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Evaluation of Coal Quality and Geomechanical Moduli Using Core and Geophysical Logs: Study from Middle Permian Barakar Formation of Gondwana Coalfield

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Abstract : Middle Permian Barakar formation is the major economic coal bearing unit of vast east-west trending Damodar Valley basin of Gondwana coalfield. Primary sedimentary structures were studied from the core holes, which represent majorly four facies groups: sandstone dominated facies, sandstone-shale heterolith facies, shale facies and coal facies. Total eight major coal seams have been identified with the bottom most seam being the thickest. Laterally, continuous coal seams were deposited in the calm and quiet environment of extensive floodplain swamps. Channel sinuosity and lateral channel migration/avulsion results in lateral facies heterogeneity and coal splitting. Geophysical well logs (Gamma-Resistivity-Density logs) have been used to establish the vertical and lateral correlation of various litho units field-wide, which reveals the predominance of repetitive fining upwards cycles. Well log data being a permanent record, offers a strong foundation for generating log based property evaluation and helps in characterization of depositional units in terms of lateral and vertical heterogeneity. Low gamma, high resistivity, low density is the typical coal seam signatures in geophysical logs. Here, we have used a density cutoff of 1.6 g/cc as a primary discriminator of coal and the same has been employed to compute various coal assay parameters, which are ash, fixed carbon, moisture, volatile content, cleat porosity, vitrinite reflectance (VRo%), which were calibrated with the laboratory based measurements. The study shows ash content and VRo% increase from west to east (towards basin margin), while fixed carbon, moisture and volatile content increase towards west, depicting increased coal quality westwards. Seam wise cleat porosity decreases from east to west, this would be an effect of overburden, as overburden pressure increases westward with the deepening of basin causing more sediment packet deposited on the western side of the study area. Coal is a porous, viscoelastic material in which velocity and strain both change nonlinearly with stress, especially for stress applied perpendicular to the bedding plane. Usually, the coal seam has a high velocity contrast relative to its neighboring layers. Despite extensive discussion of the maceral and chemical properties of coal, its elastic characteristics have received comparatively little attention. The measurement of the elastic constants of coal presents many difficulties: sample-to-sample inhomogeneity and fragility and velocity dependence on stress, orientation, humidity, and chemical content. In this study, a conclusive empirical equation VS= 0.80VP-0.86 has been used to model shear velocity from compression velocity. Also the same has been used to compute various geomechanical moduli. Geomech analyses yield a Poisson ratio of 0.348 against coals. Average bulk modulus value is 3.97 GPA, while average shear modulus and Young's modulus values are coming out as 1.34 and 3.59 GPA respectively. These middle Permian Barakar coals show an average 23.84 MPA uniaxial compressive strength (UCS) with 4.97 MPA cohesive strength and 0.46 as friction coefficient. The output values of log based proximate parameters and geomechanical moduli suggest a medium volatile Bituminous grade for the studied coal seams, which is found in the laboratory based core study as well.

Keywords : core analysis, coal characterization, geophysical log, geo-mechanical moduli
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