THE ONAPING INTRUSION, SUDBURY, CANADA – AN IMPACT MELT ORIGIN AND RELATIONSHIP TO THE SUDBURY IGNEOUS COMPLEX. D. Anders[1], G. R. Osinski[1] and R. A. F. Grieve [1,2], [1]Dept. of Earth Sciences/Centre for Planetary Science and Exploration, Western University, Canada (dander53@uwo.ca, gosinski@uwo.ca), [2]Earth Sciences Sector, Natural Resources Canada, (rgrieve@nrcan.gc.ca).

Introduction: The Sudbury impact structure, located in Ontario, Canada, was formed at ~1.85 Ga [1] and, with an estimated diameter of 200–260 km, it counts among the largest impact structures on Earth. The impact basin contains the Sudbury Igneous Complex (SIC); a coherent, but differentiated, impact melt sheet composed, from bottom to top, of: Norite, Quartz Gabbro, and Granophyre [1]; covered by rocks of the Onaping Formation and post-impact sediments of the Onwatin and Chelmsford Formations. Peculiar igneous bodies – the so called "Onaping Intrusion" – form sheets and sills mainly at the contact between the SIC and Sandcherry Member of the overlying Onaping Formation, where it occupies approximately 50% of this contact zone [3].

Based on a preliminary recent study, the Onaping Intrusion has been interpreted to represent the roof rocks of the SIC [4]. This study focuses on further investigations of the Onaping Intrusion to examine the proposed impact melt origin and the relationship to the underlying SIC.

Samples and Analytical Methods: The 70011 drill core analyzed in this study was taken in 1981 from the North Range of the SIC (Northing 482140, Easting 396338). Samples were kindly provided by Vale. Polished thin sections of samples from the drill core were examined by optical and scanning electron microscopy (SEM), in order to characterize mineralogy, microstructures and textures (Hitachi SU6600 FEG, University of Western Ontario). Quantitative analyses of feldspars were carried out using a JXA JEOL-8900L Electron Microprobe (McGill University Montreal). X-ray-fluorescence (XRF) analyses provided major and trace element abundances and X-ray-diffraction (XRD) analyses revealed mineral compositions (both at University of Western Ontario).

Observations: The samples at depths of 50 to 298' are composed of a dark, black aphanitic assemblage that contains lithic clasts of several sizes, shapes, and compositions (Fig. 1). The matrix is characterized by an intergrowth of feldspar and quartz. K-feldspar, the dominant feldspar, occurs either as anhedral mineral grains or as euhedral laths showing simple Carlsbad twinning. Isolated, small euhedral sodium-rich plagioclase grains or laths showing multiple twinning are present in a small amount. Microprobe analyses of alkali feldspars and plagioclase revealed only Ca-depleted sanidine and albite compositions. Chlorite, often in contact with decomposed hornblende laths, occurs as small needles and laths distributed within the groundmass, sometimes clustered to aggregates. Epidote within the igneous matrix ranges from small grains and laths to large crystals and aggregates. Minor minerals within the matrix are pyroxene, calcite, pyrite, titanite and very rare biotite. Grain size tends to increase with increasing depth (Fig. 1), which is in particular notable for alkali feldspar and quartz.

Lithic clasts of different composition (felsic, quartzitic, and mafic) encountered within the matrix decrease in number with increasing depth. All clasts are characterized by a rounded to subrounded shape and show a sharp contact with the surrounding matrix. Felsic and quartz clasts are often surrounded by a rim composed of hornblende, epidote, chlorite and pyroxene; while mafic clasts sometimes are rimmed by a felsic assemblage. Decorated and annealed PDFs (Fig. 2) have been detected in the lower parts of the Onaping Intrusion starting at 260'. They occur in large quartz grains of more than 500 µm in size, within coarse-grained quartzite clasts.

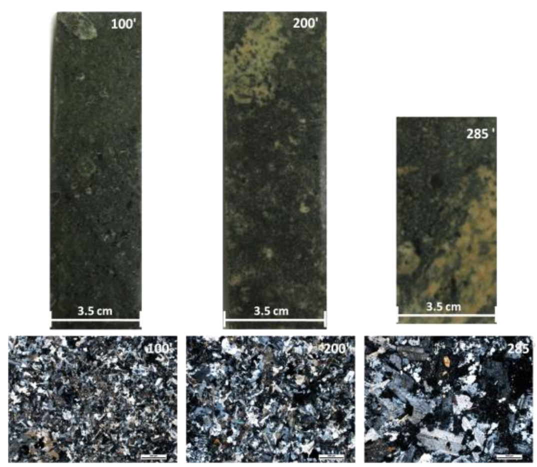

Fig. 1: Photographs of core samples at depths of 100, 200 and 285 feet, showing a black aphanitic assemblage. The microscope pictures below (crossed polars) illustrate the increasing grains size with increasing depth.

The contact between Granophyre and Onaping Intrusion is abruptly gradational – there is no sharp contact between the two units. The first isolated patches of graphic intergrowth (granophyric texture) of alkali feldspar and quartz occur at a depth of 282' within the matrix of the Onaping Intrusion. The amount of granophyric texture then increases with increasing depth and is the dominant texture at 298', where the core becomes pure Granophyre.

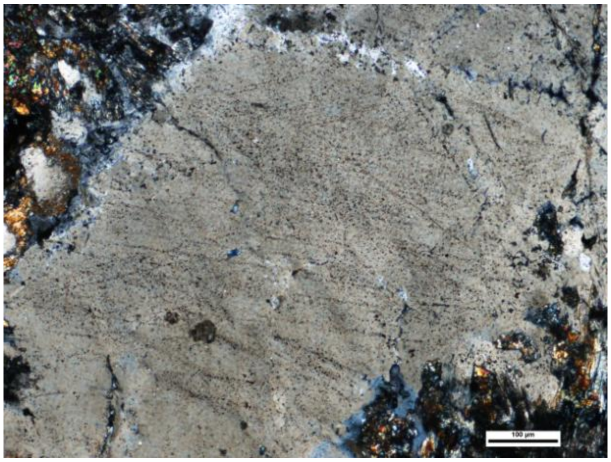

Fig. 2: Optical photomicrograph (crossed polars) showing decorated and annealed PDFs in quartz at depth of 282'.

Interpretations: Our observations clearly indicate the igneous nature of the matrix of the Onaping Intrusion, which is a sign of cooling and subsequent crystallization from a melt. Skeletal intergrowth of alkali feldspar and quartz points to rapidly and simultaneously cooling of those components within the melt. Embayments and budding extensions of lithic clasts and, sometimes even, mineral grains is an indication of resorption and melting processes. Rims around clasts can be interpreted as a result of interaction processes between liquid melt and entrained target rock clasts. Epidote, chlorite and calcite are secondary minerals that have been formed by alteration of hornblende, pyroxene and biotite due to post-impact hydrothermal activities. Increasing grain size with increasing depth points to the existence of a temperature gradient within the melt assemblage during crystallization with slower cooling in proximity to the SIC, leading to longer crystallization times. The varying amounts of clasts with increasing depth is also associated with a temperature gradient. Close to the SIC, temperatures remained high over a longer period of time enabling assimilation of clasts; whereas at lower depths, temperatures were not sufficient for assimilation, resulting in quenching of the melt before clasts could have been digested.

The abruptly gradational transition between Onaping Intrusion and Granophyre implies an interaction between both units during formation. It suggests that they are related and may have originated from one melt pool. Granophyre, in general, displays similar mineralogy to the Onaping Intrusion; it is composed of quartz and alkali feldspar, includes mafic minerals of which some are altered to chlorite and epidote. Feldspars within the Granophyre are of K-rich sanidine and Na-rich albite composition, identical to feldspars within the Onaping Intrusion. XRF analyses reveal that the non existent amount of Ca-rich feldspars and the Ca-depletion within the Onaping Intrusion is not associated with albitization, leading to the assumption that the Onaping Intrusion is composionally related to the SIC. PDFs as indicators for impact melt rocks occur as decorated to annealed PDFs as a result of post-impact alteration of fresh, non-decorated PDFs, leading to a complete recrystallization of the amorphous silica lamellae [5, 6].

Conclusions: The observations of this study provide further evidence of the impact melt origin of the Onaping Intrusion and elucidate a possible relationship to the SIC. Increasing grain size, decreasing amounts of clasts with increasing depth and and an abruptly transitional contact between Granophyre of the SIC and Onaping Intrusion are general features of roof rocks leading to the hypothesis that the Onaping Intrusion is, in fact, the roof rock of the SIC.

Similar mineralogy and feldspar compositions of Granophyre and Onaping Intrusion confirm a probable relationship between both units and suggest that they might have originated from the same melt; however, the Onaping Intrusion did not undergo a differentiation, as seen in the SIC. A suggested water-rich environment at the time of, and after, the impact might have influenced the formation of both units and needs to be further investigated.

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