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Glacial till Sr-Nd-Hf isotopes imply late Pleistocene unroofing of Canadian Shield

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Relationships between climate, glacial substrates, and the geochemistry of glacial tills have motivated research for decades, following Goldschmidt's conjecture that the composition of tills reflected an integrated sample of unweathered continental crust. In the early 2000s, putative feedbacks between evolving glacial substrates and climate (e.g. the regolith hypothesis) stimulated new investigations of the geochemistry of continental tills. Additionally, recent work in Antarctica suggested that weathering of glacial deposits may regulate climate via feedbacks with marine iron and carbon cycling. Though these studies highlight the potential for continental tills to serve as important archives of Pleistocene history, the climatic implications of the unroofing of the Canadian Shield remain largely unexplored. To address these questions, and better constrain the timing of Shield exposure, we conducted a geochemical analysis of Pleistocene till matrix materials. We determined the trace element and Sr-Nd-Hf isotope composition of 8 North American glacial tills, including a set from Missouri (MO) USA that are the oldest known Pleistocene tills in North America, dating to approximately 2.4 Ma. A second set of samples from Indiana (IN) USA includes Middle Pleistocene tills that likely range in age from ~0.8 to ~0.15 Ma. The IN and MO samples are compared with a set of previously analyzed late Pleistocene tills from Minnesota (MN) USA, which represent the youngest (~20-40 Ka) and most lithologically diverse materials. In Sr-Nd isotope space, each of the regions plots in distinct zones consistent with their provenance. Samples from MO resemble Cenozoic and Mesozoic sediments from the Midcontinent; IN samples appear to be influenced by Proterozoic intrusive rocks of the Sudbury basin and Grenville province; MN samples are the most diverse, including samples derived from erosion of Archean bedrock. Although secondary influences from localized sources are discernable in some samples, Hf-Nd isotope relationships indicate that the tills are, for the most part, representative of the rocks they are eroded from, with minimal influence of sediment reworking. When compared against a compilation of North American Phanerozoic sediments, the isotopic evolution of our till samples supports a relatively late (Mid-Pleistocene or later) unroofing of the Canadian Shield.