Geophysical Characteristics of the Grenville Front in Ohio, U.S.A

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1. Introductuion

The Grenville Front is a metamorphic boundary and/or fault where it is exposed in the Canadian Shield. It represents the western margin of the Grenville orogen. The rocks east of the Grenville Front are younger and more highly metamorphosed than the rocks to the west. Interestingly, Grenvillian rocks are of approximately the same age. Though considerable progress has been made in increasing our knowledge of the nature and evolution of the Grenville Province and its western margin, the Grenville Front, thick Phanerozoic sedimentary rock cover of the midcontinent limits our understanding of the geology of the Grenville Province and its associated boundary.

It is known only from sparse and widely distributed outcrops and drillhole samples that penetrated only a few meters into the Precambrian basement. Consequently, scattered basement drillhole samples and outcrops provide only limited information on the Grenville Province and the Grenville Front in the midcontinent of the United States. This has encouraged the use of geophysical data, particularly Bouguer gravity anomaly and total intensity magnetic anomaly, to study the Grenville Province and the associated front in the eastern craton.

2. Data set

Four main types of data have been used in this study; gravity, magnetic, seismic reflection, and basement drillhole lithologic data. The gravity data are complete Bouguer gravity anomaly values reduced for a density of 2.67 g/cm3 and gridded at a 2 km interval. The magnetic data are 1 km grid of the magnetic anomalies obtained from the U.S. Geological Survey on open-file computer tape and regridded at 2 km intervals. To minimize spatial distortion of anomalies relative to geologic sources with negligible moments of remanent magnetization, the data were reduced to the north geomagnetic pola, using a wavenumber domain filter for a statewide average inclination of 70° and

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west declination of 4°.The seismic data are Ohio lines 1 and 2, which together make up a nearly continuous east-west profile across Ohio. The lithologic data were obtained from a basement drillhole sample data set that penetrated into the Precambrian surface in Ohio. In most cases, penetration into the Precambrian was less than 30 m, and only two of the wells penetrated as much as 300 m.

3. Potential-field analysis

The study area covers two basement geologic provinces, the Eastern Granite-Rhyolite Province (EGRP) and the Grenville Province. The contact between two provinces in Ohio is particularly well represented on the magnetic anomaly map . On the Bouguer gravity anomaly map it is more subtly delineated by truncation of anomaly trends and decreased anomaly gradients over the EGRP. In Ohio, a number of the sharp, circular magnetic signatures correlative with positive gravity signatures can be observed.

The magnetic anomalies in the Grenville Province represent high-wavenumber, large-amplitude circular anomalies, while the Bouguer gravity anomalies generally show broader wavelengths than the magnetic anomalies. The variations in magnetic signature are prominent and correspond rocks of different metamorphic grade and different mafic content. The Grenville Province in the northern Ohio is generally characterized by magnetic and gravity lows having a broad northeast trend . However, a circular high-amplitude magnetic and gravity high having a diameter of approximately 28 km is prominent in the northern Ohio.

4. Seismic line analysis

The Consortium for Continental Reflection Profiling (COCORP) conducted a seismic reflection survey along an east-west line in central Ohio that traverses the Grenville Front. The seismic reflection line contains three remarkable elements. They are an extensive sequence of Precambrian layered rocks beneath western Ohio (OH-1), a broad zone of east-dipping basement reflectors associated with the Grenville Front beneath western Ohio (OH-1), and a wide region of west-dipping reflectors penetrating most of the crust beneath eastern Ohio (OH-2).

The seismic reflection line has provided an image of widespread layered rocks beneath the Phanerozoic sedimentary rocks of westernmost Ohio, which are more or less continuous and relatively flat. The layered rocks are clearly visible beneath the Phanerozoic sedimentary rocks at two-way travel time (TWT) of 4 to 5 second on the OH-1. It is suggested that the strata are several times thicker than the Phanerozoic sedimentary rocks.

No continuous reflectors are observed below the reflectors at a depth of

approximately 5 sec in western Ohio. The outstanding feature in the seismic section is a remarkable zone of east-dipping reflections on OH-1 line, which coincides with the *Grenville Front Tectonic Zone (GFTZ)* as interpreted from drillhole data and gravity and magnetic anomaly patterns. Its western boundary truncating a band of strong subhorizontal reflections of Eastern Granite-Rhyolite Province to the west of the GFTZ corresponds closely with the position of the Grenville Front predicted from the lithologic and geopotential data. The east-dipping reflections at the GFTZ extend from the base of the Phanerozoic sedimentary rocks to midcrustal depths, possibly to the lower crust. Another remarkable feature in the seismic secton is a zone characterized by strong, west-dipping reflections extending from mid to deep crustal depths beneath eastern Ohio. Strong, west-dipping reflections are recorded to at least 10 sec, suggesting that they penetrate the entire crust. These west-dipping reflections are considered to be a thrust zone in the eastern Ohio. The west-dipping reflections are more intense and the apparent dip of the reflections is greater than that of the easterly dipping reflections at the GFTZ. These reflectors are not very apparent above 3 to 4 sec TWT, possibly because of multiples of the primary reflections associated with the Phanerozoic sedimentary rocks. However, there is a suggestion that the reflectors flatten out above this level and perhaps even reverse in dip. A complex set of reflections exist between the major zones of easterly and westerly dipping reflections. These reflections may result from a series of isoclinal folds with reflections occurring along the axes of the anticlines and the synclines. Another possible interpretation is that the west-dipping reflectors represent an older, pre-Grenville feature preserved within the middle and lower crust.