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Compositional Characterization and PVT Properties of Individual Hydrocarbon Fluid Inclusions: Method and Application to Hydrocarbon Systems Analysis

Pressure-volume-temperature (PVT) analysis of fluid inclusions that are trapped in source rocks, migration pathways, and reservoirs is a powerful tool for quantitatively estimating paleopressures, paleotemperatures and changes in fluid compositions over time. Use of hydrocarbon inclusions for PVT modeling has, however, been hampered by difficulties in acquiring detailed compositional characterization of single inclusions. This study presents an approach for determining the composition and PVT properties of hydrocarbons hosted within individual inclusions. The procedure involves the integration of (1) bulk chemical analysis of inclusion hydrocarbons using gas chromatography, (2) measurement of fluid properties from individual inclusions using microthermometry, fluorescence spectroscopy and confocal laser scanning microscopy, and (3) PVT simulations of fluid properties constrained by the measured data. Natural fluid inclusion samples that have homogenization temperatures consistent with present-day trapping within hydrocarbon reservoirs were chosen to test the precision of this methodology. Results show that the method calculates fluid properties of included oils with a precision of a few percent and pressures within 15%.

The method was tested within the Tampen Spur hydrocarbon system of the northern North Sea. This area has a well-documented migration history for oil and gas. Fluid inclusion PVT analysis on the Brent reservoir from six fields suggests that changes in hydrocarbon compositions observed along the migration pathway result from the gradual displacement of earlier reservoired oil by later migrated gas. This study provides quantitative limits on and confirms the value of fluid inclusion technology in such applications as evaluating oil quality, migration timing, trap-fill history, paleopressures, and in constraining the outputs of basin modeling.