Discovery of distal ejecta from the 1850 Ma Sudbury impact event

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Abstract

A 25–70–cm–thick, laterally correlative layer near the contact between the Paleoproterozoic sedimentary Gunflint Iron Formation and overlying Rove Formation and between the Biwabik Iron Formation and overlying Virginia Formation, western Lake Superior region, contains shocked quartz and feldspar grains found within accretionary lapilli, accreted grain clusters, and spherule masses, demonstrating that the layer contains hypervelocity impact ejecta. Zircon geochronologic data from tuffaceous horizons bracketing the layer reveal that it formed between ca. 1878 Ma and 1836 Ma. The Sudbury impact event, which occurred 650–875 km to the east at 1850 ± 1 Ma, is therefore the likely ejecta source, making these the oldest ejecta linked to a specific impact. Shock features, particularly planar deformation features, are remarkably well preserved in localized zones within the ejecta, whereas in other zones, mineral replacement, primarily carbonate, has significantly altered or destroyed ejecta features.

The Sudbury impact layer in the Paleoproterozoic iron ranges of northern Michigan, USA

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Abstract

A layer of breccia that contains fragments of impact ejecta has been found at 10 sites in the Paleoproterozoic iron ranges of northern Michigan, in the Lake Superior region of the United States. Radiometric age constraints from events predating and postdating deposition of the breccia are ca. 1875 Ma and 1830 Ma. The major bolide impact that occurred at 1850 Ma at Sudbury, Ontario, 500–700 km east of these sites, is the likely causative event. The Michigan sites described here, along with previously described sites in Minnesota and Ontario, define an extensive ejecta-bearing deposit throughout the Paleoproterozoic iron ranges of the Lake Superior region that we refer to as the Sudbury impact layer. The layer at the sites in Michigan exhibits a range of thicknesses, lithologic characters, and sedimentary settings. The diversity of rock types and internal stratigraphic details of the layer imply that several different processes of transport and deposition are represented, but the detailed investigations needed to document them are incomplete. Many of the sites had been described and interpreted previously as products of common terrestrial processes, but the presence of relict shock-induced planar deformation features in quartz indicates that the breccia layer is in fact the product of an extraterrestrial impact. At most localities, this layer also contains relict fragments of altered devitrified glass and/or accretionary lapilli. One immediate use of the impact layer is as an ultraprecise time line that ties together the well-known stratigraphic sequences of the various geographically separated iron ranges, the correlation of which has remained controversial for many decades. The Sudbury impact layer most commonly lies at a horizon that records a significant change in the character of sediments across the region. The impact layer marks the end of a major period of banded iron formation deposition that was succeeded by deposition of fine clastic rocks, commonly black shales. The impact may have produced regional, if not global, changes in the environment that resulted in this widespread synchronous change in sedimentation style.