High TOC Shale Core Samples Complex Resistivity Measurement and Its Applications

Gang Yu[1], Wenbao Hu[2], and Zhanxiang He[3]

[1]BGP
[2]Yangtze University
[3]BGP Inc.

Abstract

Total Organic Content (TOC) is one of the key and important parameters to effectively evaluate the shale gas formation production potential. According to the geological deposition theory, the TOC is the basic key element that controls the form of pyrite in the marine sediment under deep water strong reducing deposition environment. There is a close relationship between the TOC and pyrite in such deep water reducing deposition environment. Through the laboratory measurement and analysis of the complex resistivity on marine shale formation core samples from South China, the high TOC shale reservoir core samples contain more pyrite, and they show clearly low resistivity and high polarization anomaly. In comparison with well log data, the laboratory measurements of TOC and pyrite are closely related to the results from the log data analysis. We concluded that high TOC marine shale formation has the characterization of low resistivity and high induced polarization (IP) anomaly. Based on the research results, the application of the induced polarization or complex resistivity method to measure the subsurface resistivity and polarization anomaly is a new approach to effectively evaluate the TOC content within the shale gas formation, and it has high potential value for future shale gas reservoir evaluation and characterization.

Based on the laboratory measurement and analysis of complex resistivity of organic rich shale core samples, we can conclude following: (1) In deep sea marine deposition environment, the TOC is the control element of pyrite existence and shale core sample analysis results support such conclusion; (2) Pyrite particles in high TOC shale samples cause strong frequency dispersion and IP anomaly; (3) Shale formation samples from lower Longmaxi and Wufeng formations have low resistivity, high IP, low density, and low magnetic susceptibility. By using induced polarization method, we can extract resistivity (ρ) and IP anomaly from shale gas formation. Based on rock physics and petrophysics study, along with integrated interpretation of logging, surface or borehole EM and seismic data, we can predict and evaluate high TOC zone (Sweet Spot) within shale formation.