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TEMPERATURE AND PRESSURE EFFECTS ON SMECTITE-ILLITE DIAGENESIS REVEALED BY WELL LOG MEASUREMENTS

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During the last six years many research programs of the Institute of Geodynamics were directed to topics related to the various geodynamic processes taking place in the Vrancea region, a well defined European seismo-active area; and a geodynamic polygon representing an area of 30,000 km^2, delimited by the 26° and 27°30' meridians and the 44°30' and 46° parallels, incorporating the Vrancea region, was set up for experimental works.

At the same time, the geodynamic polygon area attracted our attention due to the huge volume of borehole geophysical measurements coming from more than 3000 wells, drilled in the depth interval 0–7025 m, for exploration and exploitation of hydrocarbon resources. The thick Miocene and Pliocene detritic sedimentary sequence penetrated by these boreholes was rapidly and deeply buried, giving rise, in sealed pores, to very high overpressures in the fluids of rocks.

According to our studies, the most important mechanism related to this overpressure generation are the aquathermal pressuring effect and the smectite-illite diagenesis.

The aquathermal pressuring phenomenon has been much discussed in the literature and a previous work carried out at our institute demonstrated the prevalent role of this overpressure mechanism in our area of study, where fluid pressure gradients reach 22 MPa/km.

As far as clay diagenesis is concerned, the chemical reaction involving smectite-illite transformation by K fixation, which releases a significant amount of bound water from clay platelets into the rock pore space, may also be considered, to a certain extent, a cause of the high overpressures recorded.

Such a process was reported by many authors as being kinetic in nature and controlled by the temperature and time history of sediment burial. Most of them indicated that such a chemical reaction is mainly a function of temperature and typically begins between 60°C and 80°C.

For instance in the Gulf Coast shales, illite-smectite is 20–80% before the diagenesis starts, progresses to 80–20% mix at about 140°C, finishing with a complete illitisation above the temperature of 250°C.

In the above mentioned rocks the customary techniques used for smectite-illite investigation were based on X-ray laboratory analyses accomplished on a preselected number of cores, samples drawn from boreholes.

Nevertheless, without any extra cost, the same objectives can be approached using the continuous measurements of well logs recorded in each borehole. It has been proved that such a technique was very suitable in a region such as our geodynamic polygon, where the number of recovered cores from geological formations is scanty.

The Miocene–Pliocene sedimentary pile is constituted of sand-shale series in which montmorillonite is the most frequent argillaceous component.

Open hole investigations comprise electric, radioactive and sonic logs. Wildcat and discovery drillings include yet more measurements, such as the lithodensity log and natural gamma ray spectrometry.

Such exquisite measurement, performed by Schlumberger equipments, supplied basic data to appreciate both the Compton scattering low-energy gamma ray interactions and the photoelectric effect arising occurring during the subsequent absorption process of gamma rays. Natural gamma ray spectrometry in its turn supplies continuous measurements of the following three radioactive isotopes: ^{40}K, ^{238}U and ^{232}Th. Because the different clay minerals have characteristic concentrations of K, U and Th, the continuous logs recorded in the boreholes have been used to identify the types of clay minerals.

Field data coming entirely from the geodynamic polygon have been processed according to Schlumberger instructions. Eight boreholes were selected to completely cover the depth interval 600–6000 m, allowing the precise monitoring of clay mineral conversion from montmorillonite to mixed layer and afterwards to illite.

All graphical presentations and interpretation are displayed on the poster. Conclusions can be summarised in the following points: a) the use of well logging measurements provide the most complete information for smecite-illite diagenesis; b) the above mentioned clay mineral conversion is kinetic in nature and seems to start almost immediately after sediment deposition; c) the higher the geothermal gradient during sediment burial, the faster is the conversion rate; d) the high lithostatic pressure gradients lead to an obvious slowing down of the illitisation process.