Note

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Notes

BEDROOK STRESS RELEASE FEATURES ON MANITOULIN ISLAND, ONTARIO

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ABSTRACT *Bedrock stress-release features on Manitoulin Island, Ontario*. Manitoulin Island has large exposed bedrock plains underlain by Ordovician and Silurian carbonates. The generally flat-lying strata reveal evidence of rock stress relased by faults at Little Current and by pop-ups elsewhere. Four pop-ups occur at widely separated localities on the island and several other small ridges may be pop-ups. Other bedrock stress-release features may be present but remain undiscovered in the extensively vegetated part of the island.

RÉSUMÉ *Formes de relâchement de contrainte dans la roche en place, à l'île Manitoulin, en Ontario*. L'île Manitoulin offre de vastes espaces plats de socle dénudé constitué de carbonates de l'Ordovicien et du Silurien. Les couches généralement horizontales revèlent des indices de relâchement de contrainte dans la roche par l'entremise des failles à Little Current et des structures de soulèvement (*pop-ups*) ailleurs. Quatre soulèvements sont survenus en des lieux très dispersés dans l'île. Plusieurs autres crêtes pourraient en être le résultat. D'autres formes de relâchement de contrainte pourraient être dissimulées dans les parties recouvertes de végétation.

INTRODUCTION

Recent work in southern Ontario has revealed numerous occurrences of local bedrock structures (pop-ups and faults) now generally attributed to near-surface stress-release (White *et al.*, 1974; White and Russell, 1982; Karrow *et al.*, 1989). Pop-ups, also referred to rock heaves, buckles, or pressure ridges, are small surface folds in solid rock (Adams, 1989). Such evidence is most accessible and obvious in areas of extensive outcrop of flat-lying bedrock. Groups of such features occur in the flat-lying Ordovician shales west of Toronto (White, 1975; Karrow, 1987, 1991), in Ordovician limestones near Lake Simcoe (Finamore and Bajc, 1983, 1984), and in Prince Edward County (McFall and White, 1987). A pop-up occurred in 1949 in Silurian dolostone east of Cambridge. It is the only natural pop-up known to have occurred in historic time in Ontario (Karrow, 1963).

Thus, when survey work on raised postglacial lake shorelines began on Manitoulin Island in 1988, attention was also given to searching for rock stress-release features in extensive plains of bedrock outcrop underlain by generally flat-lying strata.

Thus far, only a few such features have been found on the Island. These few are widely scattered and do not justify detailed interpretation at this time. They are simply recorded here to stimulate interest in a hitherto unstudied area and supplement existing knowledge of the distribution of stress-release features.

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GEOLOGICAL SETTING

Manitoulin Island is located in northern Lake Huron (Fig. 1). It is about 120 km long and 10 to 50 km wide and is known as the largest freshwater island in the world. It is underlain by Ordovician and Silurian bedrock which dips gently southward toward the centre of the structural Michigan Basin. The Island's surface form is dominated by cuestas of resistant carbonates with scarps facing north to form steep slopes along the north coast (Ordovician limestone) and across the middle (Silurian dolostone). The south coast is a gentle slope dipping beneath Lake Huron. The Island is separated by North Channel from Precambrian Huronian metasediments on the mainland to the north. A few inliers of quartzite are present in the northeast part of the Island along strike from the Killarney Peninsula to the northeast. The Grenville Front, a major tectonic boundary in the Canadian Shield between the Southern and Grenville provinces, extends beneath the Paleozoic cover in the eastern part of the Island. Bedrock geology maps at a scale of 1:50,000, published by the Ontario Geological Survey, cover the island.

The island has very little drift cover, although pockets of drift in topographically lower areas include drumlins of sandy till, and lacustrine sand, silt, and clay. Although there are extensive bedrock outcrops, large areas of the island — particularly in the west — are covered by second-growth bush which obscures the bedrock.

BEDROCK STRESS-RELEASE FEATURES

Faulting of the limestone bedrock (Ordovician Lindsay Formation: Johnson and Telford, 1985a) has been noted at

Little Current, the island's principal town, which is in the northeast corner. The fault is exposed on the south side of Sim Street, east of the centre of town (Fig. 2). Tilted bedrock on the east side, interpreted as drag, indicates movement down to the east. The fault strikes 165° and is nearly vertical. The amount of displacement could not be determined.

Sim Street curves to the south not far east of this fault. In July of 1988, a trench was excavated in the limestone to provide services for a new tourist information building along Highway 6 at the east end of Little Current. Just north of the trench, along the east side of Sim Street, a zone of crushed rock was exposed. It was marked with considerable iron oxide staining, such as is found where sulphides are weathering, suggesting a possible fault striking at about 145°. Limestone beds could not be correlated across this zone, although no tilting of the beds was evident. The limestone surface there bears glacial striae ranging from 195 to 215°, with an average near 200-205°. A specimen of the surface rock (Fig. 3) with striae, from the edge of the trench, shows vertical calcite-filled fractures approximately parallel with the trend of the possible mineralized fault.

M.D. Johnson (personal communication, 1988) found a bedrock pop-up southeast of Highway 6 and 1.3 km northeast of its intersection with Highway 542 (Fig. 4). The pop-up occurs in the dolostone of the Silurian Fossil Hill Formation (Johnson and Telford, 1985b) and is in a low area east of a low rock scarp trending northeast, parallel to Highway 6; the pop-up strikes northwest. It is about 1 m high and has a length of about 200 m, with its northwest end about 300 m southeast of Highway 6. Near its northwest end, where crossed by a minor creek bed, the thin-bedded dolostone has been heaved up and dips away from the crest (Fig. 5).

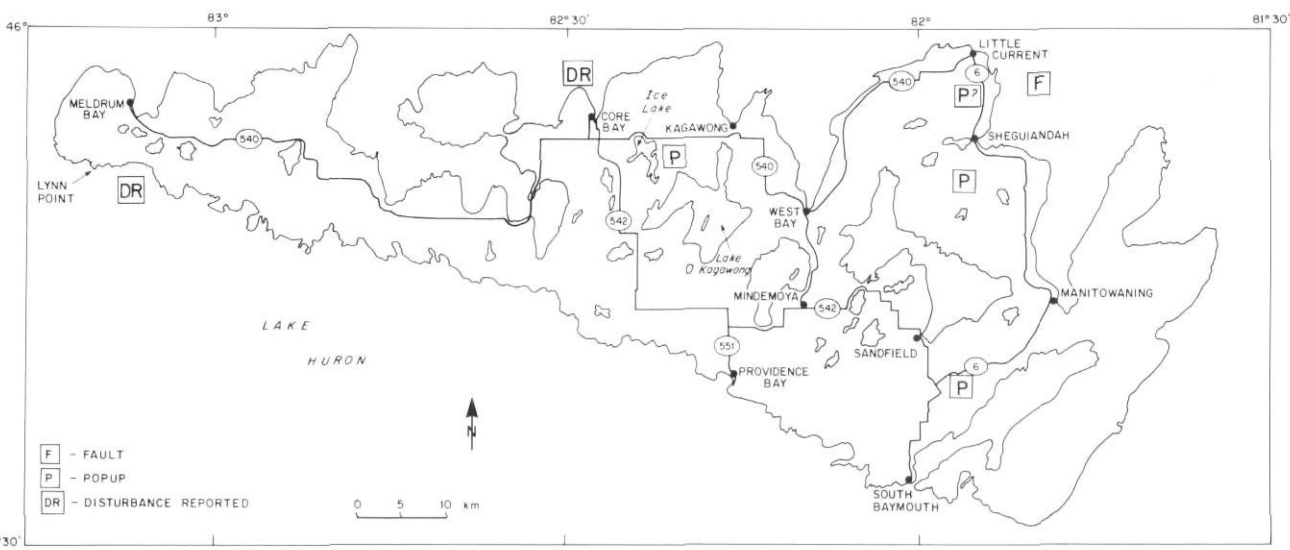

FIGURE 1. Manitoulin Island showing location of features described in text.

Île Manitoulin et localisation des éléments décrits dans le texte.

FIGURE 2. Faulted limestone on the Lindsay Formation, south side of Sim Sreet, Little Current.

Calcaire faillé de la Formation de Lindsay, côté sud de la rue Sim, à Little Current.

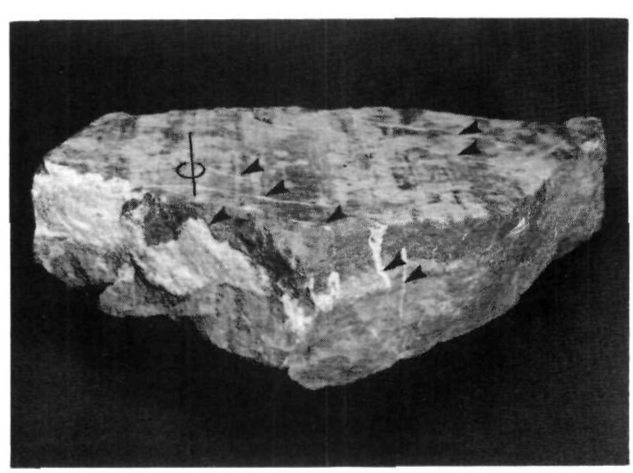

FIGURE 3. Striated limestone, Lindsay Formation, showing calcite-filled fractures.

Calcaire strié de la Formation de Lindsay, montrant des fractures comblées par de la calcite.

FIGURE 4. Air photo showing pop-up (arrow) southeast of Highway 6 (Ontario Ministry of Natural Resources 73-4528, 3-174).

Photo aérienne montrant une structure de soulèvement (flèche), au sud-est de la route 6 (Ministère des Ressources naturelles de l'Ontario, 73-4528,3-174).

FIGURE 5. Pop-up southeast of Highway 6 showing heaved limestone in anticlinal structure.

Structure de soulèvement au sud-est de la route 6, montrant du calcaire soulevé dans un anticlinal.

M.D. Johnson (personal communication, 1988) also reported seeing a pop-up in the dolostone of the Silurian Amabel Formation (Johnson and Telford, 1985c) on the south coast of the Island near its west end. The pop-up, which trends perpendicular to the shoreline, is situated somewhere along a 13 km-reach southeast from Lynn Point. The area has difficult access and the site has not been revisited during the present work.

M. Byerley (personal communication, 1989) reported a bedrock deformation at Janet Head, about 4 km northwest of the town of Gore Bay. On visiting the area, some minor, poorly exposed, tilted bedding was seen in the high rock scarp forming the coast in that area. The deformation appears to have been caused by slope movement.

A pop-up was found during the current work north of Turtle Lake, about 6.3 km southeast of the village of Sheguiandah. It trends north-south across the road but bends to the southeast at its south end. It extends for about 750 m and has a height of up to one metre (Fig. 6, 7). Johnson and Telford (1984a) mapped the bedrock there as the upper limestone-rich part of the Georgian Bay Formation (Ordovician). The area is generally a bedrock plain with a thin cover of soil and sod. Bits of tilted rock can be seen locally along the ridge.

The largest pop-up known to the author was first identified on air photos (Fig. 8). It is located north of Prior's Bay of Lake Kagawong, and east of Ice Lake, about 7 km southwest of the village of Kagawong. It trends northwest, extends for 3 km, and has a height of up to 2 m (Fig. 9). Tilted bedrock slabs can be seen at different locations along its length. Although the pop-up is overall a straight ridge, there are several small kinks or jogs along its length (Fig. 10) and there is a slight bend of a few degrees at about its middle. The bedrock here is Silurian dolostone of the Manitoulin Formation (Johnson and Telford, 1985d).

Some other ridge features, which may be pop-ups, were seen on the high bedrock plain northwest of Sheguiandah and southwest of Little Current. Although examined on foot,

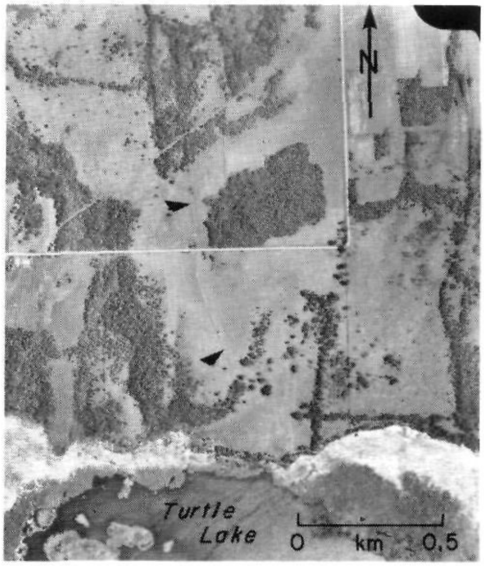

FIGURE 6. Air photo of pop-up (arrow) near Turtle Lake (Ontario Ministry of Natural Resources 73-4535,9-59).

Photo aérienne d'une structure de soulèvement (flèche), près de Turtle Lake (Ministère des Ressources naturelles de l'Ontario, 73-4535,9-59).

FIGURE 8. Air photo of pop-up (arrow) near Ice Lake (Ontario Ministry of Natural Resources 73-4536,8-155).

Photo aérienne d'une structure de soulèvement (flèche), près du Ice Lake (Ministère des Ressources naturelles de l'Ontario, 73-4536,8-155).

FIGURE 7. Pop-up near Turtle Lake.

Structure de soulèvement, près de Turtle Lake.

FIGURE 9. Ice Lake pop-up. Person standing on crest with photo taken from eye height of 183 cm to show height of pop-up and tilted rock slabs on south flank.

Structure de soulèvement, à l'est du Ice Lake. Le personnage sur la crête a été photographié à hauteur d'yeux, à 183 cm, afin de montrer la hauteur du soulèvement et les dalles de roche basculées sur le flanc sud.

FIGURE 10. Ice Lake pop-up showing kinks in crest.

Structure de soulèvement, à l'est du Ice Lake, montrant des flexures sur la crête.

conclusive evidence of pop-up origin was not found. The smallest feature is about 30 m long and trends 140°. It crosses the north-south road 0.7 km south of Greenbush Road. and 3.75 km north northwest of Sheguiandah. Two more subdued ridges trend at about 30° from near the northwest end of the first ridge and diverge slightly to the northeast. Another ridge crosses Greenbush Road north-south 0.8 km west of the north-south road; it has a length of 0.8 km and curves gently to the southeast. A fifth ridge, 1 km to the northwest, is slightly offset to the west of this one but follows a similar trend, north-south in the southern part, but curving more northwesterly in the northern part.

CONCLUSION

Several pop-ups have been identified on Manitoulin Island. Three certain pop-ups have been located, whereas a fourth has an uncertain location. Some additional ridges of unknown origin, but with surface forms similar to pop-ups form have also been located. Evidence of faulting at Little Current has also been described. Examination of air photos of most of the Island has not revealed any other similar features. However, considering the large areas of bedrock plain on the Island, and the extensive vegetation coverage, particularly in the western part, it is possible that other pop-ups (and faults?) are present on the island. Because the pop-ups are surface features which could be easily disrupted by an overriding glacier but show no signs of disturbance, they are probably postglacial in age. The age of movement on the Little Current fault is unknown. Possible causes for similar features near Hamilton, Ontario were considered by White *et al.* (1974). Here too, evidence favours the presence of high horizontal stress in the crust, most easily relieved at the surface by buckling. Too few structures are known in the area to see any strong orientation pattern but as in south-central Ontario, there seems to be some slight preference to northwest-southeast trends. This suggests maximum stress northeast-southwest, which could be related to regional glacioisostatic tilting up to the northeast.

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