Heavy Mineral Studies for Petroleum Exploration

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The provenance and correlation of clastic sedimentary rock units has long been inferred from their inventory of detrital heavy mineral accessory phases such as zircon, monazite, apatite, rutile, garnet and tourmaline. The significance of such heavy mineral studies to the petroleum industry lies in the ability to reconstruct the stratigraphy and paleodrainage pathways in sedimentary basins that host prospective oil and gas reservoirs. This is particularly important where rock units have few index fossils or are known only from subsurface drill holes. Over the past decade new technologies have transformed heavy mineral studies into a rigorous and highly quantitative science. Recent advances in automated scanning electron microscopy provide accurate measurements of the relative abundances, sizes and shapes of mineral phases in a systematic, unbiased fashion. These data are combined with specific chemical and isotopic measurements of the minerals, particularly major element zonation patterns determined by electron microprobe analysis; uranium-lead isotopic geochronology by laser ablation-inductively coupled plasma mass spectrometry (LA-ICPMS); and hafnium, neodymium and lead isotope analyses by LA-multicollector (MC)-ICPMS. As an example, this approach was applied to potential oil-and gas-reservoir, Late Jurassic to Early Cretaceous sandstones from industry exploratory wells in the deep water, Flemish Pass and Orphan basins, Grand Banks, offshore Newfoundland, Canada. Results for Jurassic sandstones in the Flemish Pass Basin support the idea of an open seaway and paleodrainage communication between the Orphan and Flemish Pass basins during the Jurassic. Thus the East Orphan Basin is likely to contain Late Jurassic, Kimmeridgian-aged source rocks, increasing the prospects for petroleum reservoirs to be found there. In the Flemish Pass basin, source regions switched from distal northwestern and western hinterlands to more proximal hinterlands during the Late Jurassic to Early Cretaceous North Atlantic rifting stage. Early Cretaceous sandstones with reservoir potential in the Flemish Pass basin can be correlated stratigraphically using detrital heavy mineral measurements. Additional case studies are proposed in conjunction with interested industry collaborators attending AOGS-2010 to (1) assist with industry exploration programs in other sedimentary basins, and (2) refine and focus details of the technique on the basis of experience with diverse ‘real world’ examples.