Reports

Precambrian Glaciated Surface Beneath the Gowganda Formation, Lake Timagami, Ontario

Abstract. *Glacial deposition of the Gowganda formation is established by the discovery of an extensive, well-marked, glaciated, basal contact surface. This surface is exposed near the southeastern end of Lake Timagami, northern Ontario. The Precambrian ice sheet advanced three times from the northeast over the area.*

The Gowganda formation, a unit of the Cobalt series, is world-famous as evidence of Precambrian glaciation (*1*). Recently, many supposed tillites have been reexamined and their supposed glacial origin has been questioned (*2*). The nature of the basal contact surface is the distinguishing criterion for glacial deposition for deposits with the lithologic and paleogeographic characteristics of the Gowganda formation.

The contact surface between the Gowganda formation and the earlier rocks is exposed near the south end of Lake Timagami, Ontario (Fig. 1), near the base of a west-facing, 15-meter cliff. The underlying rock is pink, medium-grained granodiorite with very weak foliation striking S50°E and dipping 75°NE (*3*). The Gowganda formation is a massive conglomeratic greywacke. At locality 1 (Fig. 2) the greywacke is laminated in places near the base. The pre-Gowganda surface as exposed by weathering is up to 1.6 m in width along a total length of 110 m. It is gently undulating, reaching an amplitude of 3 m over a wavelength of 6 m. The surface strikes S20°E and dips 30°E.

The exposed surface of the underlying granodiorite is polished smooth, striated, grooved, and pitted (Fig. 3). The striae and grooves are continuous over the surface and under the overlying greywacke. They trend from N20°E to N50°E depending on their location on the larger-scaled undulations. The large undulations also trend northeasterly. Small fractures and joints in the granodiorite are jagged on their northern edges and smoother on their southern edges. No feature common to both the Gowganda beds and the granodiorite is offset at the contact.

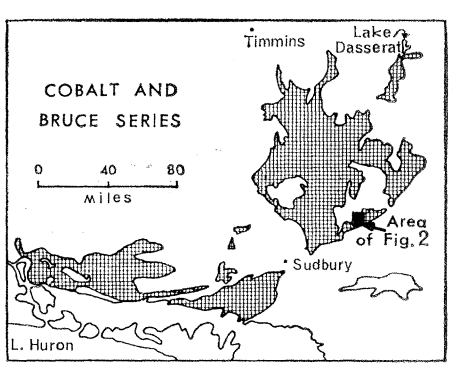

Fig. 1. Location map and areal distribution of the Cobalt (including the Gowganda formation) and Bruce series. The southern end of Lake Timagami is situated within the black square labeled *area of Fig. 2.*

The contact surface is also exposed at locality 2 (Fig. 2). The lithologic and structural relationships are the same as at locality 1. However, the exposure is only a 30-cm triangle striking S15°E and dipping 10°E. The smooth surface bears faint striae which trend N20°E.

At locality 3 (Fig. 2) is displayed another feature of the Gowganda—pre-Gowganda contact. The underlying rock is Keewatin-type metagreywacke that strikes S80°E and dips 75°N. The Gowganda formation rests with sharp angular unconformity on this unit. The Gowganda here is a granite conglomerate with massive greywacke matrix. The contact surface is not exposed, but from cross-sections I infer that it dips westward at 80 degrees. One meter west of this contact, the Keewatin metagreywacke is exposed as an elliptical inlier within the Gowganda formation. The inlier trends N25°E. The eastern contact dips 20°E; the western contact dips 80°W under the granite conglomerate. The metagreywacke reappears 4 m to the southwest along the trend of the major inlier. This raised belt of pre-Gowganda rock is a ridge, defining a groove to the east. The groove trends N25°E and was cut in the west flank of a northerly trending pre-Gowganda arête.

The contact surface, best exposed at locality 1, was abraded by glacial ice which ground over pre-Gowganda rock units. A number of features indicate that this surface is pre-Gowganda in age and not tectonic. The contact surface is exposed only where the overlying Gowganda is laminated. The contact surface crops out in smooth, clean, strong undulations. Neither breccia, gouge, nor mylonite is found along the surface. Basal Gowganda clasts having lithologies similar to basement rocks are very rare. The Gowganda clasts along the contact surface are not sheared, nor do they show any sign of post-depositional movement. Silicification or other mineralization is absent from the contact; there are no metamorphic minerals along the surface. Optic strain of minerals close to the contact is not higher than that of minerals farther away. Dikes, veins, or fractures may continue from the basement into the Gowganda but never after offset. Drag folding of basement foliation is not present, despite the orientation of the foliation approximately perpendicular to contact surface markings. These striae and grooves trend in a similar direction over an east-west distance of 10 km and a north-south distance of over 160 km (*4*). Striae at locality 1 vary in trend; slickensides are usually consistently parallel to each other (*5*). These striae and grooves tend to be horizontal on the sloping contact surface; slickensides tend to be parallel to dip direction (*5*). Moreover, the contact surface displays striking similarity to surfaces of the same lithology that have been exposed to Pleistocene glaciation.

The similarity in trend of striae and grooves at localities 1, 2, and 3 in the vicinity of Lake Timagami, in Cooke's area over 160 km to the north, and in Pettijohn's preliminary fabric analysis across northern Ontario (*6*) is in accordance with widespread glaciation. That the movement of the Precambrian ice sheet at Lake Timagami was from the northeast is shown by: (i) the northeast-sloping, striated and grooved contact-surface undulations which I interpret as the northeast-facing stoss sides of a number of *roches moutonnées*; (ii) the northerly plucking and southerly smoothening of fractures, pits, and gouges in the contact surface; (iii) the absence in the conglomeratic greywacke of clast lithologies similar to rocks to the south; (iv) the two nail-head striae with pits to the northeast on the northeasterly dipping contact surfaces.

In the area shown in Fig. 2, three distinct units of conglomeratic greywacke in the Gowganda are separated by three distinct units of argillite-quartzite (*7*). The discovery of the extensive, well-marked, basal contact surface proves the glacial origin of the Gowganda formation. The Precambrian ice sheet advanced three times from the northeast across the south end of Lake Timagami.

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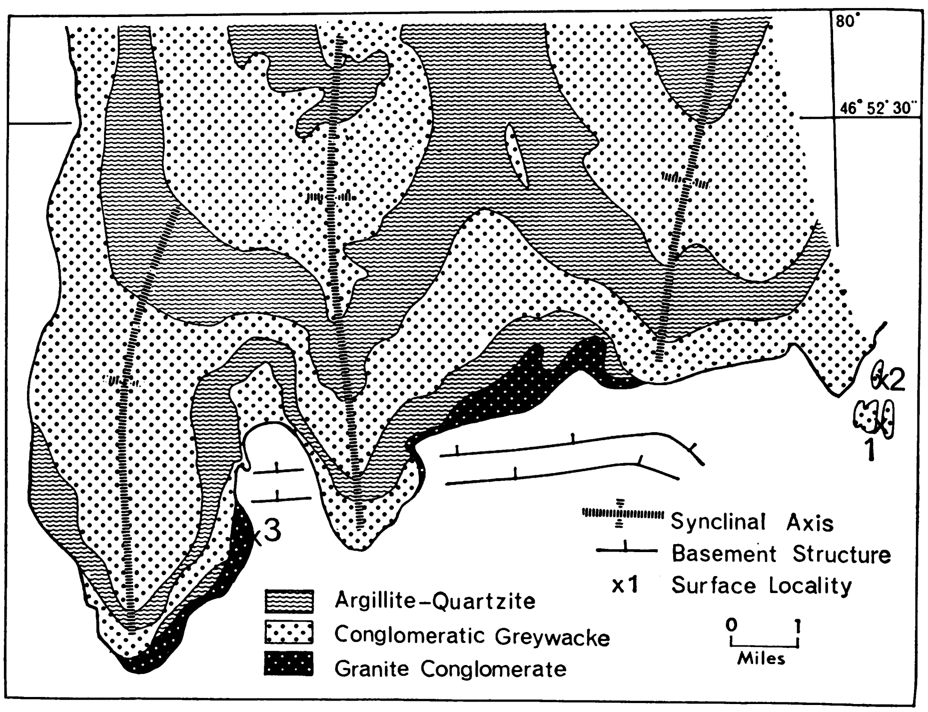

Fig. 2. Geologic map of the Gowganda formation in the area shown in Fig. 1.

Fig. 3. Contact surface as exposed at locality 1. The overlying conglomeratic greywacke is weakly laminated. The contact surface is polished smooth and striated parallel to the matches.

References and Notes

1. A. P. Coleman, *J. Geol.* **16**, 149 (1908); M. E. Wilson, *ibid.* **21**, 121 (1913); W. H. Collins, *Can. Dept. Mines Tech. Surv. Geol. Surv. Can. Mem. 95* (1917).
2. R. H. Dott, Jr., *Bull. Geol. Soc. Am.* **72**, 1289 (1961).
3. J. A. Grant, *Rept. Ontario Dept. Mines Geol. 22* (1964).
4. H. C. Cooke, *Can. Dept. Mines Tech. Surv. Geol. Surv. Can. Sum. Rept. D, 19* (1922). Cooke discovered two small (10 by 15 cm) wedges of the contact surface exposed in a ravine at the south end of Dasserat Lake, Quebec, over 160 km NNE of Lake Timagami. The contact between post-Timiskaming diorite porphyry and overlying conglomeratic greywacke is sharp and smoothly undulating, reaching an amplitude of 15 cm over a wavelength of 30 cm. The two surfaces are smoothly polished and striated. The surface dips 10 to 15 degrees southwest. Striae and undulations trend 60 to 62 degrees. Cooke believed that direction of ice flow in the area was from the southwest by lithic correlation of a clast in the Gowganda with a granite which crops out 8 km to the southwest.
5. F. H. Lahee, *Field Geology* (McGraw-Hill, New York, 1952), p. 233.
6. F. J. Pettijohn, *Science* **135**, 442 (1962). Pettijohn observed a preferred north-south alignment of major axes of clasts in the tillite at four localities in northern Ontario. The localities are from 300 km WSW to 57 km NNE of Lake Timagami. The alignment indicates either a northerly or southerly movement of ice.
7. P. E. Schenk, *J. Sediment. Petrol.*, in press.

8. This study was suggested by Dr. L. M. Cline, who with Drs. R. H. Dott, Jr., and the late S. A. Tyler, all of the University of Wisconsin, contributed advice and suggestions on the problem. Dr. J. A. Grant of the University of Minnesota assisted with discussions in the field.

20 May 1965