Integrating Controlled-Source Electromagnetic (CSEM) as an Exploration Tool

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Controlled Source Electro-Magnetic imaging (CSEM) is a recently developed technology that maps subsurface resistivity variations (Eidesmo et al., 2002). It uses a horizontal electrical dipole (HED) which emits a low frequency (0.25Hz – 10 Hz) electromagnetic (EM) signal into the underlying seabed and into the subsurface. In the presence of an anomalous resistor the dispersion of the EM field is distorted, which may be considered analogous to seismic refraction. Energy is constantly refracted back to the seafloor and is detected by receivers placed on the sea floor. The detection of the 'guided and refracted' energy is the basis of CSEM. Archie's law indicates that the method is more sensitive to high saturation hydrocarbon pore fill and due to the low frequency nature only relatively large accumulations of high saturation will be detectable.

With such low frequency sources the 3-D interpretation of the data is complex, and requires robust and advanced 3-D forward modelling of ultra-low frequency propagation of EM fields and close integration with other sub-surface data such as seismic to constrain the required 3-D structural information and interpretation.

In this paper three examples are provided in different geological settings, illustrating the use of CSEM. Although the technology holds great potential, it is still rather primitive and is not a 'silver-bullet' to exploration success. Further advances of the technology are arising from sophisticated 3-D acquisition, imaging and inversion of all EM effects constrained by acoustic and potential field data, which Shell is currently testing in the Asia-Pacific region.