When Seismic Doesn't See to Depth: Applications of Ground-Based Magnetotellurics in Oil and Gas Exploration

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Seismic methods are the dominant geophysical method employed in the search for oil and gas worldwide today. However, there are a number of key scenarios in which seismic methods may not deliver the results that explorationists expect. These include a number of common applications including exploration in regions of volcanic cover and beneath salt domes – both of which degrade seismic results due to the dispersal of energy. They may also include other specialized situations such as prospecting in ice-covered terrains – an application that will become more important as the search for oil and gas in the polar frontier areas accelerates. As a result of the "small footprint" of a Magnetotelluric site, the method is also applicable in environmentally sensitive areas where seismic acquisition is not possible, or allowed.

Reliable and productive exploration in these challenging terrains requires additional input from deep penetrating geophysical methods that can serve both to augment seismic results and to provide new information of value for continuing exploration.

One technique of interest is ground-based magnetotellurics (MT) which probes the earth to depth using passive electromagnetic fields generated by lightening strikes, solar flares and ionospheric resonances. Depths may be from near surface to 10+ km or more, depending on reading intervals. MT has been used very effectively in exploration, particularly in Russia and East Asia where the method has been relied on since the 1950s and 1960s. With the challenges in prospecting outlined above, explorationists in other globally are also taking a renewed look at MT for resolution of a variety of challenges with seismic data.

This paper provides an in-depth look at an MT prospecting system which acquires full tensor data to depth. The system has a number of advantages in exploration, including providing a flexible survey (200 m stations for detail, or 500 m or 1000 m stations for reconnaissance); depth of exploration; random locations that allow recording sites to be positioned over optimal geology or topography, etc.; and tensor measurement to provide best quality data and accuracy.

Finally, we look at several case histories from the literature and other sources which illustrate the benefits of MT in the search for economic oil and gas reservoirs. Benefits include complementary data to seismic; data acquisition in areas that are problematic for seismic; data acquisition at a lower cost than seismic; imaging of structure, alteration and geology to depth; direct detection of hydrocarbon traps; discriminating targets (such as saltwater); and others.