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Near-Surface Hydrocarbon Migration: Mechanisms and Seepage Rates

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ABSTRACT

In April 1994 the AAPG Hedberg Research Conference "Near-surface expression of hydrocarbon migration" was held to critically examine the process of hydrocarbon migration and its varied near-surface expression. The conference resulted in the publication of AAPG Memoir 66 (Schumacher and Abrams, 1996). Key conclusions resulting from the research conference and publication include:

- hydrocarbon accumulations are dynamic
- all petroleum basins have some type of near-surface expression
- leakage is not always detectable by conventional methods
- near-surface seepage rates and concentrations vary
- migration does not always occur vertically
- relationship between subsurface and surface expression is often complex

Continued studies over the years since the conference have further demonstrated the wide variety of near-surface expressions of hydrocarbon migration:

- ***seepage activity***: qualitative expression of comparative rates at which hydrocarbons leak to the near-surface, active versus passive
- ***leakage rates***: episodic or non-continuous versus continuous leakage
- ***seepage type***: magnitude of leakage to the near-surface, macro-visible versus micro-only chemically detectable
- ***migration focus***: surface signal nearly vertical versus very large lateral displacement
- ***surface seep distribution***: near-surface expression focused from point source, lateral displacement, or dispersed

The rate and volume of seepage to the surface greatly controls the near-surface geological and biological responses. The variety of near-surface responses to hydrocarbon leakage include seabed fluid or gas escape features (pockmarks and mud volcanoes), chemosynthetic organisms, ocean column geochemical anomalies, wave dampening features (oil slicks), and acoustic anomalies (wipe out zones, chimneys, pull downs, bright spots, and BSRs). Factors which control subsurface to surface migration pathways and flow rates are determined by the interrelationship of sediment fill, sedimentation rates, tectonics, and fluid flow.

One key issue not fully addressed in either the conference or book was a migration mechanism capable of moving hydrocarbons in a relatively short time (weeks to years) vertically through thousands of meters of strata without observable faults or fractures. Many mechanisms have been proposed over the years for microseepage: diffusion,

effusion, advection with moving waters, colloidal bubble ascent via microfractures, and continuous gas-phase flow (Price, 1986; Brown, 2000). Diffusion most likely contributes to the near-surface movement of hydrocarbons, but can not account for the relatively rapid movement observed in many studies. Effusion requires the hydrocarbons to move as an immiscible fluid through water saturated pore spaces. This would require a relatively porous migration pathway to overcome capillary pressures. Advection with moving waters was discounted by Price (1986) because it requires significant vertical water movement. The gas bubble ascent concept assumes small colloidal bubbles (microbubbles) move vertically via a micro-fracture network. Lastly, continuous gas-phase flow in fractures where small colloidal size gas bubbles migrate as a continuous, non-wetting phase in water wet rock through microfractures.

The 2001 AAPG Hedberg Research Conference "Near-surface Hydrocarbon Migration: Mechansims and Seepage Rates" has been designed to evaluate mechanisms responsible for geochemical signals observed in near-surface soils and sediments as well as why these signals may not always be easily observed. The first session, seepage rates and fluxes, includes papers looking at both ancient and present day seepage measurements. The second session includes papers relating the role of hydrocarbon seepage in the analysis of subsurface fluids. Session three is designed to examine interpretation and analytical methods to help enhance the evaluation of near-surface hydrocarbon migration. The last session will address the migration mechanism issue.

References:

Brown, A, 2000, Evaluation of possible gas microseepage mechanisms, American Association Petroleum Geology Bulletin, v. 84, no. 11, p. 1775-1789.

Price. L. C., 1986, A critical overview and proposed working model of surface geochemical exploration. *in* M. J. Davidson, ed., Unconventional Methods Exploration for Petroleum and Natural Gas - IV: Southern Methodist University Press, Dallas, p 245-304.

Schumacher, D. and M. A. Abrams, 1996, Hydrocarbon migration and its near surface effects: *American Association Petroleum Geology Memoir 66*, 450p.