Recognition of Mudrock Types from Integration and Upscaling of Geologic, Petrophysical and Geochemical Data Examples from Haynesville, Woodford and Marcellus Shales

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Integrated petrologic analyses are used to develop a proprietary gas shale classification that captures the textural and compositional variability of shales and provides a scheme to more precisely recognize shale types and their associated petrophysical parameters. The classification incorporates two components: 1) the lithology based on bulk composition as determined by X-ray diffraction (XRD) analyses, and 2) microfabrics recognized by thin section petrography.

Mudrock types are differentiated in core samples at macro-, micro- and nano-scales using new technologies as well as standard petrographic techniques. Integration of compositional variations from XRD (bulk and clay volume %) plus TOC analyses with thin section petrography provide clarification of how and where minerals occur. Intra-basinal versus extra-basinal sediments, quartz origins (biogenic versus detrital), and diagenetic cements can be differentiated.

Whole cores and specially prepared, ultrathin, wedged thin sections are examined to distinguish sedimentary features such as types of laminae, erosion surfaces, ichnology (burrows, microburrows, tracts and trails), textures (particle relationships) and to identify skeletal and other grain types. High resolution, digital scans of entire thin sections (1X to 40X magnifications) are examined using an Innova Genetecs VPViewer©. These images and standard thin section photomicrographs undergo contrast enhancement with Jasc® Paint Shop Pro™ to reveal details of sedimentary structures and compositional variations previously masked by the dark coloration of these organic-rich shales.

3D CT scans of unslabbed whole cores provide an approximation of relative density as well as a view of fractures, fracture-filling cements, carbonate- and organic-rich intervals, the distribution of pyrite and barite, bedding contacts, skeletal fragments, and ichnofacies distributions.

Nano-scale pore systems are identified in argon ion-milled samples using FE-SEM (field emission electron microscopy) with low-vacuum back-scattered electron imaging capabilities. Samples that were identified by the petrophysical model (by V. Shchelokov and J. Milovac) show large interconnected systems with a mixture of sub-resolution pore and organic material. Permeability appears to be enhanced by a series of nanopores through the organic material.

Boundaries in the shale classification that matter to petrophysical properties can be defined by upscaling the features observed in the FE-SEM and thin sections to those revealed by the CT scans, and by incorporating biostratigraphy, petrophysics, geochemistry and rock mechanics. Controls on porosity, permeability, tendency to fracture naturally and hydraulically can be determined.

A variety of mudrock types have been differentiated for the Haynesville, Marcellus and Woodford shales that can be used to model potential completion zones, recognize the highest reservoir quality intervals, and to extrapolate our local knowledge into regional geologic models.