Unique geologic insights from 'non-unique' gravity and magnetic interpretation

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(PhysOrg.com) -- In many fields of applied science, such as geology, there are often tensions and disagreements between scientists who specialize in analyses of problems using mathematical models to describe sets of collected data, and those that rely on on-the-ground observations and empirical analyses. One common source of these disagreements arises from applications of geophysics -- studies of variations in gravity or Earth's magnetic field -- that use models that are strictly (from a mathematical point of view) non-unique. For example, using theories derived from Isaac Newton's studies of gravitational attraction, a geophysicist who measures local variations in gravitational acceleration that are produced by contrasts in the density of rocks below Earth's surface can calculate an infinite set of mathematically valid sources (with different shapes, depths, and contrasts in density) that would explain the measured gravity difference (or anomaly). This theoretical non-uniqueness leads many geologists to conclude that such geophysical information is of limited value, given the infinite number of possible correct answers to those numerical problems.

In the December 2011 issue of *GSA Today*, Richard Saltus and Richard Blakely, two U.S. Geological Survey scientists with extensive experience using gravity and magnetic field models to help improve the understanding of a number of geological problems, present several excellent examples of unique interpretations that can be made from "non-unique" models. Their motivation for this article is to improve communication among various geologists regarding the ability (and limitations of) gravity and magnetic field data to yield important information about the subsurface geology of an area or region.

This communication barrier is an important issue, because a great deal of our understanding of the geology of Earth and the planets is primarily derived from these types of geophysical measurements. More practically, geophysical tools such as gravity and magnetic field measurements are used in mineral and hydrocarbon exploration, so the utilization of these methods can aid economic development by locating subsurface mineral resources more efficiently that other techniques (such as drilling and excavating).

In their article, Saltus and Blakely advocate a holistic approach to geological studies. By combining other observations -- such as the surface location of a fault or the likely density contrast between a set of different rock units based on their composition -- the infinite array of theoretical solutions to some of these potential-field geophysical models can be narrowed down to a few, or even one, best interpretation(s). They present a number of examples where this approach can successfully solve important geological issues -- one of the best is an analysis of magnetic anomaly data from the Puget Sound area that allows a detailed image of the active Seattle Fault zone to be constructed.

More information: "Unique geologic insights from "non-unique" gravity and magnetic interpretation," www.geosociety.org/gsatoday/

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