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Journal of Stratigraphy and Sedimentology Researches University of Isfahan
34th Year, Vol. 73, No. 4, Winter 2019
pp. 39-56
Received: 26.11.2018 Accepted: 28.01.2019

Geochemical evolution of saline formation water of the Mozduran gas reservoir

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Abstract
The Mozduran gas reservoir in the Khangiran gas-field is formed in the Kopet-Dagh sedimentary basin in the form of sequential sequences of clastic and carbonate sediments of the old sea water. The reservoir is located in the formations of Shurijeh and Mozduran, consisting of limestone, dolomite, sandstone and shale. The Mozduran Formation was deposited in a carbonate platform and Shurijeh Formation in the river systems to coastal deltas during the Jurassic. The origin of brine formation waters was the old evaporated seawater. The old evaporated seawater has been in contact with various formations since the burial time, and their initial composition has altered. Ion concentration of major, minor and trace elements in the produced waters and two deep brine samples below the Shurijeh reservoir were measured to investigate the geochemical evolution of the brine formation waters. The concentration of all ions has increased to saturation in brine due to the evaporation of sea water. However, over the time, the concentrations of Ca, Li, Sr, B and I ions have been increased compared to the original source and the concentration of Na, Mg and SO4 ions have been decreased. The geochemical evolution of this reservoir has been affected by evaporation, water-gas and water-rock reactions such as dolomitization, albitization of plagioclase, ilitization of Smectite, sedimentation or dissolution of sulfate minerals, magnesium carbonate precipitation. Concentration of potassium and chloride ions was mainly influenced by the process of evaporating the old sea water. The results of this research are used to identify the history of sedimentation, secondary geochemical processes in the reservoir, determination the origin and the salinization mechanism of produced water from the gas reservoirs area to achieve sustainable management of the reservoir.
Keywords: Mozduran gas reservoir, Evaporated seawater, Chemical evolution, Brine formation water.

Introduction

The concentrations of brine formation waters reflect both the chemical characteristics of the sources from which they originated and the diagenetic reactions that had taken place. The modified original seawater, locked in during the time of sedimentation, is proposed as an origin of most deep saline formation waters. The evaporated seawater has been in contact with various formations in oil/gas fields since the time of burial. The chemistry of produced water in oil and gas reservoirs can be changed over the time by various processes and secondary reactions such as water-rock and/or water-gas interactions. The study area, Khangiran gas field, is located northwest of Iran. This gas field composed from three reservoirs of Mozduran, Shurijeh B and Shurijeh D. Mozduran reservoir consists of thick layer of carbonate rocks and interlayers of marl and shale. According to geological, hydrochemical and isotopic studies, the old evaporated sea water is proposed as main origin of the produced water and salinity. Over the time, the effect of various secondary processes inside the reservoir has caused a change in the initial concentration of the main ions of the brine relative to its original source (evaporated sea water). The main agent of this research is to investigate the geochemical evolution of the brine below the Mozduran gas reservoir and also to identify the secondary processes that affect its chemical composition during the geological times.

Material & Methods

Two brine water samples were taken from observation well no. 13 and 17 which drilled to Shurijeh B and D reservoir.

Doi: 10.22108/jssr.2019.114104.1074

The water content in the wellbore was drained by gas flow and after that, the brine sample was brought to the surface from a depth of 3000 m below sea level using a bottom-hole sampling device. In this study, the 6 samples are also taken from saline and fresh produced waters of the Mozduran gas wells to measure the concentration of major ions and trace elements. The trace elements, and Br and I anion concentrations were analyzed by ICP-MS, ICPOES and IC techniques.

Discussion of Results & Conclusions

Various methods have been used to investigate the geochemistry evolution of the Mozduran reservoir. The water chemistry of brine formation waters can be altered by evaporation or water–rock interactions during burial. Br is conservative ions and cannot be easily removed from solution and used to study for geochemical evolution; therefore, Br ion concentration of Mozduran reservoir waters is most probably equal to the original Br concentration of its source, evaporated seawater. The brine and produced waters in the study area are enriched in Ca, Sr, Li, I and Rb, and depleted in SO_4, Na and Mg ions, with respect to the initial evaporated seawater. Therefore, the seawater evaporation is not the only process controlling the geochemical composition of the brines in the area. The ion concentration variations are due to processes such as sulfate reduction, anhydrite precipitation, organic material-water reactions, limestone dolomitization, and albitization of plagioclase feldspar. Based on the chemical evolution after seawater evaporation, the KA waters are classified into four groups: (1) no evolution (Cl, K ions), (2) water-rock interaction (Na, Ca, Mg, Li and Sr ions), (3) water-gas interaction (SO_4 and I ions) and (4) both water-rock and water-gas interactions (Mn and B ions). The chemical evolution processes of the KA waters include dolomitization, precipitation, ion exchange and recrystallization in water-rock interaction. Bacterial reduction and diagenesis of organic material in water-gas interaction also occur. Therefore, the concentration of all ions increases due to the evaporation of seawater up to saturation, but some of the ions' concentrations have changed under the influence of rock/gas-water interactions. The chemical evolution of the brine waters is classified into four groups: (1) only evaporation, (2) water-rock interaction, (3) water-gas interaction and (4) the interaction of both rock and gas with water.