

Crustal structure of the Midcontinent rift system: Results from GLIMPCE deep seismic reflection profiles

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ABSTRACT

Interpretation of Great Lakes International Multidisciplinary Program on Crustal Evolution (GLIMPCE) seismic reflection profiles indicates that the Midcontinent (Keweenaw, 1100 Ma) rift system of volcanic rocks and postvolcanic and interbedded sedimentary rocks extends to depths as great as 32 km (about 10.5-s reflection time) along profiles crossing western, central, and eastern Lake Superior and the northern end of Lake Michigan. This area may overlie the greatest thickness of intracratonic rift deposits on Earth. Times to Moho reflections vary along strike from 11.5 to 14 s (about 37–46 km depth) in the west, to 17 s (about 55 km) in the center, and 13 to 15 s (about 42–49 km) in the eastern end of Lake Superior. The prerift crust, however, was thinned 25–30 km beneath the central rift (compared with its flanks), providing evidence for crustal extension by factors of about 3–4. The Midcontinent rift system differs from Phanerozoic rifts in having total crustal thicknesses equal to or greater than the surrounding (presumably unextended) regions.

INTRODUCTION

Lake Superior (Fig. 1) lies at the northern end of the Midcontinent (Keweenaw) rift system (MRS), an arcuate crustal-scale structure, delineated by high-amplitude potential field anomalies, that extends 2000 km from Kansas to south-central Michigan (Wold and Hinz, 1982; Van Schmus and Hinz, 1985). On the basis of interpretations from rock exposures and drilling data, the primary source of the potential field anomalies is a thick sequence of basaltic lavas and minor intercalated volcanogenic sedimentary rock overlain by a postvolcanic clastic section. This Keweenaw suite of rocks was deposited in a rift environment during a time span centered about 1100 ± 10 Ma (Van Schmus et al., 1982). Several large Keweenaw intrusive complexes occur along the margins of the MRS.

Previous seismic experiments have revealed a variable crustal structure associated with the MRS. Broad-scale refraction studies conducted in Lake Superior during the early 1960s (Steinhart and Smith, 1966; Halls, 1982) showed crustal thicknesses of 50–56 km beneath its central region compared to typical values of

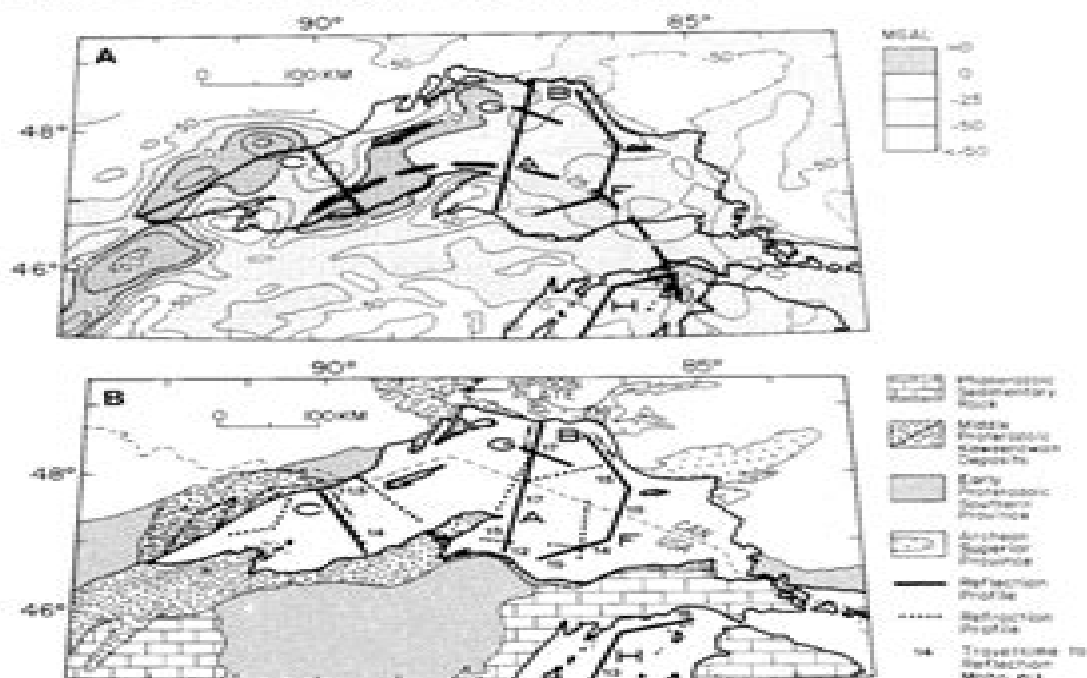


Figure 1. A: Bouguer gravity anomaly map of Lake Superior region. Contour interval = 25 mgal. Letters indicate locations of seismic reflection profiles A, B, C, F, and G in Lake Superior (855 km) and parts of H in Lake Michigan. Dashed line connects thickest rift section interpreted on lines C, A, F, and H; it is approximate rift axis based on reflection data. B: Generalized geologic map showing outcrops of Keweenaw rocks. Locations of seismic reflection profiles as for A. Dotted lines = refraction profiles from earlier surveys described by Luetgert and Meyer (1982) and Luetgert (1987). Reflection profile C is coincident with one of refraction profiles of Luetgert and Meyer (1982). Traveltimes to reflection Moho, M, are in seconds. Brackets on lines A, B, and C indicate locations for parts of record sections shown in Figure 3.

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L.L. Sloss



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U.S. Geological Survey Professional Paper ,1994 **Geological Survey Professional Paper** Geological Survey (U.S.),1993 *The Petroleum System* Geological Survey (U.S.),1989 Investigations about porosity in petroleum reservoir rocks are discussed by Schmoker and Gautier Pollastro discusses the uses of clay minerals as exploration tools that help to elucidate basin source rock and reservoir history The status of fission track analysis which is useful for determining the thermal and depositional history of deeply buried sedimentary rocks is outlined by Naeser The various ways workers have attempted to determine accurate ancient and present day subsurface temperatures are summarized with numerous references by Barker Clayton covers three topics 1 the role of kinetic modeling in petroleum exploration 2 biological markers as an indicator of depositional environment of source rocks and composition of crude oils and 3 geochemistry of sulfur in source rocks and petroleum Anders and Hite evaluate the current status of evaporite deposits as a source for crude oil

NUREG/CR. U.S. Nuclear Regulatory Commission,1978 Revised Instrumental Hypocenters and Correlation of Earthquake Locations and Tectonics in the Central United States David W. Gordon,Geological Survey (U.S.),1989 New determinations of hypocenters and magnitudes of instrumentally recorded earthquakes 1931 1980 in the central United States and an investigation of the association of seismicity with geologic structure in the region **Geophysical Framework of the Continental United States** Louis Charles Pakiser,Walter D. Mooney,1989 A review and evaluation of our knowledge of the structure of the crust and upper mantle of the continental United States exclusive of Alaska as determined from geophysical observations Covers geophysical methods of studying the crust and upper mantle a region by region review of crustal and upper mantle structure continental overviews based on the different geophysical methods and geologic and petrologic syntheses based largely on the geophysical results **Sedimentary Cover—North American Craton: U.S.** L.L. Sloss, The sedimentary cover refers to the stratified rocks of youngest Proterozoic and Phanerozoic age that rest upon the largely crystalline basement rocks of the continental interior This volume presents data and interpretations of the geophysics of the craton and summarizes the craton s tectonic evolution It also presents the stratigraphy structural history and economic geology of specific sedimentary basins e g Appalachian basin and regions e g Rocky Mountains It concludes with a discussion of the currently popular theories of cratonal tectonics unresolved questions are identified Energy Research Abstracts ,1978 Semiannual with semiannual and annual indexes References to all scientific and technical literature coming from DOE its laboratories energy centers and contractors Includes all works deriving from DOE other related government sponsored information and foreign nonnuclear information Arranged under 39 categories e g Biomedical sciences basic studies Biomedical sciences applied studies Health and safety and Fusion energy Entry gives bibliographical information and abstract Corporate author subject report number indexes **Basement and Basins of Eastern North America** Ben A. Van der Pluijm,Paul A. Catacosinos,1996-01-01 *U.S. Geological Survey*

Bulletin ,1983 **Middle Proterozoic to Cambrian rifting, central North America** Richard W. Ojakangas,Albert B. Dickas,John C. Green,1997-01-01 Based on the Tenth International Basement Tectonics Conference held at the University of Minnesota Duluth in August 1992 this volume contains 19 papers 13 of which focus on the Middle Proterozoic Midcontinent Rift An introductory essay discussing the Middle Proterozoic to Cambrian rifting in central North America is followed by contributions addressing topics including the Midcontinent Rift in Michigan and Minnesota the Port Coldwell veins of northern Ontario and petrography and sedimentation in the western Lake Superior region The last five papers deal with the pre Mount Simon basins of Ohio the English Graben and the newly proposed East Continent Rift Complex the Reelfoot Rift Rough Creek Graben in the evolution of the Illinois Basin and the A type sheet granites in the Oklahoma Aulacogen of Cambrian age Bandw illustrations Annotation copyrighted by Book News Inc Portland OR **U.S. Geological Survey Bulletin** Geological Survey (U.S.),M. J. Pawlewicz,Richard L. Dart,Romeo M. Flores,Stephen Leroy Robbins,T. S. Dyman,Timothy C. Hester,William J. Perry,C. William Keighin,George Randy Keller,James W. Schmoker,Howard L. Sahl,1983

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