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ISOTOPIC STUDY OF CO_2 FROM 15/3-1, 15/3-3 AND 15/3-4 WELLS (offshore Norway)

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ABSTRACT

This study deals with the isotopic study of the gases from the 15/3-1, 15/3-3 and 15/3-4 wells from the Norway offshore (see note GEO/LAB/PAU 1003-81) ; the aim of this study being to determine the origin of the low concentrations of CO_2 present in the Bathonian to Oxfordian reservoirs.

Although some hypothesis have to be done before the interpretation, the minor CO_2 gas concentrations trapped in the reservoirs appear to be due to a thermal decomposition of the organic matter, in relation with the hydrocarbon generation. The temperatures to which CO_2 has been generated vary between 115 to 150°C for the 15/3-3 and 15/3-4 samples, and are close to 90°C for the 15/3-1 sample in which the CH_4 generation seems to correspond to a maturation level close to the beginning of the oil window.

6 pages

1 table
1 figure

I - ANALYTICAL RESULTS

Different analytical data have been taken into account in this study, that is to know :

- molar compositions of essentially the CH_4, C_2H_6, C_3H_8 and CO_2 compounds,

- isotopic compositions of the CH_4, C_2H_6 and CO_2 gases,

- and mean carbon isotopic ratio of the calcitic cementations present in the reservoirs.

Most of these data was already presented in a previous note from SOURISSE and BARADAT (GEO/LAB/PAU 1003/81NI)). The complete synthetical data are reported on the attached table.

It is here to be noted that the 15/3-1 sample in fact corresponds to a mixing of different FIT performed between 4.089 and 4.443m. So, this sample is not very representative and its results should be considered with caution.

II - COMMENTS OF THE RESULTS

Origin of the gaseous hydrocarbons :

The following interpretation comes from SOURISSE and BARADAT's report and from the comparison of their data from the 15/3-1 and 15/3-3 samples with those from the 15/3-4 one.

According to these authors, the CH_4 would correspond to a gas associated with an oil generation in 15/3-3 and to a gas originating from the beginning of the oil window in 15/3-1. The 15/3-4 samples appear as intermediate, but closer to the 15/3-1 gas than to the 15/3-3 one.

On another hand, CH_4 and C_2H_6 appear in 15/3-3 and, but to a lesser extent, 15/3-1 as cogenetic compounds. Such a result also seems to be valuable for the 15/3-4 samples.

These results may be compared to those of the organic matter study of the 15/3-3 well (note GEO/LAB/BSS 0/1857 from CAILLEAUX and ROBERT), for which the DST 2bis condensate has been generated by Callovian/Bathonian source-rocks with degrees of catagenesis corresponding to those of the syngenetical hydrocarbons about 200m below the reservoirs.

Origin of the CO_2 :

The origin of the CO_2 may be only discussed if one considers the isotopic relations which exist between the CO_2 gas and the other carbon-rich compounds, that is to know the gaseous hydrocarbons and the in-situ carbonates. A good thing would be also to consider the isotopic compositions as well of the liquid hydrocarbons as of the kerogen.

For such an isotopic approach, some hypothesis may be done : the most important one being to consider that no late isotopic reequilibration takes place in the reservoirs for that concerns the CO_2 and CH_4 gases. Such an hypothesis reveals correct for the CH_4, for which the isotopic ratio really denotes its degree of maturity according to the nature of the organic matter. For the CO_2 and taking into account the more important sensibility of the CH_4 isotopic ratios (variations of 80 δ ; see figure) to the temperature than the one of the CO_2 (variations of 25 δ), this same hypothesis may be advanced.

So, if one considers the CO_2-CH_4 system, it is then possible to calculate the temperature for which both compounds were isotopically equilibrated. Such an approach may also be done for the CO_2 gas-CO_2 carbonate system. These results are reported on the attached table. For the 15/3-3 and 15/3-4 samples, the temperatures obtained in the CO_2-CH_4 system are comprised between 115° and 150°C, that is to say identical to those of the present reservoirs but also close to those required for the hydrocarbon generation in the oil window maturation level. The 15/3-1 sample provides an isotopic equilibration temperature of 90°C. Such a result may also correspond to the temperature which prevailed during the CO_2-CH_4

cogenesis if one considers that the CH_4 comes from a maturation state corresponding to the beginning of the oil window. However, the results from the 15/3-1 sample may be considered with caution due to the mixing of different FIT.

In the CO_2 gas-CO_2 carbonate system, the temperatures obtained for the 15/3-1 and 15/3-3 samples are too high to imagine these both compounds as being isotopically equilibrated. Only, the FIT 2bis, and to a lesser extent the FIT 1, from 15/3-4 present isotopic ratios which might indicate that the two compounds concerned are isotopically equilibrated in the reservoir conditions ; that is to say CO_2 may be possibly regarded as originating from a thermal decomposition of the carbonates. This assumption remains however uncertain according to the low carbonate concentrations.

At last, a deep (volcanic or magmatic) origin may not be envisaged for the CO_2 according to the isotopic equilibrium temperatures deduced from the CO_2-CH_4 system which well denote the cogenesis of these both gases.

III - CONCLUSIONS

In spite of some discrepancies in the results, notably for the 15/3-1 sample, the CO_2 analysed in the samples studied appears to be due to a thermal decomposition of the organic matter in relation with the hydrocarbon generation. The main data which allow us to arrive to this conclusion are :

- the quite identical molar composition of the total gases of all the samples studied with almost similar low CO_2 concentrations (the 15/3-1 sample excepted) ;

- the good agreement of the temperature obtained for the CO_2-CH_4 isotopic equilibria with those required for the hydrocarbon generation taking into account that CH_4 rather comes from an oil window maturation state close to those of the actual reservoir ;

- the similarity between these latter temperatures and those of the present reservoirs which are also close to the source-rock horizons ;

- the impossibility of a deep origin ;

- and the possible but only minor incidence (only in 15/3-4) of a CO_2 generation from the thermal decomposition of the carbonates.