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A possible new impact structure near Lac de la Presqu'île, Québec, Canada

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Abstract—Lac de la Presqu'île is a sub-circular lake, about 7 km in diameter with a prominent central peninsula. The shape of this lake and the occurrence of shatter cones to the east suggest that an impact created a crater with an original diameter of at least 12 km (Tait, 1990). Deep erosion of the structure suggests that it was formed in the distant past, at least several hundred million years ago.

INTRODUCTION

THE REGION SURROUNDING Lac de la Presqu'île (74°48'W, 49°43'N, Fig. 1) is one of low rolling hills, typically 15 to 25 metres high. Glacial till covers the whole region, typically to a depth of about two to three metres. Outcrops are generally sparse and are commonly restricted to the banks of rivers and lakes. Shatter cones attributed to meteoritic impact were first noted during mapping of the area by the second author for the Ministry of Energy and Resources of the Québec government.

REGIONAL GEOLOGY

This region forms part of the Abitibi greenstone belt in the Archean Superior Province of the Canadian Shield (Fig. 1). The Obatogamau Formation comprises the oldest supracrustal rocks exposed in the region. It is a very widespread formation and is dominated by a series of pillowed and massive basalt flows, typically containing plagioclase phenocrysts. Andesitic flows and more acidic rocks are also present, but sparse. In this region, the Obatogamau Formation was metamorphosed to greenschist facies, with the development of a schistosity that is generally oriented east-west and with a vertical dip.

The Obatogamau Formation was intruded by a tonalite body in the northwest part of the region. The first signs of the intrusion as it is approached are the presence of veins and dykes of tonalite within the basaltic flows. Over the next 100 metres these increase in width and quantity until the basalt is ultimately replaced by tonalite containing sparse xenoliths of basalt. The tonalite is usually weakly foliated, except locally, indicating that it was emplaced late in the tectonic history of the area.

The gravity and aeromagnetic fields in this region are dominated by signatures related to the Presqu'île tonalite intrusion, and show no evidence of a cryptic circular structure (MERQ, 1982; MRN, 1976, 1978).

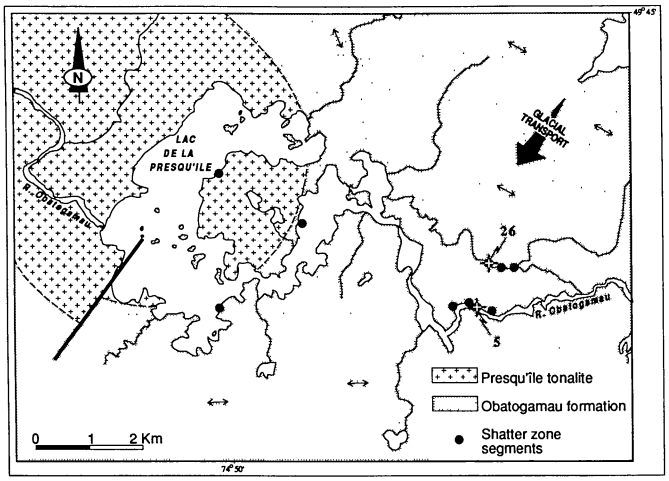

FIG. 1. The Lac de la Presqu'île impact structure, near Chapais, Québec, Canada.

SHATTER CONES

Poorly exposed segments of shatter cones are exposed at three points on Lac de la Presqu'île in Obatogamau basalts or basalt xenoliths in tonalite (Fig. 1). These surfaces have the typical "horsetail" structure (Milton, 1977), but few surfaces were developed and it was not possible to determine the orientation of the master-cones at these locations.

Shatter cones are much better developed in outcrops of massive, fine-grained basalts and rhyodacites (Obatogamau formation) about five kilometres east of the lake on the Obatogamau river and an unnamed tributary (Fig. 1). More heterogeneous rocks in this area, such as pillow basalts, are devoid of shatter cones.

No complete cones have been found, but the segments exposed (Fig. 2) are morphologically similar to occurrences at other impact sites (Milton, 1977; Roy, 1978). Cone segments up to 60 cm long have been found, but they are more typically 10 to 20 cm long. In many outcrops parts of the shatter cone surfaces that are parallel to particular planes are more strongly developed, commonly to the exclusion of other parts of the cone. This is probably related to the anisotropy of the rock, which generates linear sets of intersecting shatter cones (Milton, 1977). The fractures and fracture surfaces which embody the shatter cones are unaltered and show no evidence of subsequent recrystallization or infilling. Typically, carbonates and/or quartz are found in open features, such as joints or vesicles, which predate regional metamorphism.

Two sites were investigated in more detail (sites 5 and 26, Fig. 1). The orientations of the corrugations were measured as well as the orientation of the tangent to the corrugations, where possible. The parameters of the master-cone for each site were estimated from these data. Site 5 has an apical angle of about 90 degrees (Fig. 3), a value typical for shatter cones (Roy, 1978), and a vertical orientation. The data from site 26, although incomplete, can be modelled with a master-cone of apical angle 90 degrees and a vertical orientation. Occurrences of shatter cones are commonly rotated (*e.g.*, Roy, 1978), therefore, because no independent data on block rotation could be determined, the original orientations of the master-cones are unknown.

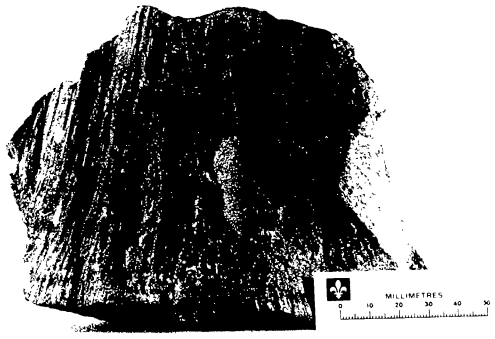

FIG. 2. Shatter cone segment from 5 km east of Lac de la Presqu'île.

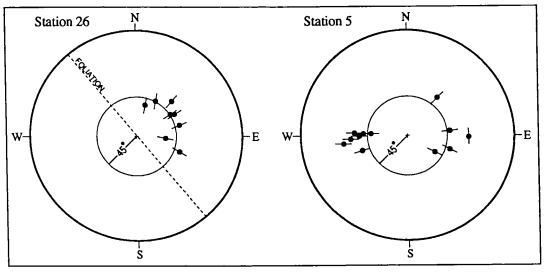

FIG. 3. Sterogram of shatter surfaces developed in the Obatogamau Formation. Points are corrigation directions. Short lines are the trace of a plane that includes the corrigation direction and the pole to the tangent to the shatter cone surface. Such lines point towards the apex of the cone.

Well-developed microscopic shock features, such as planar features in quartz or other minerals have not been found. Neither has evidence of microbrecciation.

DISCUSSION AND CONCLUSIONS

The presence of shatter cones near Lac de la Presqu'île constitutes, in the opinion of the authors and most workers in this field (*e.g.*, Grieve, 1987; Milton, 1977), definitive evidence that there has been shock metamorphism. However, it should be mentioned that some authors consider that some shatter cone occurrences could be related to tectonic events (*e.g.*, Simpson, 1981). The lack of post-metamorphic volcanism in this area indicates that the shatter cones are not crypto-volcanic features, but must be related to a meteorite impact.

The original size of the crater is difficult to establish. Shatter cone occurrences so far found can be incorporated into a circle with a diameter of six km. If the shatter cones die out at 0.5× diameter (Robertson, 1975) then the diameter of the crater must have been about 12 km. However, if the center of Lac de la Presqu'île is taken as the center of the impact and again shatter cones die out at 0.5× diameter then the crater must have had an original diameter of about 24 km.

The age of the impact is also difficult to establish, though it is clearly post-metamorphic (approximately 2.7 Ga) and pre-glacial. The low relief of the region suggests prolonged preglacial erosion. A structure of this size would produce high-pressure shock metamorphism in the floor of the crater. That such rocks have not been observed suggests a large amount of erosion. Together these data suggest a minimum age of several hundred million years.

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