INTRODUCTION

In the oil industry, the formation water requires a detailed geochemical and hydrologic characterization (Archer and Wall, 1994) since the establishment of type and origin of this bodies water allow it to deduce the vertical and horizontal proximity of a certain hydrocarbons reservoir, as well as providing essential parameters such as salinity to calculate the oil reserves (Archer and Wall, 1994; Fiorillo et al., 1983). Orinoco Oil Belt (OOB) is regarded as the biggest accumulation of extra heavy and heavy crude in the world. It is located on the southern of Eastern Basin of Venezuela, south of Guarico, Anzoategui, Monagas and Delta Amacuro states, Orinoco river it represent southern bound. OOB covers an area of approximately 54,000 km², with 600 km from east to west and 70 km from north to south (Fiorillo et al., 1983). OOB has been divided into four (4) operational areas that from east to west which are called: Boyacá (formerly Macheta), Junín (formerly Zuata), Ayacucho (formerly Hamaca) and Carabobo (formerly Cerro Negro) (Fig. 1).

In that sense, the main objective of the present study was to characterize the formation water in Carabobo’s area through classical system (Stiff, Sulin and Pipier) looking for its integration with the others fluids present in the reservoir.

RESULTS AND DISCUSSION

32 samples of formation water extracted of different depth were used for this study. These samples were extracted during drilling of 10 stratigraphic wells. The water samples were transferred from the collecting tool, avoiding any contamination with oil or drilling mud. Subsequently, the samples were stored in HDPE bottles with 120 ml capacity. Before storage, HDPE bottles were treated with a little volume of HNO₃. (dilutied) until to reach pH 2. This treatment avoid precipitation, co-precipitation and heavy metals adsorption on the walls of the container. Finally, bottles were washed with deionized water. Measurements of temperature, conductivity and pH were made in the field using a pH/Cond Thermo 4-star meter. The water samples for the dissolved species (cation and anion) were prefiltered with 0.45 µm filters and acidified with HNO₃ just for anion determination. Dissolved species determination were followed established procedure in ISO-11885 and ASTM D-4327 metodolog norm.

Fig. 2 Piper's Diagram that show the type of water in Carabobo's area

Several combinations of hydrogeochemical processes and water-rock interaction reactions have been proposed to explain the origin of this type of groundwater as dissolution of CaCO₃ in the presence of sodium-rich mineral such as albite (NaAlSi₃O₈) (Cheng et al., 2006): (1)

\[
\text{Na}^{+} + 4H_4SiO_4(aq) + Al_2Si_2O_5(OH)_4(s) \rightleftharpoons \text{Na}_2Si_2O_5(aq) + 2H_2O(l) + 2H_2SiO_4(aq)
\]

The characterization of a particular body of water is based on the concentration of major ionic species and the relation between them. To execute such a characterization, classification and identification of type of water in the Carabobo’s area was a Piper’s diagram (Fig. 2) that includes water formation samples at different depths, this enabled us to identify that other process must add Na⁺. On the other hand, Stiff’s figures (Fig. 4) suggest an meteoric origin that match with show in Fig. 3 and further samples rise their meteoric character with depth. In some wells, as well C (shallower sample) and well D, Stiff’s figures show the existence of connate water although NaCl relation suggest a connate origin for well C sample and meteoric for well D samples. This fact indicate the presence of a mixture zone (Fig. 5) between connate water (Na-Cl) and meteoric water (Na-HCO₃) at southwest to study area or maybe indicate communication of sands in the reservoir. It recommended, to realize a study with chemical or natural tracers to determine the exact spatial position of this mixture zone and choose between these possibilities.

Fig. 3 Na/Cl relation of Carabobo's area formation water

CONCLUSION

The results generated in the various tests on samples of formation water for Carabobo’s area concludes that the research area presents predominance water Na-HCO₃ type proposing its genesis to a meteoric origin. Shallower sample of well C and samples of well D suggest the presence of a mixture zone in the southwest area, including water NaCl type and water Na-HCO₃ type. As regards to origin, Stiff’s figures and Sulin’s relation show predominance of meteoric origin for mostly samples and rising this with increasing depth of sand that contains the aquifer.

Finally, the jointly application of standard system (Piper, Stiff and Sulif) allowed the characterization and possible birth determination for the formation water in Carabobo’s area from Orinoco Oil Belt.

REFERENCES