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Geological Processes over Time in Central Canada as Recorded by the Geoelectric Structure

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Summary

The electric resistivity of the Earth's crust and mantle is extremely sensitive to a small number of minor constituents including clay minerals, metallic minerals, graphite, and water and serves as an important record of geological processes involving these constituents. In this review, the resistivity results from large- and small-scale electromagnetic surveys in Manitoba and adjacent areas are used to illustrate a record of geological processes in central Canada, from the Archean through the Quaternary to today. These results have been obtained in projects involving the Department of Geological Sciences at the University of Manitoba over the last twenty years and include contributions from undergraduate, graduate, and field-school studies.

Large-scale lithospheric processes reflected in the deep electrical resistivity structure of the crust and lithospheric mantle and can be studied using the deep-penetrating magnetotelluric method. For example, the Archean amalgamation of subprovinces in the Superior Province is recorded in east-west oriented deep geological strikes over much of southeastern Manitoba and adjacent Ontario. In western Manitoba and Saskatchewan, and extending into the United States, a series of north-south trending electrical conductors defines the geological boundary developed between the buried Archean Sask craton and Dakota Block and the Superior Province during Proterozoic orogenic events. The 2000 km long North American Central Plains conductor is interpreted to delineate rocks of the western Trans Hudson Orogen that were also deformed during these events. Observed geoelectric strikes oblique to subprovince boundaries in central and western Manitoba are interpreted to be due to late brittle deformation.

Smaller-scale geological processes occurring at subprovince or terrain boundaries or at the Earth's surface can be investigated using small-scale electromagnetic surveys. As an example Archean-aged shearing at the margin of the Wabigoon and English River subprovinces of the Superior Province is recorded in the anisotropic resistivity developed in a sheared iron formation at this boundary. In other examples, electrical well-logs (and higher frequency magnetotelluric results) define spatial variations in resistivity in lower Paleozoic sedimentary rocks in southern Manitoba that can be interpreted in terms of changes in the depositional environment, Mesozoic karst features in the Manitoba Interlake can be mapped using the conductive kaolinite deposits they host, and Quaternary iceberg scours can be mapped by their electrical resistivity signature in lake Agassiz sediments. Finally, modern-day freezing of the shallow soil can be delineated using the significant time-changes in the shallow resistivity structure.