ND-ISOTOPIC EVIDENCE FOR THE ORIGIN OF THE SUDBURY COMPLEX BY METEORITIC IMPACT; B. E. Faggart, A. R. Basu, and M. Tatsumoto, Department of Geological Sciences, University of Rochester Rochester, New York 14627; and U. S. Geological Survey, Box 25046, Denver, Colorado 80225

The Sudbury Complex, an elliptical structure of 60 km by 27 km in south-central Ontario, Canada has at various times been interpreted as a volcanic caldera, a ring-dike complex, a folded sill, and, more recently, as a meteoritic impact structure or astrobleme (1-3). Two major units of the complex (4) are: (a) The main Igneous Complex consisting mainly of a lower zone of predominantly norites, a middle zone of gabbros and an upper zone of micropegmatite; (b) This main Igneous Complex is overlain by the Whitewater Group of Rocks, and the lowest formation of this group is the Onaping Formation consisting of 1800 m of pyroclastics and ash flows. The Ni and Cu sulfide ores, for which Sudbury is well-known, are found around the margin of the Igenous Complex in various host rocks, such as in norites, gabbros and quartz diorites, collectively known as the Sublayer. The highly siliceous nature of the lower-lying norite and of the Sublayer rocks and the disproportionately thick lens of overlying micropegmatite point to extreme crustal contamination of the initial melt. A recent trace element and Sr-isotopic study on the Sublayer (5) has proposed varying degrees of coupled assimilation and fractional crystallization for the origin of the Sublayer. We have recently proposed (6), on the basis of a Nd-isotopic study, that the Sudbury Igenous Complex, along with the Onaping Formation, formed by melting of crustal rocks by meteoritic impact. Here we present our Sm-Nd data (Figure 1) on the whole rock samples in terms of ε_{Nd} values and discuss further the implications of our data.

We analyzed the Sm-Nd systematics of sixteen whole-rocks from north and south ranges of the complex. Ten mineral separates from five of these rocks were also analyzed. Two whole-rock norites and their six mineral separates from the lower part of the complex gave an isochron age of 1845±20 Ma with an initial $^{143}Nd/^{144}Nd$ ratio of 0.50986±4. We consider this age to be the igneous crystallization age of the complex. This age is in excellent agreement with U-Pb dates of zircons from the same unit (7).

Sm and Nd concentration range from 14 to 62 times and 32 to 161 times the chondritic abundances, respectively. In terms of the relative abundances of these elements, the sublayer quartz diorite is most enriched, followed by the micropegmatite and the norite. The initial ε_{Nd} values at 1845 Ma range from -6.98 for a norite to -8.83 in a quartz diorite sample from the sublayer, with the majority of the rocks at around -7 to -8. The migmatitic country rock from the north of the complex has an ε_{Nd} value of -11.5.

These large negative ε_{Nd} values indicate that the Sudbury Complex formed by extensive crustal contamination. In fact, our data suggest that all the lithologic members of the Sudbury Igenous Complex, along with the gray member, the black member plus the melt rocks of the overlying Onaping formation, formed entirely from the melting of crustal rocks by way of

meteoritic impact. This interpretation is also supported by previous observations such as shatter cones in the surrounding country rocks as well as shock features, including planar features within quartz and feldspar fragments of the Onaping Formation. It is also instructive that the model Nd-ages of all the rocks analyzed in our study define a narrow range of 2.56 ±0.13 AE, which is remarkably similar to the age of the early Proterozoic metavolcanic and metasedimentary rocks of the Huronian Supergroup and of the Archean Superior Province-style basement underlying the Sudbury structure. We propose that these above metavolcanic, metasedimentary and plutonic rocks were impact-melted to produce the Sudbury Complex.

References

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Figure 1