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The role of offset dykes in complex crater formation; the Sudbury example

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The 1.85 Ga Sudbury Structure of Ontario is now widely accepted to be a 200–250 km multi-ring impact basin. The structure consists of the 27 x 60 km Sudbury Igneous Complex (SIC), which is a differentiated impact melt sheet, and the Whitewater Group, which is composed of fallback and overlying sedimentary rocks, as well as various impact breccias in the footwall.

The so-called offset dykes consist of melt-breccia dykes that emanate from the SIC. They can occur as radial, concentric or discontinuous dykes. Quartz Diorite is the local term for the rocks of the offset dykes, but most are granodioritic to monzodioritic in composition. There are ten known offset dykes: five radial dykes (Copper Cliff, Worthington, Whistle-Parkin, Ministic, and Foy), three concentric (South Range Breccia Belt, Manchester, and Hess), and two discontinuous (Creighton and Maclennan). The radial offset dykes are generally linked to the Main Mass by means of a funnel-shaped embayment, which typically contains abundant sulphides associated with the Sublayer unit.

The offset dykes contain a variety of different rock types. These include Quartz Diorite (QD), containing little or no inclusions, Inclusion-bearing Quartz Diorite (IQD), Radial Breccia, Mafic Sulphide Bearing Breccia (MSBB), Sudbury Breccia, and Sublayer.

Field relationships between the various rock units are variable. In general, the Sublayer is restricted to the embayment areas of radial offsets but is also found as discontinuous lenses around the SIC. Radial dykes differ between the North Range and the South Range of the Sudbury Structure. North Range radial dykes consist of IQD, QD, Radial Breccia, and MSBB, whereas South Range radial dykes consist of IQD and QD only. Relationships between these rock units indicate a multi-stage emplacement mechanism. Rock types in concentric dykes consist of QD, IQD, and Sudbury Breccia.

Radial and concentric offset dykes record all three stages of Complex crater formation. The contact/compression stage of impact crater formation is responsible for creating the radial and concentric cracks, which are later exploited during the crater excavation stage as inclusion-rich breccias forcefully injected into radial cracks. Modification stage processes generate the Sudbury Breccia in concentric dykes and allow for the injection of melt from the overlying melt sheet into both the radial and concentric dykes.