THE LOCH LEVEN CRATER: ANATOMY OF A LOW-ANGLE OBLIQUE IMPACT STRUCTURE.

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Synopsis: The Loch Leven basin (56° 12' N, 3° 23' W) in the Midland Valley of Scotland has been identified as the site of the primary impact of a low-angle oblique impact event dating from the end of the Carboniferous. Together with two further downrange structures, it forms a chain of craters which appear to have been produced by fragments of a large asteroid which disintegrated on impact.

Topography: The Loch Leven crater of Kinross-shire, East-Central Scotland is an elongated structure (18 x 8 km) which lies 30 km N of Edinburgh and 40 km SW of St. Andrews (Fig. 1). It has been preserved by a quartz-dolerite sill which was emplaced around the edges of the crater infill and dates from 290 Ma. The sill was intruded at a depth of 1.8 km, so that the structure which survives represents the eroded base of the crater. The structure has a central ridge and a series of lateral terraces (Fig 2). By analogy with the features of the lunar crater Schiller [1] and other elliptical craters [2], Loch Leven is believed to be a low-angle oblique impact structure. These structures result from impact of objects which disintegrate into multiple fragments before burial. The fragments ricochet downrange, forming multiple secondary impact structures [2].

Petrology: Impactites of the structure include impact melts, suevites, lithic breccias and friction-melt rocks. The country rocks of the Loch Leven area are mostly lower Carboniferous sandstones and some of these have been affected by the impact. At the eastern (proximal) end of the structure, thermal effects dominate, with formation of indurated quartzitic rocks containing tridymite (Fig 3, SEM) and devitrified glassy textures (Fig 4, XPL) but no Planar deformation features (PDFs). At the western (distal) end of the structure, however, target rocks do contain PDFs (Fig 5, XPL), supporting previous theoretical predictions of an asymmetric "canoe-shaped" distribution of shock pressures in these oblique structures [1]. Interstitial melting textures are common in these rocks, and new-growth micas are seen between grain boundaries in otherwise "normal" sandstones (Fig 6, SEM).

The most altered lithologies are found in the central ridge of the structure which contains some highly vesicular rocks one of which is mainly composed of vesiculated lechatelierite (Fig 7, SEM). Unaltered quartz grains in this rock contain planar fractures and PDFs (Fig 8, oil mount, XPL).

The structure also contains a distinctive suite of pale flow-banded glassy rocks which are interpreted as friction melts. These are preserved along the southern rim of the crater and are believed to be the product of melting of a mixture of asteroid material and sedimentary target rocks. The rocks contain altered glassy pyroxenes in a flow-banded quartzo-feldpathic matrix (Fig 9) which shows a distinctive laminated devitrification texture (Fig 10, XPL).

Suevites (Fig 11) are found in many places in the crater and contain abundant felsic clasts in which feldspar phenocrysts display a "checkerboard" texture (Fig 12, XPL).

There are numerous outcrops of basalt in the northern and western parts of the structure. These are believed to represent the remains of melt-sheets of the crater floor. Basalts of the central ridge include composite rocks in which a macroporphyritic and microporphyritic component are present simultaneously and behave as immiscible liquids (Fig 13). This phenomenon has been reported in "Tagamites" of the Popigai structure [3].

References: [1] Melosh, H. J. (1989), *Impact Cratering* (OUP). [2] Schultz, P.H. & Gault, D.E. (1990), *GSA Spec. Pap. 247*, 239-261. [3] Masaitis, V.L. (1994), *GSA Spec. Pap. 293*, 153-162.

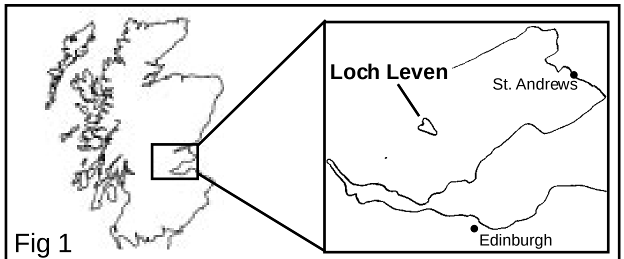

Fig 1

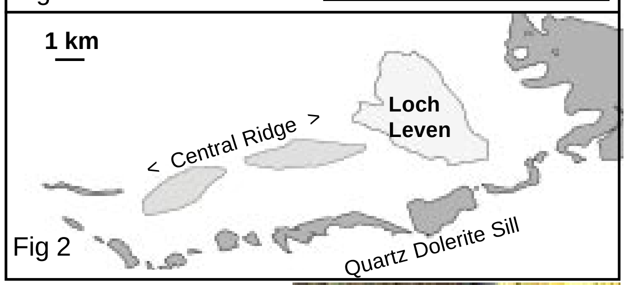

Fig 2

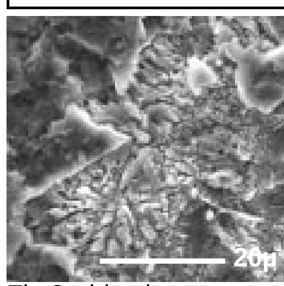

Fig 3 tridymite

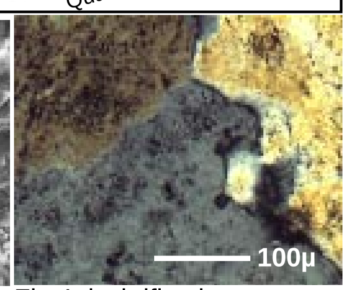

Fig 4 devitrification texture

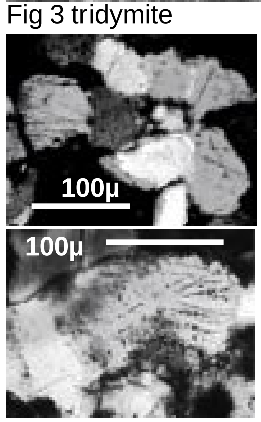

Fig 5 PDFs

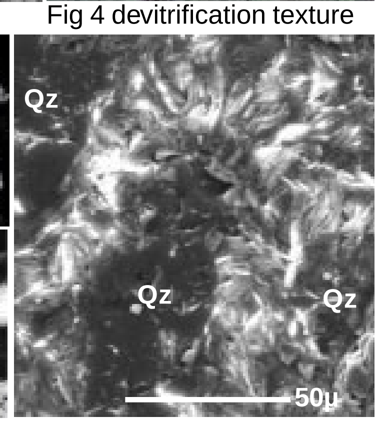

Fig 6 interstitial mica growth

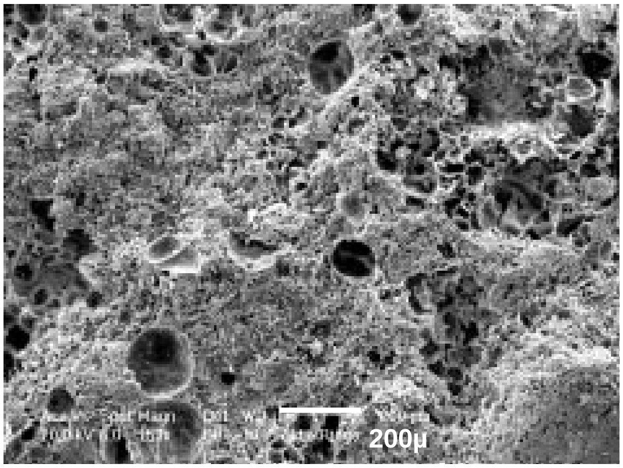

Fig 7 vesicular lechatelierite rock

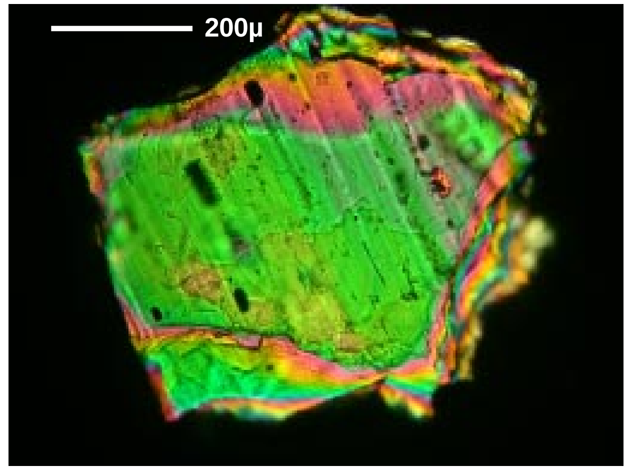

Fig 8 PDFS in quartz grain

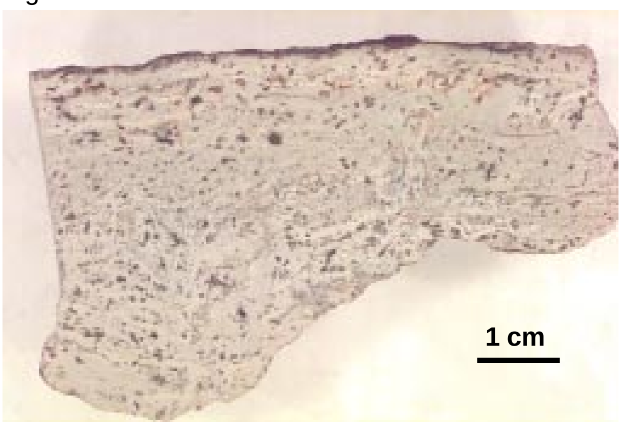

Fig 9 flow-banded friction-melt rock

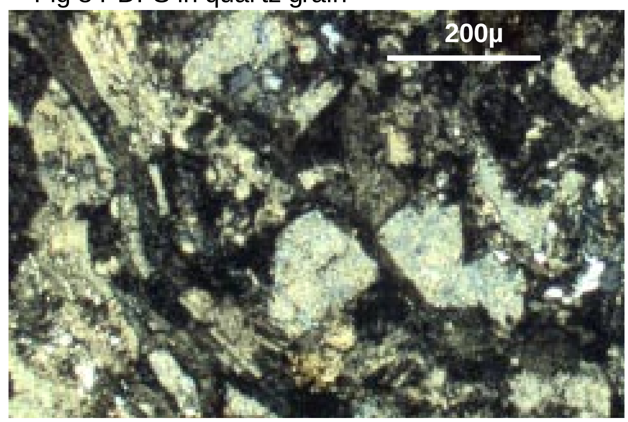

Fig 10 laminated devitrification texture

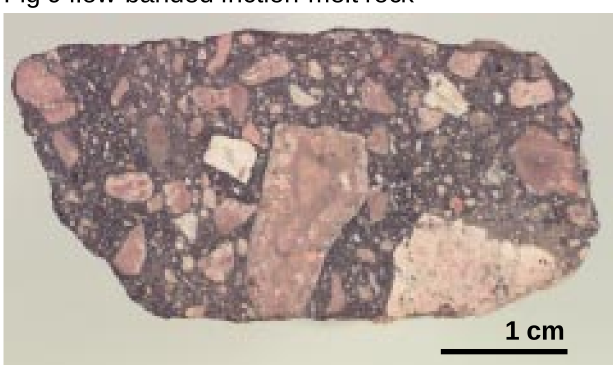

Fig 11 suevite

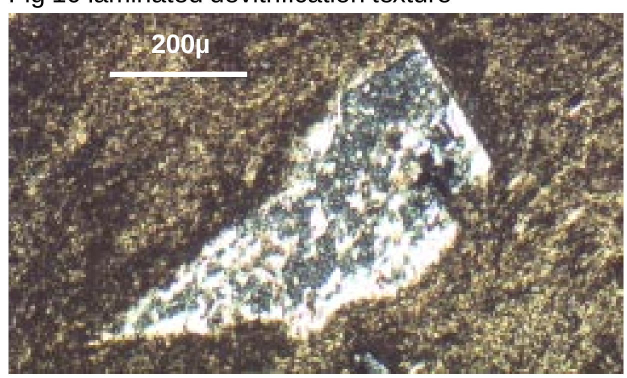

Fig 12 checkerboard texture in feldspar

Fig 13 Composite melt-rock ("Tagamite?") showing a macroporphyritic and microporphyritic component present simultaneously, and behaving as immiscible liquids