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Fundamental Skills in Core to Log Correlations in Unconventional Resource Plays: Examples from the Montney Formation

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A thorough understanding of formation rock properties is at the crux of accurately correlating downhole well logs to sedimentary facies in unconventional reservoirs. These rock properties provide the "ground truth" necessary to accurately calibrate sedimentary facies and reservoir properties to log signatures, especially in unconventional, or "resource" plays. This almost always requires the integration of analytical results obtained from selected and targeted sampling of full diameter core in order to accurately characterize rock fabric, mineralogy, lithology, composition and reservoir quality. The most valuable tools in conducting such analyses are X-ray Diffraction (XRD), Routine Core Analysis (RCA), thin section petrology, organic geochemical analyses (SRA/Rock Eval) and basic sedimentology (detailed core description).

A fundamental first step in core-log calibration is accurately determining the precise depth to which a cored interval coincides. The simplest and most direct means of doing this is through correlation of the core gamma ray log ("Core Gamma") to the downhole gamma log by virtue of the log signatures and their variability on a coinciding API scale (most commonly 0-150 API units). For a variety of reasons measured core depths commonly differ from log depths by at least a few metres making core to log calibration a challenging but extremely important exercise. It should be noted that it is imperative to use measured depth (MD) logs in calibration of core depths to a downhole log signature. Conversely, a cored interval should always be described by its measured core depths for accurate calibration to a log suite and also to any lab-based core analyses.

Once calibration is established, and once a cored interval has been described in detail on a sedimentologic basis, sedimentary facies, stratigraphic intervals and significant stratal surfaces can be correlated to the suite of downhole log signatures (Fig. 1). The routine logs of greatest significance and utility to which formation/reservoir rock properties (ie. lithology, mineralogy, porosity, density and composition) can be correlated are the Gamma, Density, Sonic and Induction. Resistivity imaging logs, such as a formation micro imager (FMI), can be extremely useful in determining specific rock properties such as porosity, bedding and fractures, but are not commonly run in most wells due to their expense and general requirement for interpretation by a log analyst.

Some of the ultimate goals in the calibration of sedimentary facies and reservoir properties to downhole log signatures include: 1. enhance the predictability and mapping of subsurface lateral variability and reservoir heterogeneity as inferred in non-cored wells, thus greatly expanding the subsurface observational data base; 2. assist in the construction of geocellular models designed to predict reservoir continuity and geometry; and 3. correlation of significant stratigraphic surfaces and construction of sequence stratigraphic frameworks for subsurface intervals.

The lower Triassic Montney Formation of west-central Alberta and northeastern British Columbia provides an excellent case example of the importance and complexity in core to log calibration and correlation. The Montney varies minimally in its texture, being siltstone or very-fine grained sandstone. However, it is lithologically, mineralogically and thus compositionally highly variable and complex. The Montney is commonly bituminous and variably phosphatic, pyritic, dolomitic and feldspathic. These mineralogical properties in particular are responsible for widely varying yet predictable well log responses. In addition, the Montney is a unique "mixed" or hybrid suite of siliciclastic, bioclastic and carbonate sediments. All of these compositional formation parameters have a very strong impact on downhole log signature. Specific examples of the sedimentary facies and stratigraphic units of the Montney formation across its basin wide extent, and their characteristic log responses, will be illustrated in this presentation.

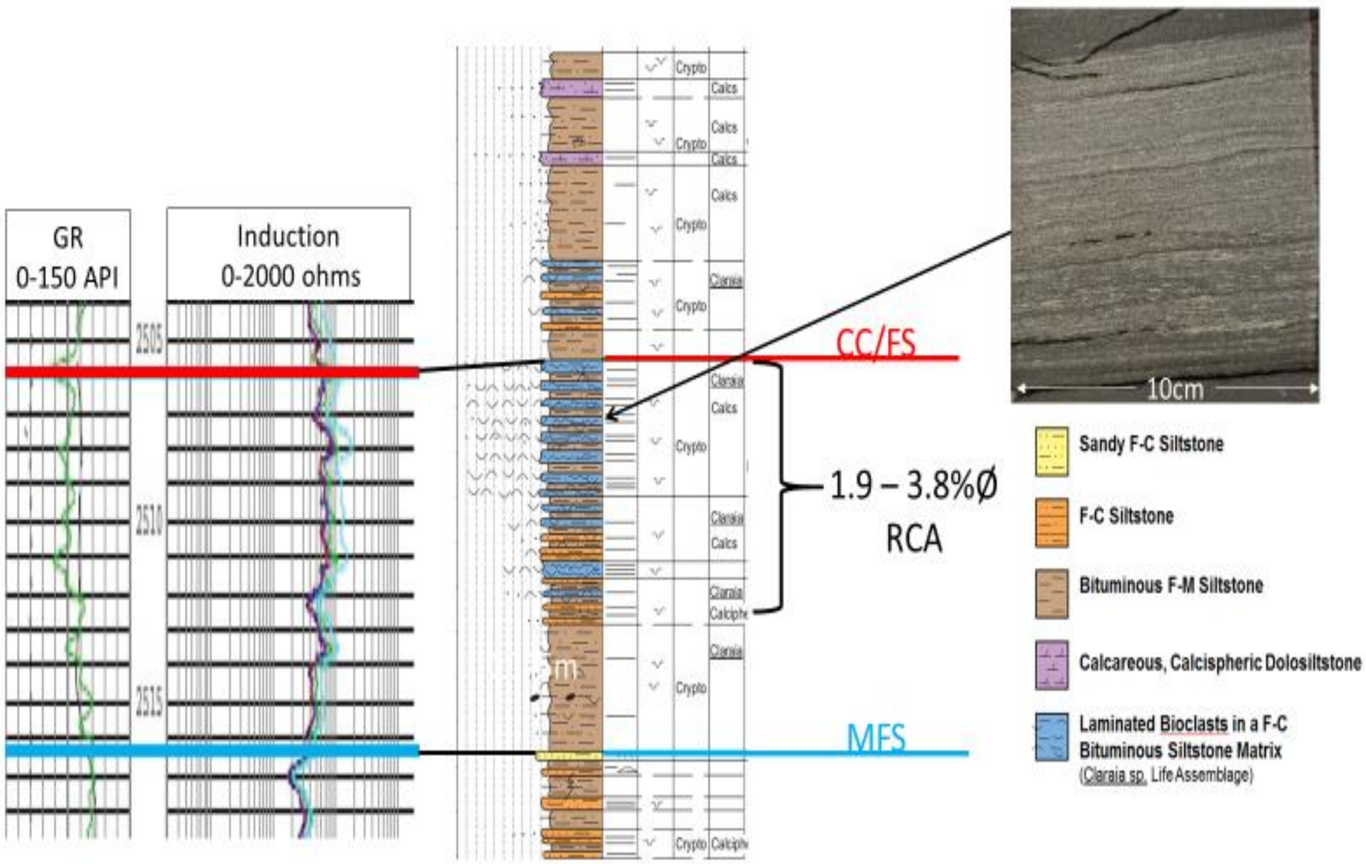

Fig. 1. Facies Association 1: Claraia Biostrome facies association, a monospecific life assemblage of Claraia sp. valves from a-34-L/94-G-7, calibrated to Gamma and Induction downhole well logs. Depths in meters. Note increased resistivity attributable to bituminous siltstone interbeds and decreased API vales, attributable to increased carbonate content, for the Claraia biostrome interval. MFS = marine flooding surface; CC/FS = coplanar Correlative Conformity/Flooding Surface coincident with the Dienerian/Smithian substage boundary. Modified after Moslow et al, 2018.