Vectoring Petroleum Systems Using Satellite Imagery Calibrated to Geochemistry

Monte Swan [1], Stan Keith [2], and Sandra L. Perry [3]
[1]MagmaChem Exploration, Inc, Evergreen, CO.
[2]MagmaChem Exploration, Inc, Sonoita, AZ.
[3]Perry Remote Sensing LLC Inc, Denver, CO.

Geochemical vectoring was developed by MagmaChem as an exploration tool for the mineral industry significantly decreasing risk resulting in the discovery of 21 economic Au-Cu-Ag deposits on 3 continents. Application to petroleum exploration, beginning in 2002, demonstrated similar risk reduction. Calibration of satellite imagery indicates that surface alteration above hydrocarbon accumulations can be spectrally characterized and modeled, thereby further reducing risk by enhancing exploration screening and targeting.

Geochemical vectoring is based on fractional differentiation-the idea that as a fluid plume moves from its source to a depositional site, its composition changes in a systematic way due to decreasing T/P and changing oxidation state and pH. The resulting “chemical trail” and element dispersion plumes can be mapped and used to risk prospects. Geochemical vectoring of hydrocarbon accumulations identifies patterns in trace-element geochemistry of soils and drill holes reflecting the hydrocarbon and brine components of the fluid. Through cluster analysis, element assemblages are determined that are groups of elements traveling and depositing together in a fluid. These are well-correlated such that their compositional gradients can be identified, mapped and integrated with single-element contour maps. Vectors are determined between and within assemblages yielding a fluid migration/depositional model from which drill targets are identified.

Digital satellite analysis seeks to extend the model’s geochemical fingerprint for exploring surrounding regions and to refine drill target locations. As a case history example, digital Landsat and ASTER multispectral satellite imagery was prepared for the productive Grant Canyon field, NV and Snake Valley, UT prospect. Fluid migration/depositional models for both sites outlined regions-of-interest on digital imagery processed to identify spectral clusters exhibiting high-spatial coincidence with known elements. Compositional modeling was accomplished by combining Landsat visible and ASTER shortwave-IR bands and selected training sites for image classification. These examples illustrate that 1) surface geochemical signatures can be spectrally characterized by satellite imagery; 2) mineral modeling can predict potential alteration constituents at the surface; and 3) surface geochemistry provides calibration for spectral models, applied regionally for exploration and locally for improving drill targeting.