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TOTAL ORGANIC CARBON EVALUATION OF HETEROGENEOUS COALY FACIES USING WELL LOGS DATA, CARBONIFEROUS LORRAINE BASIN (FRANCE).

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The last coal mine in Lorraine (France) closed down in 2004 due to the loss of French mines competitiveness. The amount of coal still buried in the Lorraine underground represent an important resource of coal bed methane. This type of resource is considered both as an unconventional reservoir and an alternative energy for France which contains a low carbon footprint. Currently a new exploration campaign is being carried out in the French part of Carboniferous basin and new data are available.

The Saar-Lorraine Carboniferous Basin is about 300 km long and 20 km wide. The main part of the sedimentary filling consists of 5 km of fluvio-lacustrine deposits of the Westphalian in which the coal series develop. Westphalian strata are overlain by fluvial-dominated continental series of Stephanian in which coal is almost absent and finally a Permo-triassic cover of about 500 m thickness.

There is an important interest in the Westphalian and Stephanian formations in the Saar-Lorraine basin as a potentially prospective coal bed methane. Coal, shale and coaly shale are the most prominent source rocks in the Lorraine basin. One key parameter to evaluate the potential gas generation is the total organic carbon content (TOC). There are well-known methods to estimate TOC in the laboratory such as carbon analyzers or Rock-Eval pyrolysis. However, sampling of the core or drill cuttings is very costly and the TOC estimated in this case is discontinuous along sedimentary profiles. To overcome this limitation, several methods are derived from well logs. In Saar-Lorraine basin well logs for analysis are readily available and some drilling cores available to provide samples to be analyzed as to calibrate the results from logging data.

Recent publications describe methods of TOC determination by well-logs applied to marine clay deposits, yet application to continental coal bearing strata is much more scarce. A major problem to over-come is linked to the complexity of the sedimentary successions. The fluvial facies are dominant and characterized by fining upward depositional sequences which evolve from conglomerate to sandstone, silt, clay and sometimes coal. Thicknesses and extension in space of facies may vary significantly, due to local controlling factors. These were characterized by the study of facies sedimentology, depositional environment interpretation and genetic depositional sequence analysis using core data and well-log analysis.

Two different TOC estimation techniques from well logs data, $\Delta\log R$ (Passey et al., 1990) and Carbolog (Bessereau et al., 1991) were used within Techlog Schlumberger software with the aim to provide a best estimation for our continental fluvio-lacustrine coal bearing strata as well and coal bed methane reservoirs. These two methods rely on the response of well logs to organic matter using an overlay of sonic wave and resistivity logs. Furthermore, contrary to Carbolog, the application of $\Delta\log R$ requires the determination of level of organic maturity (LOM) for each formation. LOM was determined using the correlation table proposed Hood et al. (1975) for vitrinite reflectance either measured by organic petrography or estimated from

Rock-Eval Tmax values. This study is applied on three wells on the eastern part of the basin (Folschviller, Diebling and Johannsweiler) and three others on the western side (Saulcy, Lorettes and Chaumont).

Results show that there is high agreement between TOC estimated values using well logs and core measurements for sandstones. However, both $\Delta\log R$ and Carbolog methods tend to underestimate TOC when compared to the available TOC measurements for coal, coaly shale and shale. It appears that the very large range of TOC values (from 0 to 100%) is a challenge in the application of the methods, especially when kerogen is very concentrated in coal seams.

Objectives of this presentation will be to explain why TOC is underestimated for shales and coal seams, how to correct the calculated values and how this impacts the source-rock volumes estimates. It will also be presented how this information combined to facies analysis, depositional environment and genetic interpretation contributes to assess source-rock distribution in these very heterogenous sedimentary series.

This work is part of the Regalor project: Coalbed Methane Resources in Lorraine for a low carbon energy. <https://regalor.univ-lorraine.fr/en/regalor-2/>

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