AN ALTERNATIVE MODEL FOR THE MANICOUAGAN IMPACT STRUCTURE. D. L. Orphal, Physics International, San Leandro, CA 94577; P. H. Schultz, Lunar Science Institute, Houston, TX 77058.

Manicouagan, located in the Canadian Shield of eastern Quebec, is one of the largest and best preserved terrestrial impact structures. Floran and Dence (1) have interpreted Manicouagan as a multiringed structure analogous to 400 km diameter lunar basins. In this paper it is proposed that Manicouagan may be more analogous to floor-fractured craters on the Moon (2).

Manicouagan was formed about 210 m.y. B.P. (3) in a terrain composed primarily of granitic gneiss intruded by a complex of anorthositic to mafic igneous rocks (4). The morphology of the preserved structure may be subdivided into six elements. The central region (1) is a topographic high about 25 km in diameter and is dominated by two uplands displaced about 5-7 km north and south of the geometric center of the structure. The northern upland includes the structure's highest elevation, Mont de Babel. The inner plateau (1) surrounds this central region with an outer diameter of about 55 km. The inner plateau is marked by a distinct rise in elevation and is overlain by a nearly continuous melt sheet up to 200 m thick (5). A circular moat 5-10 km wide bounds the inner plateau. This moat is inferred to be a 65 km diameter ring graben and is the most prominent feature of the structure (1). Outside the moat and extending to a radius of about 50 km is the inner fracture zone characterized by a complex and closely spaced joint pattern and drainage towards the center of the structure (4). Surrounding this zone, the outer fracture zone extends to a radius of about 75 km. The boundary between the inner and outer fracture zones corresponds to an abrupt change in jointing pattern and drainage direction. The Manicouagan structure is bounded by an outer circumferential depression which is revealed in both satellite photography and detailed topographic maps and has a diameter of about 150 km (1,6).

Aeromagnetic surveys reveal a prominent 2000Y anomaly with very high horizontal gradients over the geometric center of the structure. The magnetic anomaly is consistent with a shallow source having several peaks or extensions that form a rough ring about 6-10 km diameter around the geometric center of the structure (7). The center of the structure is also associated with a small relative gravity high (8). Mont de Babel and the nearby peaks of the northern uplands and the topographic highs of the southern uplands are associated with a low magnetic field and a relative Bouguer gravity low.

In contrast to the Floran and Dence model (1) it is proposed that the impact event at Manicouagan formed a transient cavity 80 km in diameter and a transient depth possibly as great as 15-20 km. About 270-455 km$^3$ of melted material (9) formed a pool about 65 km diameter at the bottom of the crater. Shortly after formation, the transient cavity partially collapsed, increasing the crater diameter to about 100 km corresponding approximately to the current boundary between the inner and outer fracture zones. Highly fractured limestone blocks in contact with the impact melt are interpreted as debris slumped to the floor during this adjustment phase. Crater collapse also resulted in uplifting a central peak-ring complex analogous to those within lunar craters (2,10). A central peak-ring structure 15 km in diameter could account for the 5-7 km displacements of the northern and southern uplands from the center of the structure. Subsequently, the crater rapidly filled with sediments thereby
Model for Manicouagan


reducing the rate of isostatic adjustments.

At some time, probably before the most recent periods of glaciation, the highly fractured and brecciated rock below the crater was intruded by a tabular magmatic body. This intrusion gradually uplifted the crater floor, forming a circular moat surrounding a central floor plate. A floor plate diameter of about 65 km is consistent with plate diameter to rim diameter data for endogenically modified lunar craters (2). This massive adjustment of the crater floor resulted in downdropping of part of the central peak-ring along steeply dipping normal faults. Dike intrusions along these faults could account for the ring-like magnetic anomaly now associated with the central portion of the crater. Similar faulting and associated intrusions can be documented in several lunar floor-fractured craters. Subsequent erosion has left exposed only the core of portions of the peak-ring complex of which Mont de Babel is a remnant. The subfloor intrusion also produced an outer ring fracture with a diameter 1.5 times the original crater diameter in a manner analogous to those surrounding lunar floor-fractured craters and in particular such craters in Mare Smythii.

Summarizing, available data are consistent with an interpretation of the Manicouagan impact structure as an endogenically modified crater as illustrated in Figure 1. The ring-like features at Manicouagan can be explained as the consequences of the collapse of the transient cavity walls, subsequent uplift of the crater floor, downdropping of portions of the central peak complex, and erosion of the endogenically modified crater to create the present structure. A number of similarly modified but well preserved craters exist on the Moon. Deep drilling of the structure and a well-controlled seismic survey of the area could provide the definitive data required to determine whether Manicouagan is an endogenically modified crater as proposed here or an analog to the multi-ringed lunar basins as suggested by Floran and Dence.

References

Model for Manicouagan


Figure 1. Proposed evolution of the Manicouagan structure. Impact produces 100 km diameter crater following collapse of transient cavity (A). Sediments accumulate within crater as topographic form is eroded (B). Magma intrudes the shock-weakened zone beneath the crater and uplifts the crater floor resulting in floor/rim fracturing and stripping of both accumulated sediments and portions of melt sheet (C). Schematic plan view of Manicouagan (after 1) shows major morphologic elements described in the text and their relation to the proposed geologic history. Striped unit indicates impact melt sheet.