BATHYMETRIC AND PETROLOGICAL EVIDENCE FOR A YOUNG (PLEISTOCENE?) 4-KM DIAMETER IMPACT CRATER IN THE GULF OF SAINT LAWRENCE, CANADA.

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Introduction: The Corossol crater (50°3'N, 66°23'W) was first discovered by the Canadian Hydrographic Service about 10 years ago while mapping the entrance to the Sept Iles harbour, Gulf of St Lawrence, Canada [1]. It is a complex circular structure about 4 km in diameter with a central uplift that rises to about -70 m and an annular valley ~160 m deep. There are no other circular structures nearby.

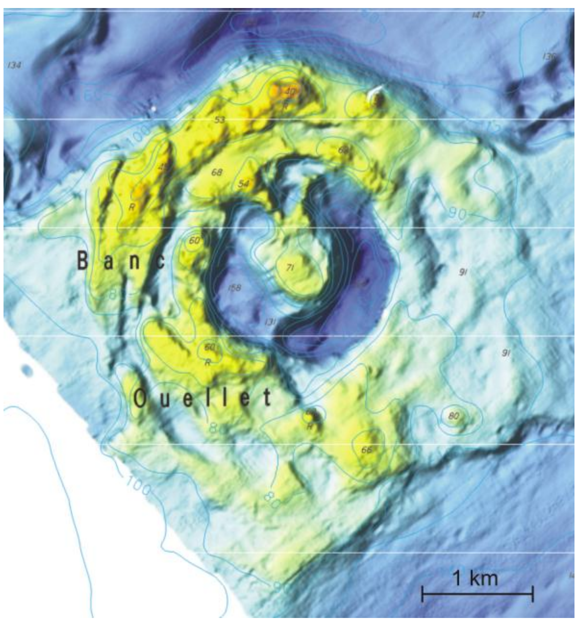

Figure 1: Bathymetry of the 4-km diameter Corossol crater, Near Sept-Iles, Gulf of St Lawrence, Canada (Canadian Hydrographic Service).

The bedrock of this region is the Sept Iles Intrusive suite, an 80 km diameter 564 Ma old layered mafic intrusion [2]. These rocks are overlain by relatively thin flat-lying Ordovician limestones that have only a few, small outcrops in this region [3]. However, the submarine limits of these rocks can be identified from cuestas (steep slopes). One such cuesta marks the northern limit of the crater and continues to both the east and the west. Hence, the crater appears to have formed in these limestones, but may well have been excavated the crystalline basement as well.

Age of impact: At present it is only possible to give age limits. The maximum age is very difficult to establish. Clearly, it is younger than Ordovician, but it is not clear if it is younger or older than the cuestas. The paucity of sediments in the crater might be taken to indicate that it is young. The minimum age was established using data from a ~7 metre core taken in the central trough, which almost reached the basement, as defined by seismic data. Calibrated ^{14}C ages of shells in the sediments can be extrapolated to give an estimate of the age of the base of the sedimentary sequence of ~12,900 cal BP, if no hiatus or older sediments were preserved between the base of the core and the bedrock. This is taken to be the youngest possible age of the impact.

The lower age limit is close to the start of the Younger Dryas cold period, which was associated with glacial advances, hence it cannot be an age of deglaciation[4]. If the age of the crater was close to the lower limit, then the impact would have been on ice. It has been proposed that the Younger Dryas was initiated by impacts in North America, but the idea remains very controversial [5, 6]. Further work on establishing the age of the impact will concentrate on finding an ejecta layer in cores sampled away from the crater, and radiometric dating of the components of the suevite (see below).

Petrological evidence of impact: Samples were dredged from the central uplift and the innermost annular rim in the hope of finding clear evidence of impact. Only angular clasts were retained, in the hope that they had not been transported significantly. Most such samples are limestones, generally brecciated and recemented. Many blocks have undulating tubes 1-2 mm in diameter, which are lined with white carbonate crystals. It is unclear if these tubes are biological in origin or related to devolatisation of carbonates. The abundance of limestone fragments agrees with the limestone bedrock in this area identified from the bedforms.

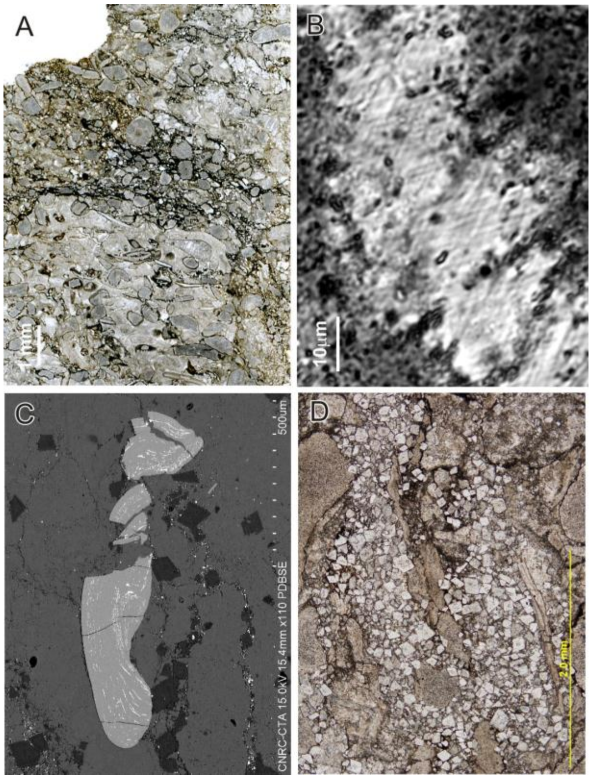

Figure 2: Suevite breccia clast. A) Scanned image of a thin section in non-polarised light. Limestone clasts are medium-grey. B) Planar deformation features in a crystal of quartz. Cross-polarised light. C) Broken fragment of a glassy droplet. Darker areas have a composition close to apatite, pale areas are pyritic. In the matrix calcite is pale and dolomite is darker. Back-scattered electron image. D) Carbonatitic material infilling between limestone fragments. Euhedral crystals are Dolomite. Plane-polarised light.

One 4 cm long clast of a very different breccia was recovered (figure 2). Most of the sub-clasts are made of limestone (figure 2A). Many of them have a dark rim of fine-grained iron oxides. In some parts of the section the fragments are separated by zones of carbonate-rich material interpreted as a melt. It consists of euhedral dolomite crystals in a fine-grained carbonate / silicate / oxide matrix (figure 2D). About 4-5 glassy 'droplets' up to 1 mm long have been found (figure 2C). They are composed of a clear phosphate glass that has a composition close to apatite, with tiny pyrite crystals exsolved along flow-planes. Although there are a number of quartz crystals only one was found to have planar deformation features (PDF) [7, 8]. The crystal has zones of lower birefringence (but not isotropic) with abundant inclusions. In between there are areas with two intersecting sets of PDFs (figure 2B). This clast is interpreted to be a suevite [7].

It is not easy to interpret the origin of the various components of this suevite clast, as we only have one sample so far. The limestone sub-clasts are clearly derived from the uppermost target rocks. The origin of the dolomitic cement/melt is not clear. It may have been derived from more dolomitic parts of the limestones by melting [9]. The phosphatic/sulphide melts are the most enigmatic component. They may be derived also from a phosphatic layer in the limestones, but they may also come from fusion of the crystalline basement. Parts of the Sept Iles Intrusive suite are very rich in apatite [2], although the geology of the basement directly at the impact site is not known. These glasses may represent the best material for radiometric dating of the impact.

References:

[1] Sanfaçon, R., *Entité sous-marine découverte près de Sept-îles. Fisheries and Ocean Canada Press Release (2001/08/29), p. 30 (2001).* , 2001. [2] Higgins, M.D. (2005) *Lithos. 83*, 199-213. [3] Sanford, B.U., ed. *Sedimentary Cover of the Craton in Canada*. Geology of Canada, ed. F. Stott and J.D. Aitken. Vol. 5. 1993, Geological Survey of Canada. [4] St-Onge, G., et al. (2008) *Quaternary Science Reviews. 27*, 2390-2400. [5] Firestone, R.B., et al. (2007) *Proceedings of the National Academy of Sciences of the USA. 104*, 16016-16021. [6] Carlson, A.E. (2010) *Geology. 38*, 383-384. [7] French, B.M., *Traces of catastrophe : a handbook of shock-metamorphic effects in terrestrial meteorite impact structures*. LPI contribution ;1998, Houston, TX: Lunar and Planetary Institute. ix, 120 p. [8] French, B.M. and C. Koeberl (2010) *Earth-Sci. Rev. 98*, 123-170. [9] Osinski, G.R. and J.G. Spray (2001) *Earth Planet. Sci. Lett. 194*, 17-29.