MODIFICATION OF PREMARE IMPACT CRATERS BY INTERMITTENT VOLCANISM AND TECTONISM. W.J. Brennan, R.A. Young, and D.J. Nichols, SUNY, Geneseo, New York, 14454

The lunar maria contain a wide variety of circular features in addition to craters of purely impact origin. These features are most commonly located around the margins of the maria where the filling material is, presumably, the thinnest. Although some circular features have been interpreted as being of endogenic origin (1,2,3), many others appear to have resulted from modification of impact craters (4,5). In contrast with impact craters, many such features have subtle rims with steeper outer slopes and gentler inner slopes. In some the interior portions exhibit extensive fracturing. In many instances modification can be seen to have been the result of magmatism and tectonism, both of which have occurred intermittently during mare filling (6).

Comparison of selected circular features (10-25 kilometer diameter) on Apollo metric and panoramic photography has revealed that their surfaces are similar in both texture and albedo to the surrounding mare surfaces, indicating that partial or complete flooding by mare lavas has occurred. Direct evidence of flooding can be seen in the Jansen R feature (Fig. 1A) the rim of which is crossed by Jansen Rille, a sinuous rille of probable volcanic origin (6).

It has been shown that some shallow circular features ('ghost' craters) may be subdued replicas of buried terrain, formed by draping of cooling lava over the rims of flooded craters (4), but many similar features appear to have had more complex modes of origin. The commonly observed steeper outer slopes and gentler inner slopes (inverted topography), which can be seen on Jansen R (Fig. 1A) and the feature to the east (Fig. 1B), are not easily explained by the draping mechanism. Formation of the rim of Jansen R only by draping of a lava crust on flooded terrain would have required that the lava tube or channel from which Jansen Rille developed be positioned directly above a topographic prominence (buried crater rim), an improbable occurrence. Alternatively, distension of the mare surface above flooded craters, due to the emplacement of plutons in and/or above the brecciated rock but under the overlying lava crust, would more easily account for such inverted topography (Fig. 2A). Many flooded craters were probably formed by impact during, rather than prior to, the filling of the maria. During subsequent volcanism the fractures and brecciated rock thus formed would have been likely sites for emplacement and/or flow to the surface of magmas.

Volcanism apparently has occurred at impact sites as at B (Fig. 1). A small ridge-like form is continuous with the southern portion of the rim, and another extends outward from the northeastern side. Volcanism along circular fractures of impact origin may result in the formation of a secondary volcanic rim around some flooded craters. A possible example can be seen in the Oceanus Procellarum (Apollo 15 metric frame 2746).

Evidence of deformation of the mare surface can be seen around a circular feature in southeastern Mare Crisium (Apollo 15 metric frame 540, best viewed stereographically). The interior portion has been down-warped relative to the rim which varies from subtle on the east side to high, steep, and scarp-like on the west. The surrounding mare surface also appears to have been deformed, especially on the southwest side where the feature is adjacent to a mare ridge. The outer, steep, scarp-like portions of the rim suggest that faulting may have occurred along portions of circular fractures of impact origin, perhaps as a result of isostatic adjustment of the crust, associated with magmatic activity at shallow depth. Another example of deformation following lava flooding can be seen in northeastern Mare Crisium (Apollo 17 metric frame 279). This feature is surrounded by a discontinuous circular ring of relatively high-albedo hills that appear to be remnants of an impact rim. The interior has been flooded by lavas which were subsequently uplifted and fractured. A later episode of lava flooding has covered the surrounding mare surface, and all but the highest portions of the uplifted and fractured interior, forming kipukas (7). This structure is illustrated diagrammatically in Figure 2(B).

It is apparent that the relative importance and sequence of plutonism, volcanism, fracturing and flexuring in the modification of individual impact craters is the primary reason for most observed variations in morphology among these features. In some cases variations may be due, in part, to whether the craters from which these features have developed were formed prior to, early or late in the history of mare filling.

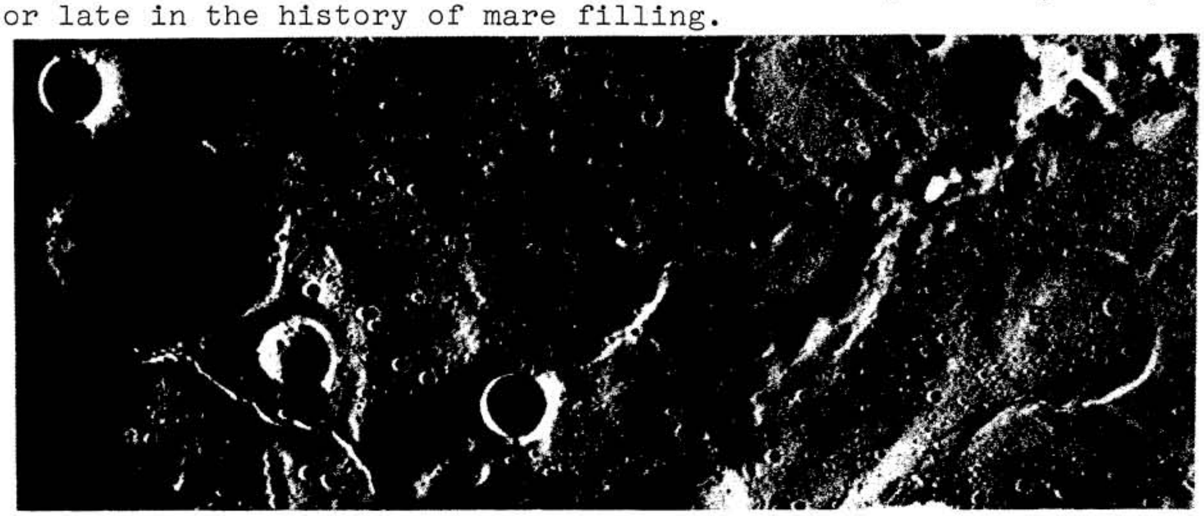

Figure 1: Modified craters in northern Mare Tranquillitatis (Apollo metric frame 17-308).

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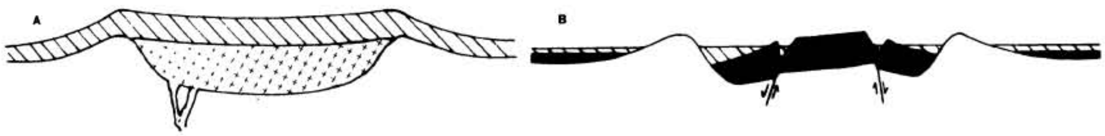

Figure 2: Hypothetical examples of modified craters. (A) Emplacement of a pluton (crosses) beneath the lava crust (lines) in a flooded crater; (B) Flooding of older, fractured lavas (dark) by younger lavas (lines) to form kipukas.

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