

How low can you go: An investigation of depth sensitivity and resolution using towed marine CSEM systems.

Roslynn B. King¹ & Steven Constable¹

¹ Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA 92093

ABSTRACT

Continuously towed controlled-source electromagnetic (CSEM) systems are gaining popularity as a valuable tool for imaging the upper kilometer of the seafloor to locate important targets such as submarine aquifers, gas hydrates, and seeps. Knowledge of the appropriate depth to limit the interpretation of inversions from these surveys is crucial for understanding the results. However, the depth of inference (DOI) has not been rigorously tested for towed CSEM systems and assuming that the DOI of towed systems is similar to nodal CSEM systems may not be appropriate. For instance, nodal surveys have been found to have a DOI typically limited to about half the maximum source-receiver spacing. In contrast, experience with continuously towed arrays suggests sensitivity to targets at depths approaching the source-receiver spacing. To investigate this, we tested two-dimensional synthetic data using two methods. A rigorous approach involves re-inverting data with the inclusion of a highly conductive or resistive basement at progressively shallower depths. By monitoring the data misfit, we can determine when the maximum depth of inference has been reached. Instead of relying solely on overall misfit, we prioritize the examination of data most sensitive to the largest depths (longest offsets and lowest frequencies). Alternatively, a more practical approach is to ascertain the depth at which a conductivity contrast can be imaged by inversion, recognizing that knowledge of the contrast holds geological significance even if the actual conductivities cannot be fully resolved. Both approaches confirm that the increased data density of towed electromagnetic systems at the longest offset extends the DOI to approximately the maximum offset distance. Additionally, we found that the data distribution achieved from continuously towing the array can resolve finer-scale shallow structure in the inversions without station location artifacts typically seen in nodal studies. Leveraging insights from these synthetic studies, we will also present results on model construction using a combination of different marine controlled-source electromagnetic systems to better constrain geology across various depths.