[PS]Geological Characterization of a Late Jurassic Carbonate Mudstone, Saudi Arabia: Sedimentology, Geochemistry, And Geomechanics*

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Abstract

Five cores from a late Jurassic (Kimmeridgian) carbonate mudstone succession from Saudi Arabia have been evaluated for sedimentologic, organic geochemical, and geomechanical properties. This interval was deposited in a basinal setting and is dominated by calcite mineralogy, with variable admixtures of lesser amounts of quartz and clays, and minor amounts of authigenic dolomite and pyrite.

Twelve lithofacies have been identified through centimeter-scale core descriptions and standard petrography. Lithofacies are grouped into three principal facies associations, with differences related to processes such as intermixed traction-suspension, traction-bioturbation, and bioturbation-suspension deposition/modification. Organic-rich facies of calcareous and mixed-calcareous mudstones with low bioturbation indices, high-redox sensitive elements, and medium to high paleo-productivity indices, corresponded to anoxic to dysoxic oxygen levels. In contrast, calcareous- and silica-rich mudstones with high bioturbation indices and low redox-sensitive elements were likely deposited in more oxygenated water

The twelve lithofacies have also been characterized by their organic richness and hydrocarbon potential using open-system pyrolysis. Organic richness in the more anoxic facies ranges up to 5.6% TOC. Geochemical attributes indicate oil- to gas-prone kerogen. Further geochemical analysis suggests that the organic-rich lithofacies fall in the category of good to very good source rock and above average hydrocarbon generation potential. Analyses of slabbed core samples were used to develop a high-resolution mechanical stratigraphy using micro-rebound testing, impulse hammer measurements, scratch testing, and ultrasonic velocity measurement methods. Calculated Leeb Hardness values range from 300 to 800 HLD, with low values associated with increased TOC and clay content. Techniques were used to compare/calibrate measured elastic properties with wireline logs. Comparisons show very similar ranges, variations, and trends, however, HLD profiles provide higher-resolution variability than matched wireline logs.

Reference Cited

Ziegler, M.A., 2001, Late Permian to Holocene Paleofacies Evolution of the Arabian Plate and Its Hydrocarbon Occurrences: GeoArabia, v. 6, p. 445-504.

GEOLOGICAL CHARACTERIZATION OF A LATE JURASSIC CARBONATE MUDSTONE, SAUDI ARABIA: SEDIMENTOLOGY, GEOCHEMISTRY, AND GEOMECHANICS

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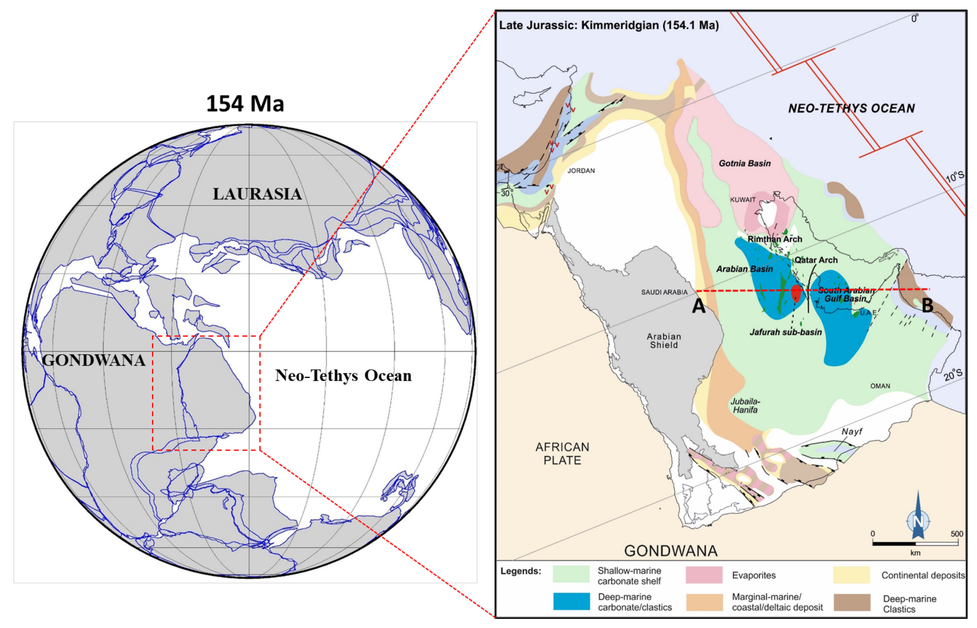
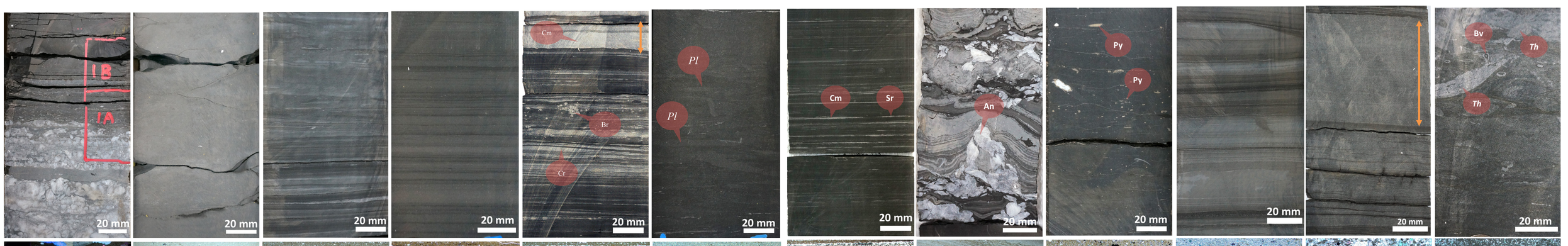
Study Area and Geological Setting



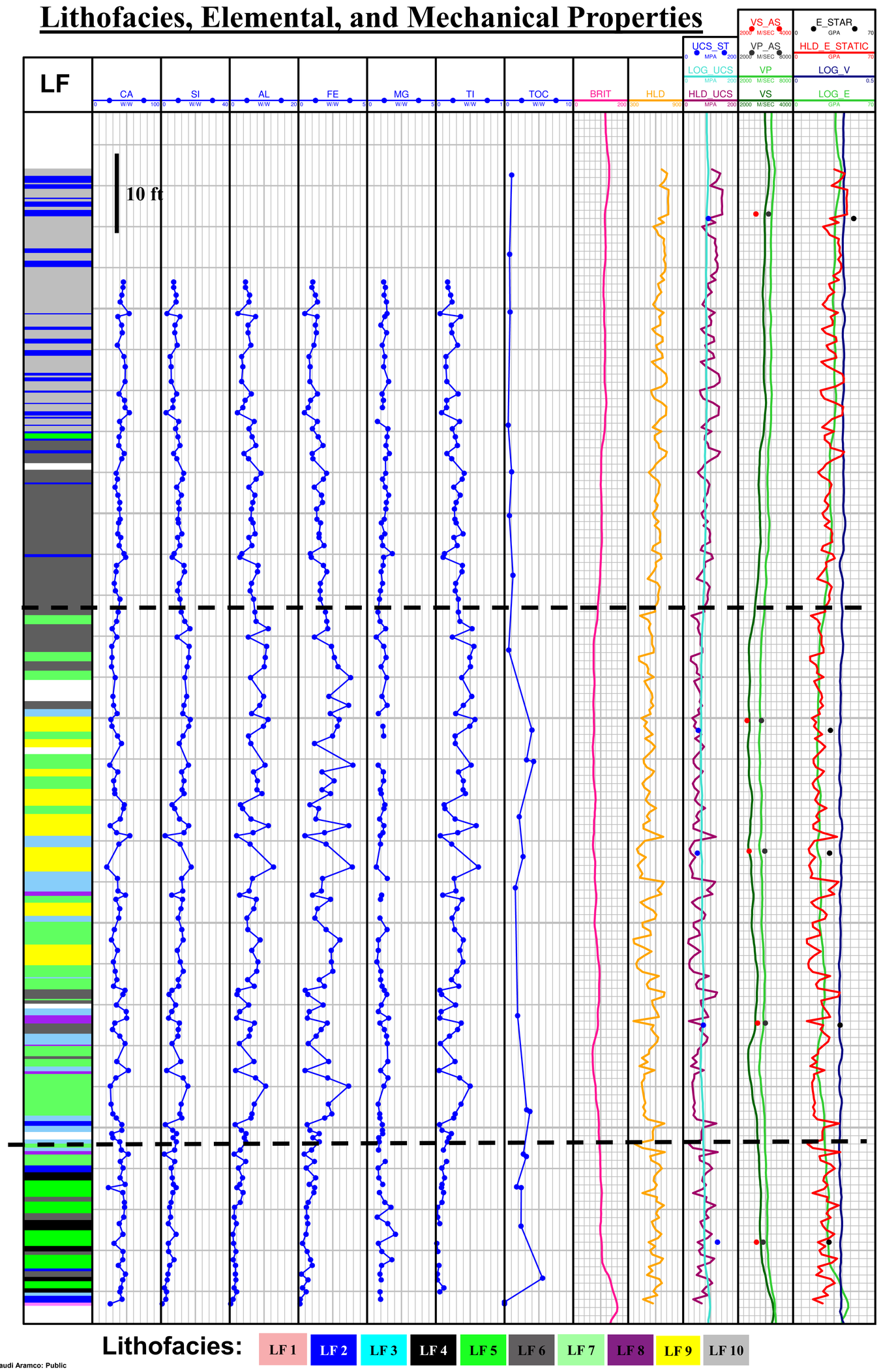
Results

Detailed (centimeter scale) core logging and description of organic-rich mudstone was conducted to understand sedimentological, stratigraphic, geochemical, and geomechanical relationship of five wells. The detailed information recorded in core descriptions included: (1) lithology, (2) texture (coarse, medium, and fine mudstone), (3) sedimentary features, (4) Bioturbation Index. There are 12 sediment lithofacies.

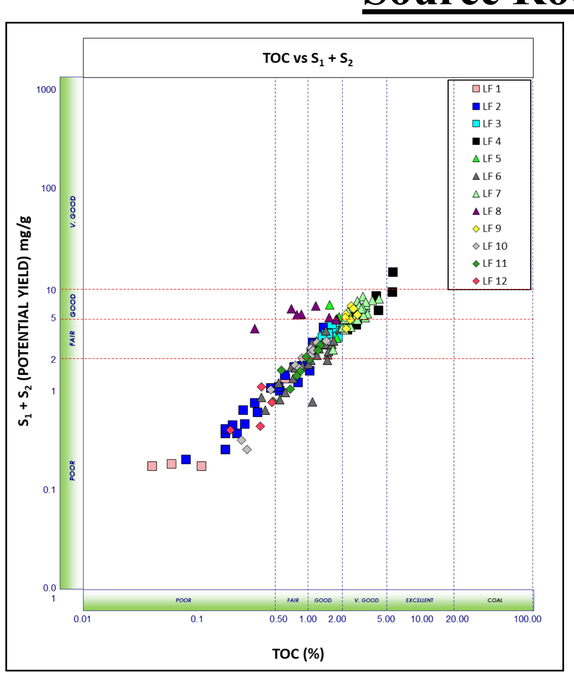


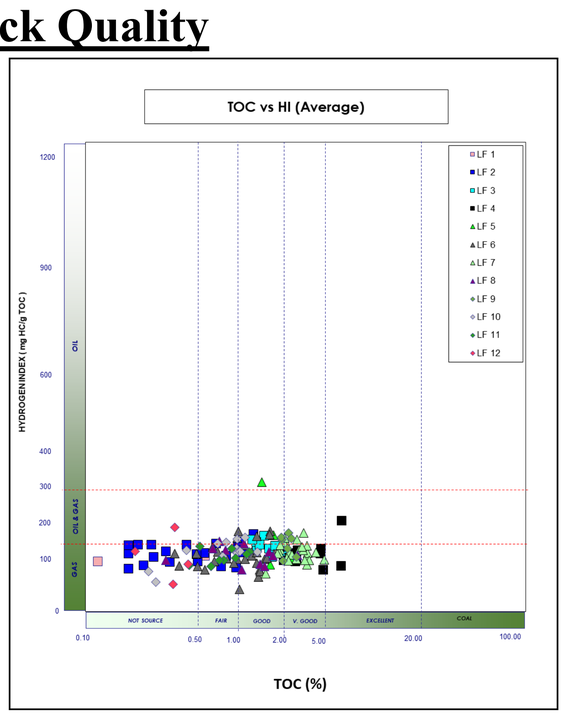
LF1: Anhydrite | LF2: Massive very fine calcareous mudstone with bioturbation | LF3: Laminated very fine & fine calcareous mudstone | LF4: Thinly dark laminated fine mudstone | LF5: Laminated coarse & fine mudstone | LF6: Massive-bioturbated fine mudstone | LF7: Laminated fine & coarse mudstone | LF8: Soft sediment deformation fine mudstone | LF9: Massive- pyritic fine mudstone | LF10: Bioturbated thin dark laminated calcareous mudstone | LF11: Thick laminated coarse & fine mudstone | LF12: Strongly bioturbated siliceous coarse mudstone

Lithofacies, Elemental, and Mechanical Properties

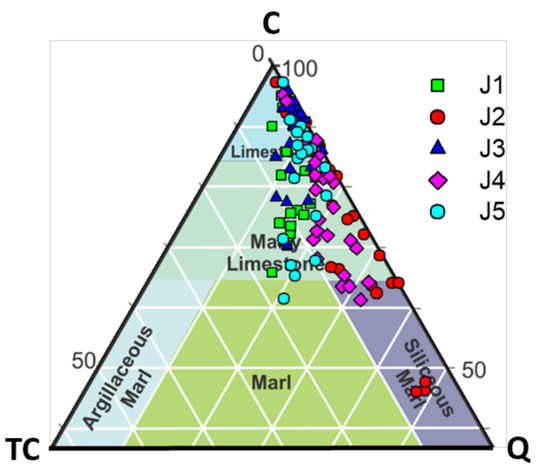


Source Rock Quality



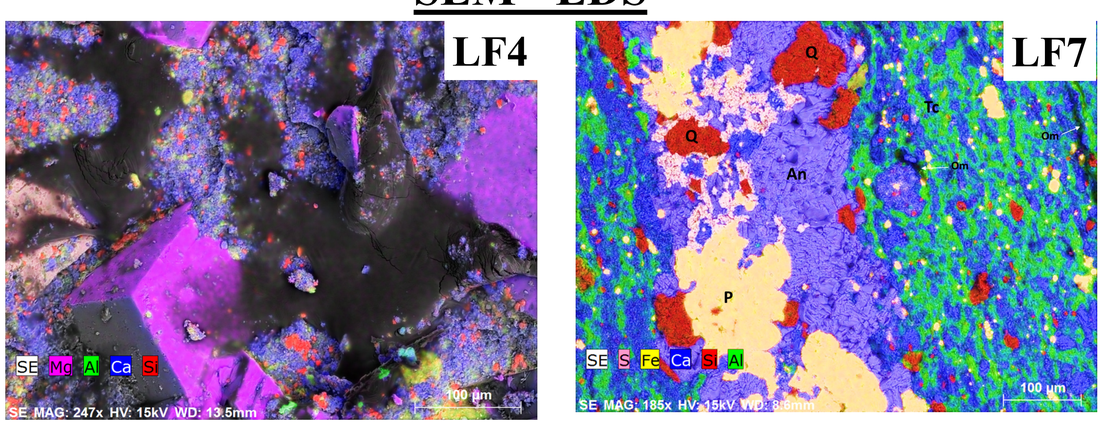


Mineralogy



- Samples are characterized by calcareous, silica-rich calcareous, and mixed-calcareous mudstones.
- Calcite is the dominant mineral, ranging from 38%-90% (average = 60%).
- Detrital components are moderately abundant in some of the samples, with quartz content ranging from 3-47% (average = 22%) and clay content (kaolinite and illite) ranging from 1-15% (average = 5%).
- Less abundant authigenic minerals include dolomite (1-10%) and pyrite (2-14%)

SEM - EDS



Conclusions

- Twelve carbonate mudstone lithofacies and three lithofacies associations have been identified within the study interval.
- Variations are present in sedimentary features, depositional processes, elemental composition, mineralogical composition, Bioturbation Index, organic content, all of which contribute to variability in mechanical properties.