Gas Shale, Oil Shale, and Oil-Bearing Shale: Similarities and Differences

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Source rock-associated hydrocarbon reservoirs are rapidly emerging as proved or potential reserves of oil and natural gas. The nature and potential of these reservoirs - even those presently on production - are poorly understood. Source rock-associated resources have important similarities and equally important differences. We show that research and development programs that cut across resource types aid both scientific understanding and technical improvement.

The confusion in nomenclature that identifies these resources is an on-going nuisance to operators, technology developers, and policy makers. We propose definitions of gas shale, oil shale, and oil-bearing shale, based on grain size, mineralogy, and hydrocarbon content, as well as kerogen content, type and maturity.

Conventional oil accumulations arise from fortuitous combinations of geological events and structures: source rocks that have experienced catagenesis, porous and permeable reservoirs, impermeable structures that prevent oil and gas from escaping from reservoirs, and migration pathways linking leaky sources to sealed reservoirs. This combination of events and structures is relatively rare and explains the patchy nature of oil and gas fields. Because conventional oil and gas reside in reservoir rocks, the overwhelming preponderance of petrophysical research over the last century and a half has focused on sandstone and carbonate facies.

Source rocks are very different than reservoir rocks. The extension of conventional petrophysical notions of porosity and permeability to source rock is not intuitive and possibly misleading. The presence of kerogen in source rocks makes the physical chemistry of hydrocarbon storage and transport much more complicated than in reservoir rock, in which kerogen is absent. Surface chemistry and organic geochemistry are central organizing principles in understanding source rock-associated resources.

There are two approaches to the systematic study of source rock-associated resources. The first approach takes advantage of the fact that hydrocarbon-bearing source rock formations are "continuous", as defined by the U.S. Geological Survey. Continuous resources are generally laterally extensive, though not necessarily laterally uniform, with depositional and burial histories varying within a formation. Continuous variations of rock and hydrocarbon properties can be mapped along transects hundreds of kilometers long. Thus the source rock plays themselves are natural laboratories for studying the effects of mineralogical and textural variation, and thermal maturity. An important means of rapidly gathering quantitative information about these formations involves the use of geophysical well logs, which can measure a number of diagnostic parameters. Determining the response functions and the inversions to determine formation properties from magnetic resonance, geochemical, and other logs is one immediate research goal.

The second approach is based on the observation that oil shale pyrolysis is a useful laboratory model for the natural maturation of gas shale and oil-bearing shale. Generation of bitumen, light oil, and gas, which can take millions of years in the earth, can be tracked over a period of days in the laboratory, characterized by kinetic equations that are consistent over these very different time scales.