Methods for Enhancing the Detectability of Hydrocarbon in MCSEM

Xuan Wang[1], **Jinsong Shen**[1,2,3], **and Zhongmin Zhu**[1]

[1]Geophysical Department, China University of Petroleum (Beijing), Beijing 102249, China
[2]State Key Laboratory of Petroleum Resource and Prospecting
China University of Petroleum (Beijing), Beijing 102249, China
[3]CNPC Key Lab of Geophysical Exploration, Beijing 102249, China

Abstract— Marine controlled-source electromagnetics (MCSEM) has been used by industry as a geophysical tool for de-risking marine hydrocarbon exploration since early of this century. At present, MCSEM has been applied successfully to identify the presence of hydrocarbon reservoirs in deep water regions. But it is hard to apply MCSEM to shallow water regions, because the air wave interacts with the electromagnetic (EM) signal from reservoirs, which lead to a low signal-to-noise ratio. On the other hand, when it turns to deep water regions with deep-buried reservoirs (4 km below sea floor), there is no air wave problem, but the signal of the reservoirs is so weak that one can barely distinguish it from MCSEM equipment noise. In order to mitigate the air wave effects and enhance the intensity of weak signal, we apply synthetic aperture source (SAS) to MCSEM. The concept of synthetic aperture was first introduced to MCSEM by Fan et al. (2010) and SAS construct an extended synthetic source by integrating a series of single sources in a specific configuration to steer the field to some specified offsets by properly weighting the single source fields. In other words, a long synthetic source is constructed by some weighted single sources and the field of long synthetic source is the interference of the fields from all single sources. There are amplitude and phase weights of the single source in SAS field according to Fan et al. (2012), which is the key to achieving significant detectability (reservoir anomalies) of reservoirs in certain model. The SAS field is not only beneficial to interpret the presence of the reservoir, but also help achieve fast and accurate MCSEM inversion.

In this study, we design two types of models, which are deep-buried reservoirs in shallow and deep water regions. Then we adopt the mode decomposition method (David and Lucy, 2008) to deduce two potential functions, so the 1D electric and magnetic fields can be numerically computed by using the integral of the Bessel function. Besides, we use the finite element method (FEM) to calculate 2.5D electric and magnetic fields. We apply SAS technique to 1D and 2.5D data on two types of models and the numerical modellings verify the effectiveness of SAS in enhancing the detectability in MCSEM. In addition, we do some research in time-lapsed MCSEM, in order to test the feasibility of MCSEM in reservoir performance monitoring.