Surveying the Moon

from G. Fielder

THE lunar geological formations known collectively as the Fra Mauro Formation have long been thought, by most students of the Moon, to be deposits of ejecta from the basin of Mare Imbrium. When, in 1971, Apollo 14 astronauts surveyed an area not far from the crater Fra Mauro itself, it was hoped that new light would be thrown on this old conjecture.

The *US Geological Professional Paper 880*, US Geological Survey, 1977 examines merely a part of the apposite evidence: that relating, principally, to the astronauts' *in situ* findings and their hand-held camera records. Accounts of the terrain characteristics and of numerous rock blocks feature prominently in the description. The rock blocks range up to several metres in size. They are all breccias thought to have been produced by the welding of impact-generated fragments. The photogeological analyses of these rocks cover discussions of their structures and descriptions of their clasts. One block of rock has a probable clast, 1.7 m in length, in which other clasts are found and which themselves contain yet other probable, small clasts: this indicates successive and discrete stages in the evolution of this particular block.

The photointerpretation is supplemented by the astronauts' own field descriptions of the samples; and the publication includes coloured geological maps, charts, and panoramic photomosaics to assist the reader with the identification of a sample's relative position and environs.

Good descriptions are presented of three kinds of rock fillet—an accumulation of fine-grained material (see photo) making contact with a coherent block or rock—and of other features which point to physical processes on the lunar surface. Among these features, the lunar grid (lineament) system is put in perspective when the authors argue for the correlation of small-scale (centimetre to metre lengths) lineament trends with trends mapped on a large scale and dismiss the proposition that lighting can have an all-important bearing on the apparent directions of most lineaments.

Although the matrix materials of the rocks studied in detail on this fine collection of photographs are frequently referred to, in the text, as of probable Imbrium origin, the Fra Mauro Formation is said (without qualification), in the Summary of Conclusions, to consist of ejecta from the Imbrium basin! □

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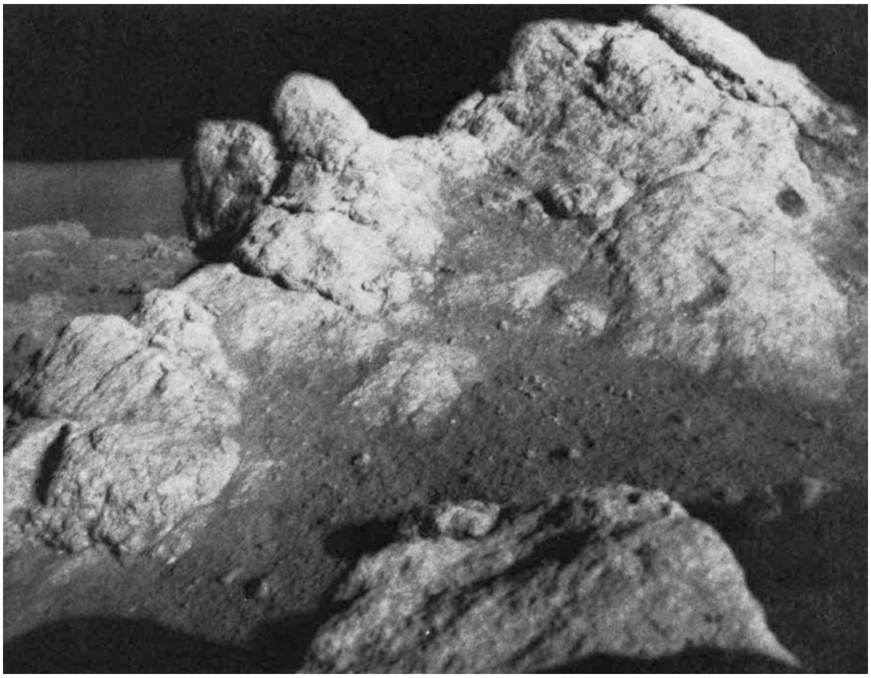

One of three kinds of lunar fillet: lunar regolith fines have been scattered on to this gently sloping, structured rock face and have settled in shallow depressions to produce a 'low angle fillet.' (*NASA photo* AS-14-68-9450)

Benioff splitting

from Peter J. Smith

BENIOFF zones are intimately associated with earthquakes. Indeed, earthquakes provide the best means of delineating such zones, indicating with startling clarity how moving oceanic lithosphere bends downwards beneath appropriate continental edges and descends at an angle of about 45° until it is ultimately assimilated into the mantle. But whereas it is customary to see a scattered pattern of earthquakes defining the outlines of a descending plate, more recent observation has indicated the presence in some cases of a fine structure of seismicity which may throw light on at least one of the processes by which Benioff zone earthquakes are produced.

A nice example is provided by Engdahl and Scholz (*Geophys. Res. Lett.* 4, 473; 1977), who have analysed the distribution of foci from all earthquakes with magnitude greater than 3 occurring from July 1974 through February 1977 in the Adak region of the central Aleutians. The resulting plot shows that most of the shallow seismicity in the area occurs within the depth range 15–27 km and has a lateral spread of about 50 km in the direction of the horizontal component of plate motion (that is, viewed in side projection, looking end-on at the arc). Immediately below, the zone of seismicity then contracts to a lateral width of no more than 10–15 km. At a depth of about 100 km, however, the seismicity splits into two distinct zones each of which has a lateral dimension of 10–15 km and is separated from the other by a practically earthquake-free region about 25 km wide. At a depth of about 175 km the two arms then come together again, forming a single zone of seismicity down to the deepest earthquakes at about 270 km.

This is not the first known example of Benioff splitting. Sykes (*J. geophys. Res.* **71**, 2981; 1966) observed a separation of about 30 km in the pattern of intermediate earthquakes beneath the Kurile arc more than a decade ago; and more recently Veith (thesis, Southern Methodist University, Texas, 1974) and Stauder and Mualchin (*J. geophys. Res.* **81**, 297; 1976) have investigated the Kurile case in greater detail. Umino and Hasegawa (*Zisin* **28**,

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