

Geology, Mineralization, and Emplacement of the Foy Offset Dike, Sudbury Impact Structure*

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Abstract

The Foy offset dike is the longest of the known radial dikes associated with the 1.85 Ga Sudbury Igneous Complex. The Foy dike extends for at least 30 km from the complex into the North Range Archean and Proterozoic footwall rocks of the Sudbury impact structure. The dike ranges in width from 400 m, where it connects to the Sudbury Igneous Complex, to 50 m at its most distal known exposure. We divide the dike into a proximal segment and a distal segment, based on where it intersects the concentric Hess offset dike. Three main dike lithologies are distinguished, all referred to as varieties of quartz diorite. Inclusion-rich pyroxene-quartz diorite occurs in the embayment, adjacent to the base of the main mass of the Sudbury Igneous Complex. This constitutes the sublayer. Northward, the sublayer gives way to amphibole-biotite inclusion-bearing quartz diorite and amphibole-biotite inclusion-poor quartz diorite. The dike is mineralized and deposits in the proximal segment have been mined. Mineralization is associated with the inclusion-rich dike phase. At the Nickel offset mine the dike contains inclusion-bearing massive Ni-Cu sulfides that also host platinum-group minerals. The orebodies occurred as strike-parallel sheets within the central parts of the dike in association with inclusion-bearing quartz diorite. The geochemistry of the dike lithologies indicates that both the inclusion-poor and inclusion-bearing quartz diorite varieties are close in composition to the postulated bulk composition of the Sudbury Igneous Complex. This implies that the dike was emplaced prior to any significant fractionation of the main melt body and, hence, very early in the evolution of the Sudbury Complex. We envisage dike emplacement rapidly following rebound and central uplift formation as part of the impact process. Early dike emplacement implies that the ore was also introduced early in the evolution of the melt sheet when the inclusion-poor quartz diorite phases were still unconsolidated. Uplift would have caused extension in the target rocks and so dilated the footwall fractures and faults that then became hosts, primarily via gravitationally driven intrusion, to the primitive polymict impact melt breccias and sulfide ores. The chilled margin compositions of the Foy inclusion-poor quartz diorite are considered good indicators of the original bulk composition of the Sudbury Igneous Complex; this idea is supported by comparison with calculated estimations of the bulk composition. A shift in geochemical trends, a grain size increase, and a decrease in inclusion content occurs ~22 km along the length of the dike, which we believe corresponds to a fault system that downfaults to the north. Given that the dense ore would have preferentially settled toward the base of the Foy dike-fracture system, postimpact downfaulting of the distal segment of the dike may have displaced any mineralized zones present to deeper levels relative to the proximal segment.

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