U.S. Geological Survey Airborne Study of Northeast Iowa

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Introduction

Beginning late in 2012 or early in 2013, the U.S. Geological Survey will initiate a series of aerial surveys of portions of Winneshiek County, Iowa, and adjoining parts of Minnesota to collect information on a series of rocks that lie buried about 2000 feet below the land surface. A part of Iowa's "basement complex," these rocks are a suite of iron- and magnesium-rich igneous rocks that were intruded into older rocks in that area about 1 billion years ago during the development of a major tectonic feature, the Midcontinent Rift System. It is suspected that these intrusive rocks could host significant deposits of strategic metallic minerals, such as nickel, copper, vanadium, and titanium, as well as gold and silver. These surveys will make careful measurements of variations in the Earth's gravity and magnetic fields in this area. With these measurements scientists will be able to create a more accurate model of the distribution and character of these intrusive rocks, perhaps leading to exploration drilling to accurately access their mineral value.

Midcontinent Rift System

The Midcontinent Rift System (MRS) is a failed rift, a tear in the crust that almost led to the development of an ocean across central Iowa about one billion years ago. The rift extended from what was the eastern edge of North America at that time, just north of Lake Erie and stretched across Michigan, along the axis of Lake Superior and across southeastern Minnesota, Iowa, the southeast corner of Nebraska and into Kansas with some structures reaching into central Oklahoma (see Figure 1). Figure 2 is a cross

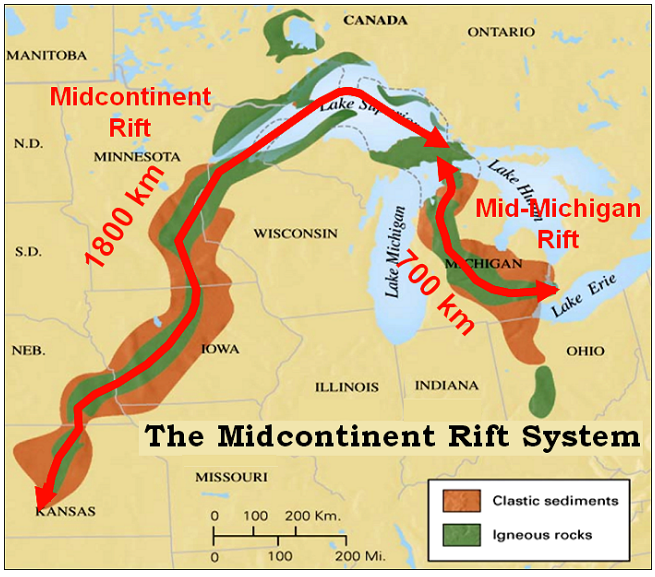

Figure 1. location of Midcontinent Rift System

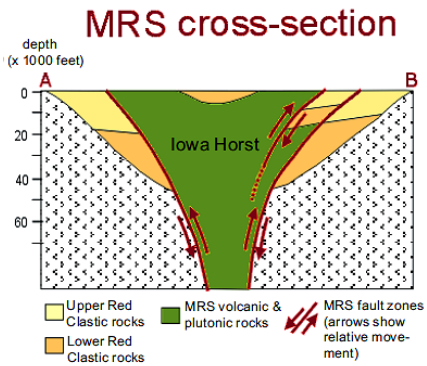

Figure 2. Cross section of MRS shows the dense igneous rocks in green and thick flanking sequences of clastic rocks (sandstones, siltstones, and claystones) shown in yellow and orange.

section across the MRS in Iowa that shows the rocks there today, a central core of dense iron- and magnesium-rich igneous rocks that originated deep in the crust, flanked by thick basins of sandstone, siltstone, and claystone deposited by rivers that flowed along its trend as the rift developed. Tectonic forces pulled the crust apart, with the dense magma flowing upward from regions near the base of the crust (see Figure 3). Parallel fractures led to the intrusion of similar dense magmas along the flanks of the rift (see ***intrusions*** in Figure 3). This is how the rocks of interest in northeast Iowa were emplaced a billion years ago. A similar suite of intrusive rocks related to the formation of the MRS can be seen along the north shore of Lake Superior in eastern Minnesota. Portions of these intrusions, known collectively as the Duluth Complex (Figure 4), are exposed at the land surface and have been the target of intense strategic mineral exploration in the last dozen years. This exploration discovered valuable concentrations of nickel, copper, titanium, and vanadium as well as gold and silver. Mining should begin in some of these areas within the next decade. These resources will be a boon to the economy of Minnesota and provide our country with an additional national source of these important minerals. The U.S. Geological Survey's gravity and magnetic surveys in northeast Iowa are investigating a series of intrusive rocks that are thought to have been emplaced in the same manner, at the same time, and from a similar source region as the Duluth Complex.

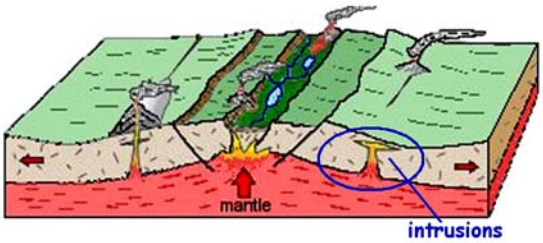

Figure 3. Model of a developing rift system. Note intrusions on flank.

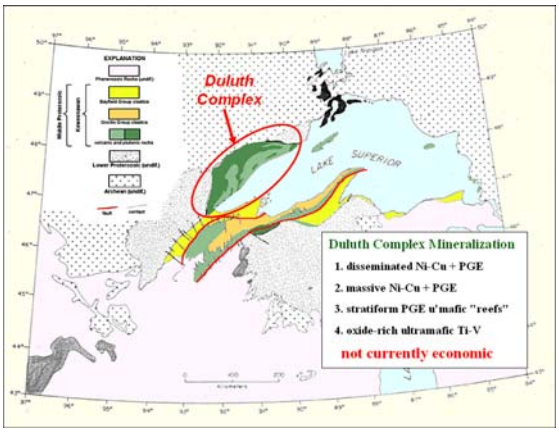

Figure 4. Location of Duluth Complex.

Northeast Iowa Plutonic Complex

The rocks that are the target of the U.S. Geological Survey investigations in northeast Iowa, called the Northeast Iowa Plutonic Complex, are known primarily from their geophysical signatures. Because of the high iron content of these igneous rocks, they are denser than the rocks around them, so they appear as positive anomalies on maps of the Earth's gravity field (Figure 5). Much of the iron in these rocks is present as Fe_3O_4, a highly magnetic mineral called magnetite that is common in many igneous rocks. Magnetite interacts with the Earth's magnetic field, producing anomalies that can be measured with sensitive magnetometers and mapped (Figure 6). Using their magnetic and gravitational anomalies, these rocks can be mapped. Figure 7 is a map of the rocks of Iowa's "basement complex" (also known as Precambrian rocks) in northeast Iowa, and the areas shown in dark green are the iron-rich igneous rocks that are the targets of the

U.S. Geological Survey's investigation. We have learned some information about these rocks by studying their gravity and magnetic anomalies, and using computer modeling to construct virtual models of their geometry. This modeling was completed in four areas by University of Iowa geology students as a part of their masters thesis work. Figure 8 shows the locations of these studies, identifies the student scientists, and the years of their research. Samples of these rocks were collected in core drilling in one of the study areas,

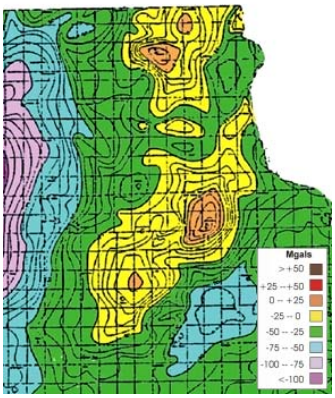

Figure 5. Gravity anomaly map of northeast Iowa.

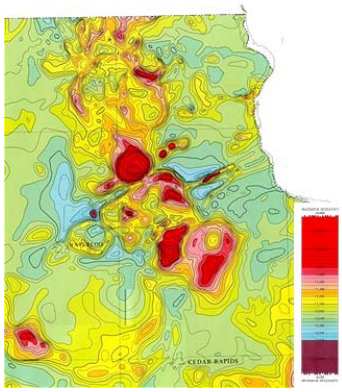

Figure 6. Magnetic anomaly map of northeast Iowa.

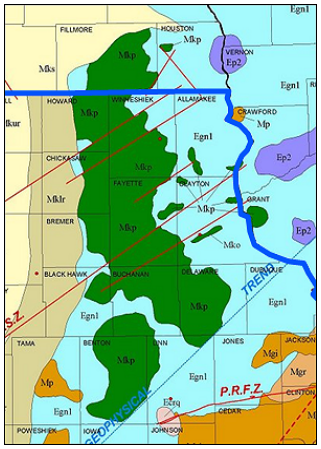

Figure 7. Map of Precambrian geology of northeast Iowa.

the Osborne Anomaly. The region of interest to the U.S. Geological Survey is near the north end of this mapped rock complex (see delineation of survey area in blue box on Figure 8). This area was chosen for several reasons, including the fact that the rocks of interest are closer to the land surface in the north than the south.

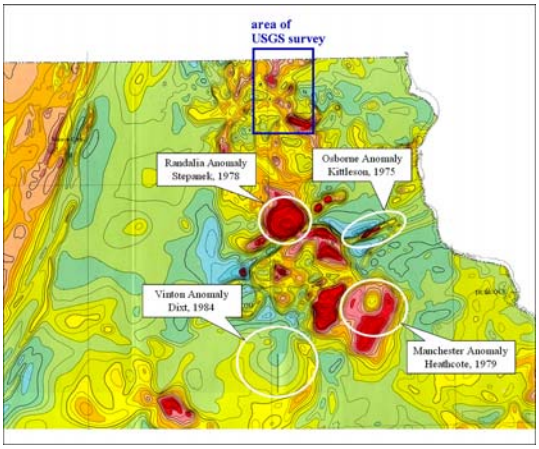

Figure 8. Geologic studies of basement rocks in NE Iowa (on magnetic anomaly map)

The Aerial Surveys

The U.S. Geological Survey contractor is planning low altitude flights over the survey area (see Figure 8) with aircraft carrying three geophysical instruments. They will be using a Geospace flying gravity gradiometer carried by a BT-67 fixed wing turboprop aircraft (Figure 9) and a magnetometer will be carried by an AgustaWestland AW119 Koala helicopter (Figure 10). The helicopter will also be carrying and a electro-magnetic (EM) antennae shaped like a large circle and suspended under the helicopter. This instrument will measure characteristics of the upper 2,000 feet of rocks in the study area. These instruments will provide much more detailed information on the rocks that are interacting with the Earth's gravity and magnetic fields than is currently available. This survey will be flown in a grid pattern, by both aircraft at different times. East-west lines will be flown ¼ mile apart at elevations from 100-500

feet above the ground, and 2 ½ miles apart in a north-south direction. All survey flights will occur during daylight hours and will be coordinated with the Federal Aviation Administration to ensure flights are in accordance with U.S. law.

Figure 9. BT-67 fixed wing turboprop aircraft that will be flying the gravity survey instrument

Figure 10. AgustaWestland AW119 Koala helicopter that will be flying the magnetometer and electromagnetic surveys (see EM detector suspended below helicopter)

After completion of the surveys, the data that are recovered will be analyzed by the U.S. Geological Survey and its contractors as well as geologists from the Iowa Geological and Water Survey and the Minnesota Geological Survey. These data should produce a three-dimensional model of the rocks of the "basement complex" in the study area and will guide the acquisition of additional data and the drilling of exploration wells in the area. These exploration wells will ultimately provide information about the mineralization in the area and its economic value.