EMPLACEMENT OF THE FOY OFFSET DYKE AT THE SUDBURY IMPACT STRUCTURE, CANADA.

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Introduction: Large impact structures are often surrounded by thick metre to hundred metre-scale dykes that occupy footwall fractures. These 'Offset Dykes' at the Sudbury impact structure in Canada offer a unique opportunity to study the formation of impact-related dykes. Their lithology is traditionally referred to as 'quartz diorite', but geochemically they are closer to granodiorite [1]. These dykes are important not just for their insight into crater formation, but also because they can host significant economic deposits. In fact, the Copper Cliff Offset Dyke hosts approximately 15% of the known Sudbury ore [2]. Recently, exploration completed by Wallbridge Mining Company Limited has uncovered many new outcrops of Offset Dykes, which has provided an excellent opportunity to study their formation.

Sudbury Impact Structure: The Sudbury structure is a 1.85Ga peak-ring or multi-ring impact structure with an estimated diameter of over 200km [3–5]. The structure can be divided into three units: the Whitewater Group, the Sudbury Igneous Complex (SIC), and the fractured and brecciated footwall rocks that host the Offset Dykes [3]. The Whitewater Group is a series of sedimentary rocks that filled the basin after the impact. The SIC is a 2.5–3km thick differentiated melt sheet roughly 60 km long and 30 km across. From top to bottom, the SIC is separated into the granophyre, quartz gabbro, norite, and the sublayer, which is often grouped together with the Offset Dykes.

Foy Offset Dyke: The Foy Offset Dyke is a radial dyke found in the north range. The host rocks are primarily the Archean granites, greenstones, and gneisses of the Abitibi subprovince. It extends 37 km along strike and ranges from 400 m across at its southern end to 50 m at distal portions. It is composed of 'quartz diorite', a historic term for the felsic, igneous rocks that are found within the Offset Dykes [6]. It is granodioritic in composition and significantly more clast rich than other Offset Dykes in the region.

Field Observations: Field work was completed at two areas of the northern section of Foy. One was at the intersection between the radial Foy and the concentric Hess Offset Dyke, where the Foy itself terminates. The second area was approximately 3 km northeast where the dyke is found again.

Lithology: The dyke is composed of three phases, all variations of the traditional quartz diorite with granodioritic composition. The outermost phase is a coarse-grained, inclusion-poor phase (<5% clasts). The inner phase is a fine grained, inclusion-bearing phase (5–25% clasts). The third phase occurs within the inclusion-bearing phase. It is similar to the inclusion-bearing phase, but is significantly more clast-rich (>25%). The inclusion-rich phase is also found as dykes 20 cm–1m thick inside the inclusion-poor phase. Figure 1 shows a typical arrangement of these phases.

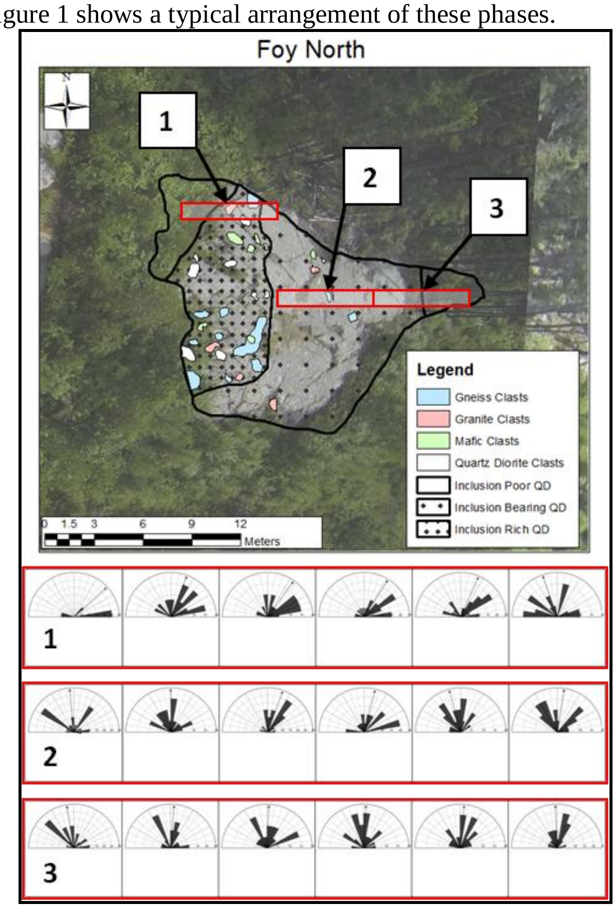

Figure 1. An outcrop map from Foy, approximately 3km northeast of the intersection between the Foy and Hess offset dykes. This shows the transition from inclusion-poor, to inclusion-bearing, to inclusion-rich, and back to inclusion-poor quartz diorite. Each rose diagram shows the orientation of the long axis of inclusions in a 1x1m square. The location of these squares is indicated by the red box on the map.

Contacts: The contact between the dyke and the host rock is typically sharp, fluidal in appearance, often with a quenched margin 10–50cm thick. Inclusions of the host rock are occasionally found adjacent to the contact. The contact between the three phases is sharp to gradational. It consists of a 'transition-zone' that varies from ~1–15cm thick. Elongate minerals in this zone are oriented parallel to the contact.

Inclusions: Clasts are typically small, <2 cm in size; however, they range from <1mm to 5m in size. Lithologies include: granites and gneisses from the host rock, metasediments, inclusion-poor and inclusion-bearing quartz diorite, as well as mafic clasts from various dyke swarms in the region (Nippissing Diabase, and the Matachewan Diabase). Granite clasts are more irregular and fluidal, and are often surrounded by smaller granite clasts broken from a larger clast. Gneiss, quartz diorite, and mafic clasts are typically well rounded with sharp contacts. Quartz diorite clasts occasionally have indistinct contacts with very irregular shapes.

Traverses were made across the dyke in 1x1m squares. In each of these squares clasts >5cm were counted and the long-axis of up to 20 clasts was measured. Our results show that clasts close to the contact are oriented sub-parallel to the contact, while clasts towards the centre of the dyke have no clear orientation (Fig. 1). The inclusion poor phase typically contained <50 clasts per m^2, the inclusion bearing phase typically contained 50–100 clasts, and the inclusion rich phase contained >100 clasts, up to a maximum of 361 clasts. Figure 2 shows this transition between the three phases on two outcrops.

Results and Discussion: Clasts of the inclusion-poor phase were included into both the inclusion-bearing and inclusion-rich phases, and inclusion-bearing clasts were included in the inclusion-rich phase. This shows that the three phases formed during separate events; from oldest to youngest: inclusion-poor, inclusion-bearing, and inclusion-rich. Dyke-like bodies of the inclusion-rich phase cutting the inclusion-poor phase further support this.

The alignment of clasts close to the contact versus the random orientation of the clasts towards the centre indicates a flow that was more turbulent towards the center. This suggests that the inclusion-bearing phase was emplaced via a strong flow rather than via trickle-down into a fracture. Future work at the south end of Foy, closer to the SIC, would provide further insight into its emplacement. Melting and assimilation of the host rock is also sign of turbulent flow [7]. This is shown by the fluidal nature of the dyke-host contact, and the presence of rip-up clasts implies close to the contact.

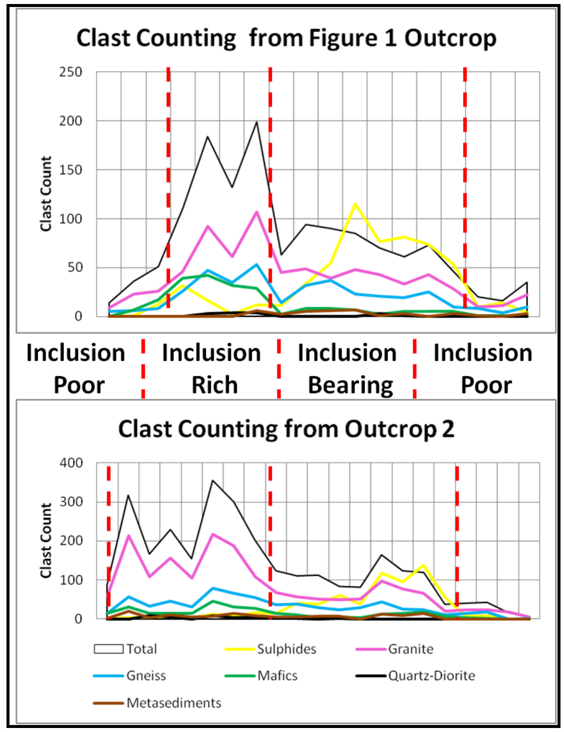

Figure 2. Clast counting results from the outcrop in Figure 1 (top) and another outcrop in the region. From west to east each figure transitions from inclusion poor, to inclusion rich, to inclusion bearing, and back to inclusion poor.

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