[7], who found that in order to generate a ring fault at a distance of ~1.4 crater radii, it was necessary to restrict asthenospheric flow to a channel at depth, one overlying a stiffer mesosphere. It is tempting to assign this asthenospheric channel to a ductile lower crust, as discussed above. Alternatively, an effectively stiffer mesosphere may be a natural consequence of truly non-Newtonian rebound. Much work remains to be done on this problem.

Overall, these estimates and models suggest that multiringed basin formation is indeed possible at the scales observed on Venus. Furthermore, due to the strong inverse dependence of solid-state viscosity on stress, the absence of Cordilleran-style ring faulting in craters smaller than Meitner or Klenova makes sense. The (1) apparent increase in viscosity of shock-fluidized rock with crater diameter, (2) greater interior temperatures accessed by larger, deeper craters, and (3) decreased non-Newtonian viscosity associated with larger craters may conspire to make the transition with diameter from peak-ring crater to Orientale-type multiringed basin rather abrupt.

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SUDBURY PROJECT (UNIVERSITY OF MÜNSTER–ONTARIO GEOLOGICAL SURVEY): (5) NEW INVESTIGATIONS ON SUDBURY BRECCIA. V. Müller-Mohr, Institute of Planetology, University of Münster, Wilhelm-Klemm-Str. 10, W-4400 Münster, Germany.

Sudbury breccias occur as discordant dike breccias within the footwall rocks of the Sudbury structure, which is regarded as the possible remnant of a multiring basin [1]. Exposures of Sudbury breccias in the North Range are known up to a radial distance of 60–80 km from the Sudbury Igneous Complex (SIC). The breccias appear more frequent within a zone of 10 km adjacent to the SIC and a further zone located about 20–33 km north of the structure.

From differences in the structure of the breccias, as for example the size of the breccia dikes, contact relationships between breccia and country rock as well as between different breccia dikes, fragment content, and fabric of the ground mass, as seen in thin section, the Sudbury Breccias have been classified into four different types.

A. Early breccias with a clastic/crystalline matrix comprise small dikes ranging in size from ~1 cm to max. 20 cm. Characteristic features of these breccias are sharp contacts to country rock, low fragment content (20–30%), local origin of fragments, and an aphanitic, homogenous matrix, which can be related to country rock. Locally corrosional contacts to feldspar minerals and small vesicles filled with secondary minerals are observed.

B. Polymict breccias with a clastic matrix represent the most common type of Sudbury breccia. The thickness of the dikes varies from several tens of centimeters to a few meters but can also extend to more than 100 m in the case of the largest known breccia dike. Contacts with country rock are sharp or gradational. Fragment content (60–75%) is usually of local origin but especially in large dikes allochthonous fragments have been observed. Inclusions of type A breccias reveal the later formation of this type of breccia. The heterogenous matrix consisting of a fine-grained rock flour displays nonoriented textures as well as extreme flow lines. Chemical analysis substantiates at least some mixing with allochthonous material.

C. Breccias with a crystalline matrix are a subordinate type of Sudbury breccia. According to petrographical and chemical differences, three subtypes have been separated. The local origin of the fragments and the close chemical relationship to the country rock point to an autochthonous generation probably through *in situ* frictional processes. For two subtypes the geometry of the dikes and the texture of the matrix indicates that at least some transport of breccia material has occurred. Breccias with a crystalline matrix have never been observed in contact with the other types of breccias.

D. Late breccias with a clastic matrix are believed to represent the latest phase of brecciation. Two subtypes have been distinguished due to differences in the fragment content. Breccias with a low fragment content show a weak lamination and sharp or gradational contacts to country rock. Inclusions of type A breccias are observed. Breccias with a high fragment content are characterized by gradational contacts and are only known from the outermost parts of the structure. Fragments of these breccias are of local origin. A possible correlation of the relative timescale of breccia formation with the phases of crater formation will be discussed.

Shock deformation features, which have been recorded within breccia fragments up to a radial distance of 9 km from the SIC, represent the shock stage I of the basement rocks. Inclusions exhibiting a higher shock stage, such as melt particles or suevitic fragments, which are known from dike breccias of, e.g., the Carswell impact structure, are lacking. This means that the dike breccias of Sudbury as presently exposed are from a deeper level of the subcrater basement than their counterparts of Carswell.

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A HISTORY OF THE LONAR CRATER, INDIA—AN OVERVIEW. V. K. Nayak, Department of Applied Geology, Indian School of Mines, Dhanbad, India.

The origin of the circular structure at Lonar, India (19°58'N:76°31'E), described variously as cauldron, pit, hollow, depression, and crater, has been a controversial subject since the early nineteenth century. A history of its origin and other aspects from 1823 to 1990 are overviewed. The structure in the Deccan Trap Basalt is nearly circular with a breach in the northeast, 1830 m in diameter, 150 m deep, with a saline lake in the crater floor.

Since time immemorial, mythological stories prevailed to explain in some way the formation of the Lonar structure, which has been held in great veneration with several temples within and outside the depression. Various hypotheses proposed to understand its origin are critically examined and grouped into four categories as (1) volcanic, (2) subsidence, (3) cryptovolcanic, and (4) meteorite impact. In the past, interpretations based on geological, morphological, and structural data were rather subjective and dominated by volcanic, subsidence, and, to some extent, cryptovolcanic explanations [1]. In 1960, experience of the Canadian craters led Beals et al. [2] to first suggest the possibility of a meteorite impact origin of the Lonar crater, and thus began a new era of meteorite impact in the history of the Indian crater.

The last three decades (1960 to 1990) reflect a period of great excitement and activity of the Lonar crater, perhaps owing to an upsurge of interest in exploration of the Moon and other planets.