Potential fields: Gaining more respect and recognition

LAWRENCE M. GOCHIOCO, TLE Editorial Board

Time flies when you are having fun. This has certainly been a fun career for me to meet and interact with interesting professionals from around the world. *TLE* celebrates its 20th anniversary June 2002. Likewise, my career odometer is about to roll into 20. I completed my graduate studies in June 1982; however, it took me a month to find a job in Houston. Thus, there is really a one-month anomaly. Twenty years of experience working in both the petroleum and mineral industries has provided me a diverse technical background in geophysics.

When you think of potential fields, two pioneers stand out. They are LaCoste and Romberg. Their contributions to our professional society, the energy industry, and scientific community are invaluable. From my point of view, potential fields have been an underrated and underutilized remote sensing technology. And in these days of environmental awareness, it is essentially a noninvasive tool. Data can be acquired from satellites, airplanes, ships, or simply on foot, offering no endangerment to wildlife and its habitats or ecosystems. Gravity and magnetics are excellent reconnaissance tools that can offer more value for the dollar than conventional 3-D seismic surveys. Despite their tremendous cost advantage, potential fields received lukewarm support from petroleum companies in the last two decades, as measured by their small exploration budget. Meanwhile, huge amounts of capital were invested in seismic imaging technology.

The development of potential fields began in the 1920s, accelerated with the deployment of the magnetometer in the early 1940s, and gained greater application when the sensor was mounted on planes to cover more territory at faster rates. The next 30 years yielded newer equipment with improved sensitivities such as the fluxgate and proton-precession magnetometers. At about the time the first *TLE* issue was published, gravity and magnetic data were evolving from the electronic computation of analog data to digital data processing. This conversion allowed the geophysicist to enhance the images by simply filtering out the background "noise." The global positioning system (GPS) was a big contributor in advancing the potential fields technology in the 1990s. With GPS, gravity and magnetic surveys can be conducted at tighter grids to yield better and higher resolution images.

Despite these incremental improvements, the United States petroleum industry showed little interest in the last decade when it went through the reengineering phase and there were rumors that the days of potential fields were numbered. At that time, major oil companies were not interested in maintaining a separate potential fields department because of its perceived limited applicability. The dire prediction or speculation was partly true. Major oil companies did lose interest in maintaining a special potential fields department, but they did not eliminate it completely. Instead, they kept a skeletal staff, as interpreters/advisers, just to maintain some type of in-house expertise. However, many of these in-house advisers still feel that they are just buying time toward retirement, with no recruits in sight to replace them. In another 10 years, most of the potential fields projects are likely to be outsourced in collaboration with independent consultants and major gravity/ magnetic contractors and data vendors—the consultants are likely to be the retirees from the major oil companies.

Despite these adverse conditions, a dedicated core of potential fields geophysicists, spearheaded by the SEG Gravity and Magnetics (G&M) Committee, remained focused and continued to push for more innovations. Their tenacity has paid off. In 1998, SEG and AAPG jointly published the first major volume of work on G&M in decades: *Geologic Applications of Gravity and Magnetics: Case Histories*. A G&M special section was recently published in the August 2001 issue of the *TLE*. In addition, a special topic on nonseismic technology was also published in the September 2001 issue of *First Break*. These two combined issues have a total of 14 papers that provide some historical background on its development and, most of all, highlight the latest innovations with some interesting case studies. It would be a daunting task to summarize these two special issues and squeeze them into two pages without losing essential information. As a result, I would recommend that you read these papers if you want more useful information.

In 2002, the G&M Committee expects to finally draft and adopt a new standard, called the GXF-3, that will facilitate the exchange of G&M data after 12 years of effort. The GXF-3 format will streamline data exchange and implementation, as the SEGY format did for the seismic industry.

In last August's *TLE*, some prominent G&M professionals such as Alan Reid, Pat Millegan, Dale Bird, Tom LaFehr, Xiong Li, Nick Gant, Jerry Hensel, etc. shared their visions for the next 10 years. Here are some of their thoughts:

- Satellite gravity data will be used to plan more 3-D offshore seismic surveys.
- Higher sensitivities and resolution will be available in satellite, airborne, land, and marine gravity surveys.
- Gravity tensor gradient measurements will be widely used, including 3-D gradient inversion.
- Borehole gravity and time-lapse gradiometry surveys will be integrated in the reservoir environment.
- Absolute gravity gradient surveying will be common.
- Tighter aeromagnetic surveying grid will help explore the sedimentary section.
- Magnetic gradiometry surveys will

be more common.

- Neural networks, wavelets, and genetic algorithms will dominate the G&M processing and interpretation business.
- Magnetotellurics and other EM methods will regain favor in petroleum prospecting.
- Integration of G&M, geology, and seismic data sets will continue to enhance 3-D interpretation, via simultaneous inversion of seismic, gravity, magnetics, and gradiometry.

Already, there are some indications that there is renewed interest in potential fields. For example, a major U.S. oil company received a patent in 2001 for its revolutionary inversion technique using tensor components of the gravity in simultaneous inversion with magnetics and full-field gravity. They claimed that this technology has given them an advantage of seeing or visualizing geologic structures beneath large salt bodies that would have been quite difficult and challenging for 3-D seismic technique to image. This technology has been successfully tested in the Gulf of Mexico and in the North Sea, with encouraging results.

In addition, a novel interpretation strategy is also being implemented in which greater emphasis is placed on understanding the geometry and evolution of salt structures and their impact on sedimentation and fluid flow—dynamics of salt tectonics. If you want to understand subsalt structuring in the Gulf of Mexico, you need to investigate the magnetic basement and the basin configuration. This is where potential fields can be used to complement advanced 3-D seismic imaging methods by constraining seismic interpretations in areas where seismic imaging is poor. Imagine, the great potential benefits of a comprehensive geophysical "Atlas-style" program study of salt tectonics and structures that can be applied not only in the Gulf of Mexico, but also worldwide.

The bottom line in petroleum and mineral exploration is risk reduction. The risk factor increases when an explorationist maintains a myopic view of using only one geophysical method as his solution to exploration problems, rather than using a full complement of various technologies that can dramatically reduce risk. In other words, it is wise to employ an integrated multidisciplinary approach to address exploration challenges. Therefore, it is a matter of time when potential fields will once again capture the imagination of geoscientists through greater use by the petroleum and mineral industries, as well as in the environmental fields.

After all, predictions of the demise of potential fields techniques in the 1970s, 1980s, and 1990s have apparently been unfounded. The G&M community is shrinking, but it still remains vital. The exploration vice president of an oil company recently remarked, "There was more content in that gravity project than I expected." Perhaps it is not a ringing endorsement, but that company has bigger plans for G&M in the next few years. TLE