fact that the present annular moat is primarily an erosional feature rather than a structural feature. This latter interpretation does not imply that the annular moat is not a reflection of the original structure. There is abundant evidence that rocks within the area of the moat have been downfaulted from their original positions (see next section). There is little evidence, however, that it is a ring graben per se [*Floran and Dence*, 1976]. Glacial action may have produced the present overdeepened moat because of variations between the competency of lithologies in the inner fracture zone and the inner plateau.

The inner plateau is a dissected plateau formed by an annulus of eroded impact melt rocks overlying shocked basement rocks. The inner plateau rises steeply, ~200 m in distances of ~1 km, from the inner margin of the annular moat (Figure 2) and has a relatively subdued topography (Figure 2), with no obvious topographic evidence of ring-like structures [cf. *Floran and Dence*, 1976]. The central region is generally a topographic low but contains an elevated central peak. The central peak, Mont de Babel, consists of a horst of shocked anorthosite, rising some 500 m above the surrounding terrain. It is displaced ~5 km to the north of the geometric center of the structure. To the south of the center is a more subdued upland area (Figure 3 in *Floran and Dence* [1976]). This area is composed of impact melt rocks overlying shocked basement gneisses. Both *Floran and Dence* [1976] and *Orphal and Schultz* [1978] suggest that this southern upland area and Mont de Babel may be part of a poorly-developed peak ring, with the greater topographic expression of Mont de Babel due to the differential uplift of anorthosite compared to gneisses. An additional possibility, however, is that the southern upland area exists because it is in the erosional shadow of Mont de Babel. The general direction of ice movement was southerly [*Kish*, 1968] and Mont de Babel may have acted as a resistant block to southward moving ice, deflecting it around itself and producing increased erosion on the east and west sides but reduced erosion to the south.

In summary, we note that the only feature which can be directly related to lunar structures is the topographically high central peak of Mont de Babel. Although we generally concur with previous authors on the principal morphological elements, we suggest that, because of erosion, their relationship to original morphologic features is less obvious than previously indicated, and that the present topography alone is inadequate for assigning the Manicouagan structure to a particular morphological class of complex structure [*Floran and Dence*, 1976; *Orphal and Schultz*, 1978].

GEOLOGY

The geology of the Manicouagan area is described by *Currie* [1972] and *Murtaugh* [1976] and details of the petrography and chemistry of the impact melt rocks are given in *Floran et al.* [1978], *Grieve and Floran* [1978], and *Simonds et al.* [1978]. A generalized geologic map of the area is shown in Figure 3 and the geology as it pertains to the form of the Manicouagan structure is discussed below.

Ordovician Limestone

The thin sequence of post-cratonic Middle Ordovician sediments, principally limestones, which overlay the Grenville basement rocks at the time of the Manicouagan impact, has been essentially removed by erosion. Today limestones exist only as occasional inclusions in the impact melt rocks and as outliers in the area of the annular moat (Figure 2), where *Murtaugh* [1976] estimates that they have been downfaulted > 1 km from their original stratigraphic position. The downdropped limestones lie unconformably on Grenville basement and occur at radial distances of between 23 and 33 km from the center (Figure 4), and their distribution led *Floran and Dence* [1976] to suggest that the premodification transient cavity had a maximum radius of 22.5 km. They argued that Ordovician limestone closer to the center was ejected and the present distribution of limestone represents material which lay on the outside of the transient cavity rim and was downfaulted during the modification of the transient cavity and formation of the 'peripheral trough.' Thus they concluded that the rim of the transient cavity lay inward of the innermost exposure of limestone.

We offer an alternative interpretation. If the limestone outliers represent the traces of blocks which have slumped downward and inward from the rim of the transient cavity, then the transient cavity rim lies outward of the innermost exposure of limestone, and this exposure at 23 km radius must represent a minimum radius for the transient cavity, assuming that there are no major limestone occurrences under the melt sheet closer to the center. Similarly, the outermost occurrence, which represents material from beyond the transient cavity rim that has been downslumped along listric faults to a position essentially on the final crater floor, provides an approximation of the radius of the original crater floor and thus a minimum estimate of 33 km for the radius of the final modified structure.

Shock Metamorphism in Basement Rocks

The Grenville basement rocks include amphibolite to granulite facies, metagabbro, anorthosite, a variety of quartzofeldspathic gneisses, and minor metasediments (Figure 2 and 3) [*Currie*, 1972; *Murtaugh*, 1976; *Grieve and Floran*, 1978]. The basement rocks of the central region and those exposed in the dissecting valleys of the inner plateau have been shock-metamorphosed and the distribution of shock effects can be used to constrain original crater dimensions. Details of the nature of shock effects in a wide variety of minerals are given in *Dressler* [1970] and *Murtaugh* [1976]. They range from the development of diaplectic quartz and feldspar glasses close to the center of the structure, through planar features in quartz, feldspar, and other minerals, to kink bands in hornblende and biotite close to the annular moat. The maximum radial distances from the center to the first appearance of particular features are given in Table 1, along with estimates of the shock pressures required to produce these features. This approach to defining the radial distribution of shock pressures is different from that of *Robertson and Grieve* [1977], which was based on a detailed analysis of the number of different orientations of planar features in quartz but was confined to a smaller pressure range of ~50–250 kb (10 kb = 1 GPa). The data of *Dressler* [1970] and *Murtaugh* [1976] on the appearance of shock features at Manicouagan, as well as the pressure estimates based on different minerals, provide relatively consistent results for the radial distribution of shock pressures (Table 1; Figure 5).

The shock data indicate pressures of ~120 kb at a radial distance of 22.5 km (Table 1; Figures 2 and 5), corresponding to the maximum radius of the transient cavity according to *Floran and Dence* [1976]. This is far in excess of the few kilobars ($\lesssim 10$ kb) generally accepted for the transient cavity rim in both simple and complex structures [*Cooper*, 1977; *Dence et al.*, 1977; *Kieffer and Simonds*, 1980]. Although shock pressures at the floor and rim of the transient cavity are likely to be higher with increasing size, due to less efficient excavation at large events [*Grieve et al.*, 1977], it is unreasonable to suppose they