The Sudbury Igneous Complex - An Impact Melt Sheet?

G.W.Johns, Ontario Geological Survey, 933 Ramsey Lake Road, Sudbury, Ontario, P3E 6B5 and B.O.Dressler, Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX, 77058

The Sudbury Igneous Complex (SIC) is a 27 km x 60 km elliptical body consisting from bottom to top of quartz diorite (Sublayer), norite, quartz gabbro and granophyre and is believed by some authors to be a fractional crystallized, crustal contaminated magma [1]. Recent isotopic investigations, REE geochemistry and theoretical considerations relating to large impact processes [2 and refs. therein] have led to an interpretation of the whole SIC being an impact melt. Faggart et al. [3] determined that the initial epsilon neodymium values for the SIC corresponded to those of average upper continental crust and thus the SIC was the result of impact melted crust. Re-Os studies by Walker et al. [4] suggest that substantial crustal fusion resulted from an impact with <50% Os from mantle derived basalt melt resulted in the SIC. Using REE evidence Chai and Eckstrand [5] suggested that the basal norite was derived from heavily contaminated mantle magma and the granophyre was the product of impact melted crust. Dence [6] and Shanks et al. [7] had earlier proposed that the granophyre was the Sudbury impact melt. High resolution seismic data [8] show no evidence of a feeder dike system or previously assumed mafic/ultramafic body at depth [9]. All this appears to support the interpretation of all of the SIC to be a coherent impact melt sheet. However, not all of the above results and interpretations are substantiated by field observations. The formation of the SIC was the result of at least a two stage process, both processes possibly the direct product of impact. Evidence against the SIC being a single melt complex, such as intrusive contacts, is described in the following.

Northeast of Falconbridge the granophyre has been deformed while quartz gabbro and norite have not (Fig.1, Sublayer at the base of the norite not shown). The latter two rock units, therefore, may be younger than the granophyre.

Near the Creighton mine, southwest of Sudbury, norite-Sublayer-footwall intrusive relationships indicate a post-norite age for the Sublayer indicating that the Sublayer is not part of a single intrusive or impact melt but represents a later event. Elongate inclusions (Fig.2) and matrix plagioclase laths in the Sublayer are oriented parallel to the norite/Sublayer contact. In two places, the Sublayer forms "internal offsets", i.e. dikes, 0.5-14m wide intruding the norite (Fig.3). West of Little Stobie Mine north of Sudbury two Sublayer phases intrude the norite. This and the other field observations indicate that the norite was solidified before the emplacement of the Sublayer. The quartz gabbro and the norite of the SIC may postdate the granophyre.

We believe that our field observations are inconsistent with the interpretation of the whole SIC being a differentiated impact melt. The granophyre (plus the North Range Basal Member of the Onaping Formation), however, may very well represent the Sudbury impact melt sensu strictu. This interpretation is substantiated by the presence of baddeleyite in the granophyre and its absence in the quartz gabbro and norite of the SIC, possibly indicating that the granophyre represents a superheated (>1700 C) melt sheet. Norite and quartz gabbro contain zircon. However, seismic profiles (North Range SIC) (8) appear to indicate that the whole SIC has been emplaced parallel to the contact with the underlying bedrock, i.e. it is not ponded, as one would expect a melt sheet to be.

The lower units of the SIC may represent lower crustal melts , impact-triggered but behaving more like common igneous rocks, while the granophyre may represent upper impact-melted target rocks.

[1] Naldrett A.J. and Hewins R.H.(1984) Ont.Geol.Survey, Sp. Vol.1, p.235. [2] Grieve et al. (1991) J.Geoph.Res. E5, p.22753. [3] Faggart B.E. et al. (1989) Science

230, p.436. [4] Walker R.G. et al. (1991) Earth Plan. Sc.L.,105, p.416. [5] Chai G. and Eckstrand R. (1994) Chem. Geol., 113, p.221. [6] Dence M.R. (1972) Geol. Ass. Canada, Sp. Paper 10, p.7. [7] Shanks et al. (1990) LPI Contr. 746, p.46. [8] Wu J. et al. (1994) Can.J.Earth Sc. 31, 11, p.1654. [9] Gupta etal. (1994) Ont.Geol. Survey, Sp. Vol. 1, p.381.

Fig. 1

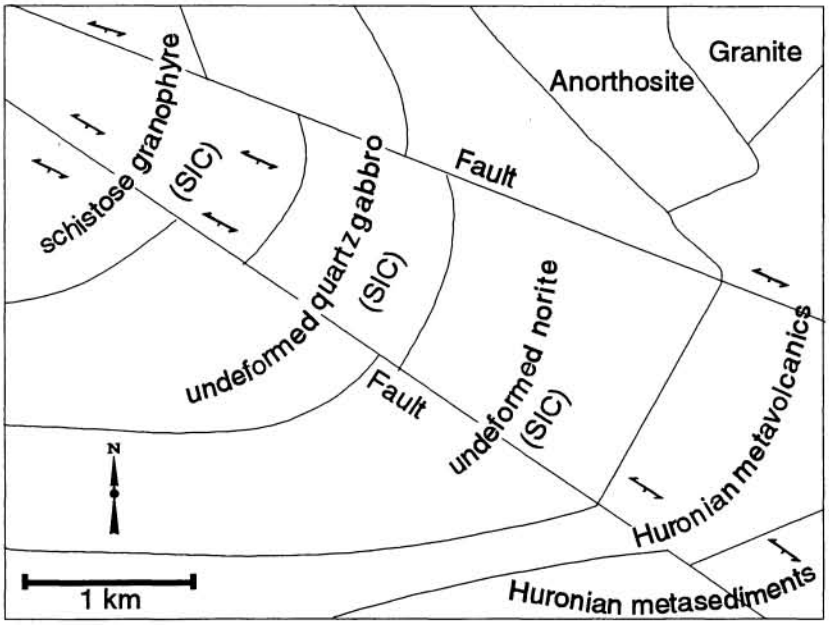

Fig. 2

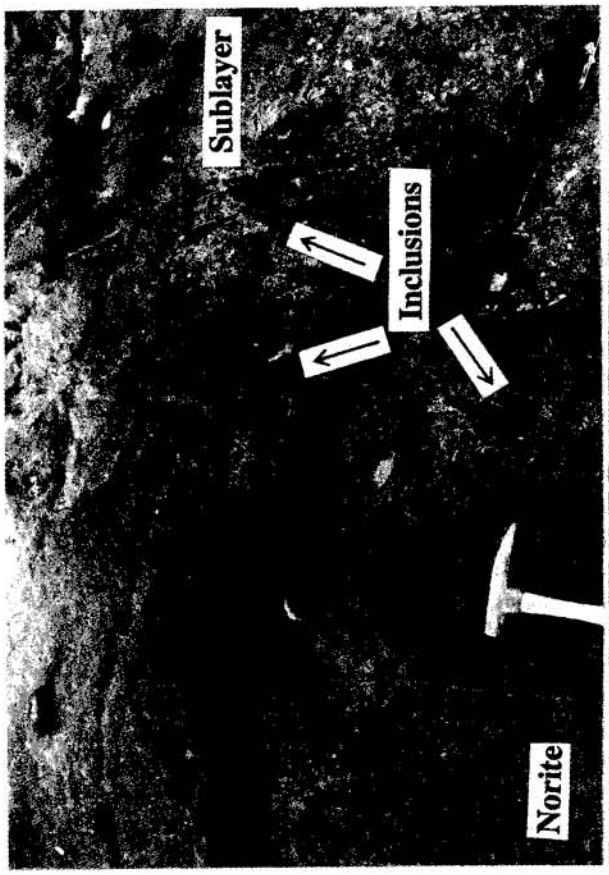

Fig. 3