain 2, may also exist in domains 3 and 4. They would be hard to recognize due to the overprinting dextral, southeast-side-up movement.

## Economic considerations

The Assean Lake deformation zone hosts significant gold mineralization south of Lindal Bay. The mineralization comprises thick (<1 m) quartz veins, which contain finely disseminated visible gold and multiple sulphide species, including galena. The emplacement of the quartz veins is within a tightly folded sequence of metasedimentary rocks, granitic and tonalitic gneiss, and layered amphibolite. The supracrustal rocks are members of the pre–3.0 Ga Assean Lake Crustal Complex (Böhm et al., 2000, 2003). Monazite and metamorphic zircon ages of 2620 Ma from a sheared granite gneiss from Lindal Bay (Böhm, unpublished data, 2003) suggest that the earliest movement on the Assean Lake deformation zone may have been Neoarchean. The shear zone was active (or reactivated) under greenschist-facies conditions, probably in the Paleoproterozoic.

Gold mineralization appears to be the product of this latest movement, which suggests a Paleoproterozoic age for the gold mineralization, possibly related to the Trans-Hudson orogeny. This timing and emplacement model bears a striking similarity to gold mineralization within the Hearne Province (*see* Sherlock et al., 2001; Deyell and Sherlock, 2003), which represents the northern hinterland to the Trans-Hudson Orogen. Accordingly, the confirmation of Paleoproterozoic timing for gold mineralization at Assean Lake has major implications for the gold prospectivity of major shear zones in the Superior Boundary Zone (e.g., Kuiper et al., GS-18, this volume).

New samples have been collected for U-Pb geochronology to reveal the age or ages of movement on the shear zone. Furthermore, samples for $^{40}Ar/^{39}Ar$ geochronology may clarify the uplift history of the Assean Lake Crustal Complex, the Split Lake Block and the Pikwitonei Granulite Domain, in relationship to the deformation on the Assean Lake (and Aiken River) deformation zones (cf. Kuiper et al., GS-18, this volume).

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