Assessment of natural gas chemistry alteration by extent of H2S production and evidences for multiple stages of TSR in two gas fields in Gavbandi-High, Iran

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Introduction

The prominent Upper Permian-Triassic gas condensate accumulations in Southwestern Iran are located at a regional paleo-high known as Gavbandi, a continuation of the Qatar- Fars arch into the coastal part of the Persian Gulf (Fig. 1).

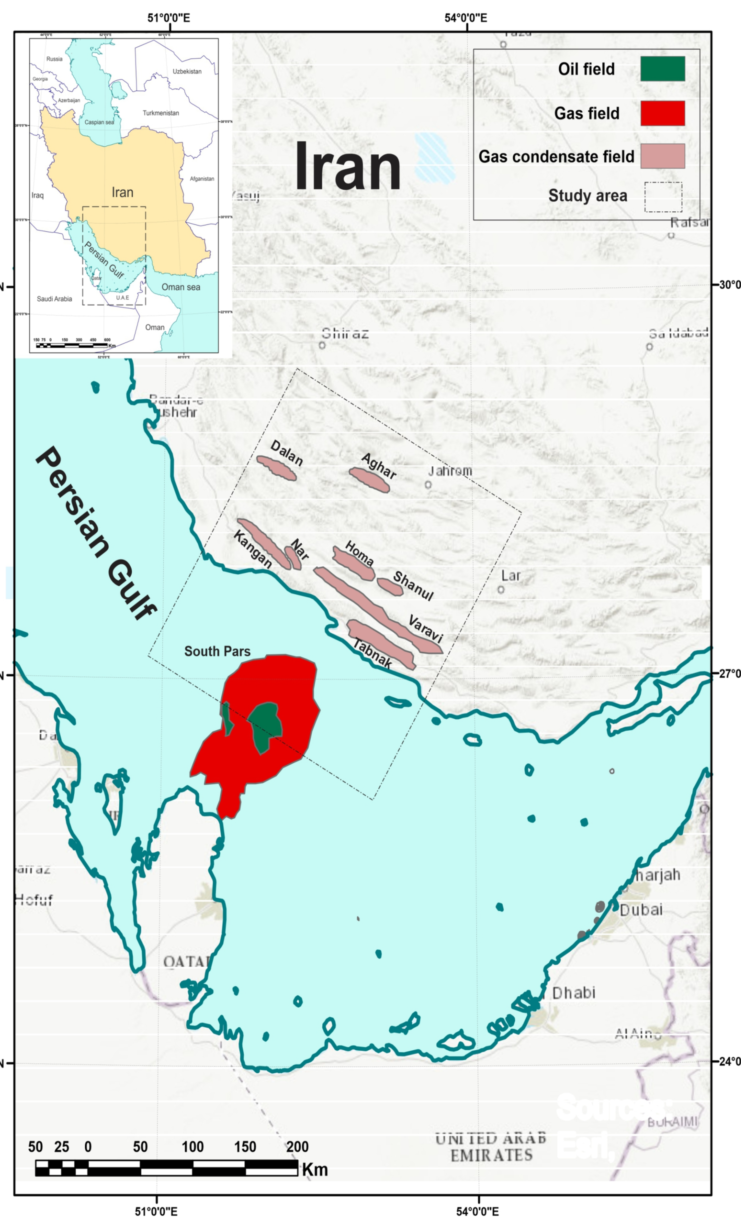

Fig.1 - Location of the study area

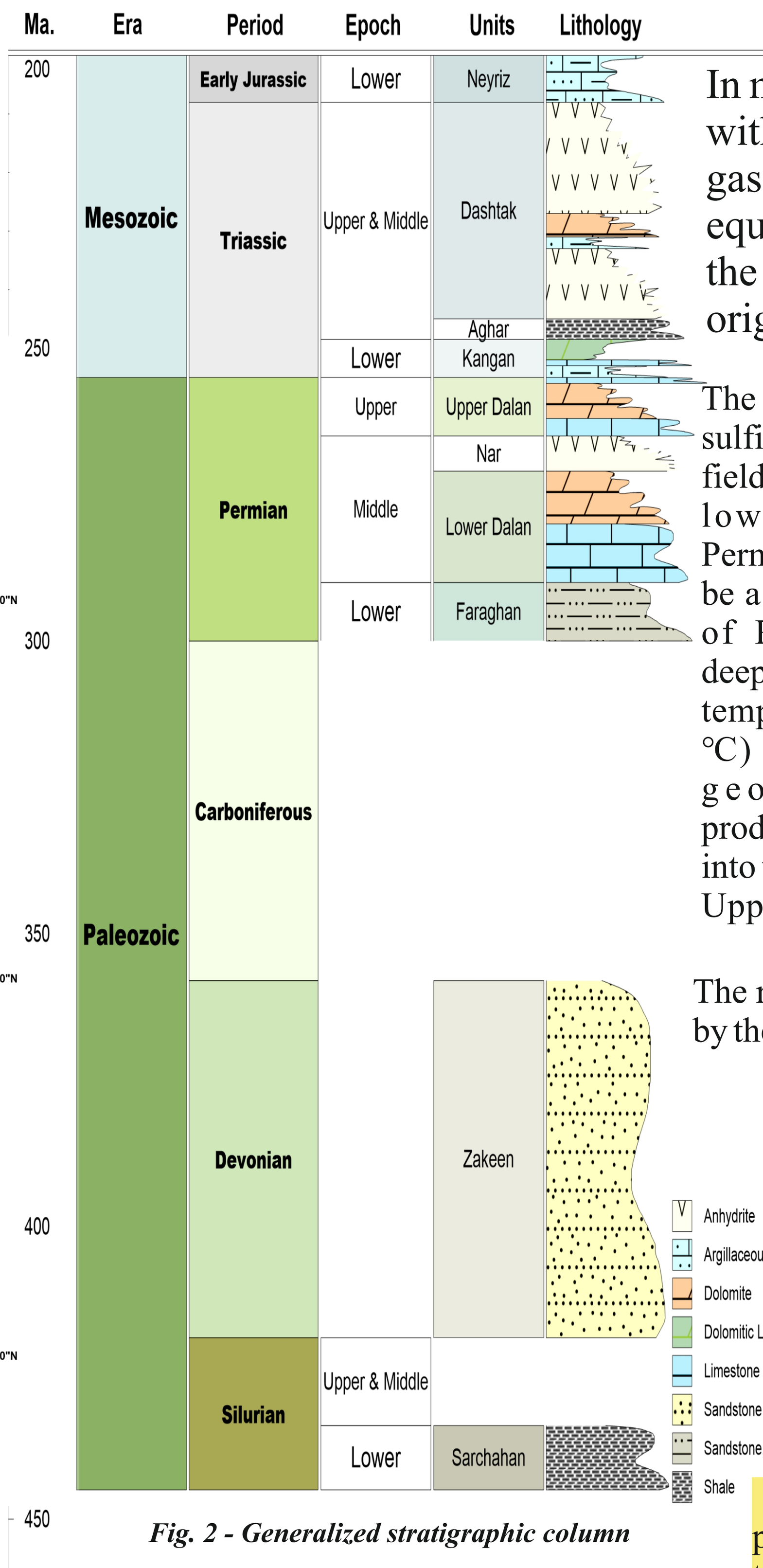

Fig. 2 - Generalized stratigraphic column

In most of the reservoirs in this region hydrogen sulfide has been produced along with gas condensate. Hydrogen sulfide is an undesirable component of natural gas and condensates, which is highly toxic and highly corrosive to production equipment. , so it is important to understand the mechanisms and conditions for the formation of H2S. Hydrogen sulfide in Gavbandi-High has thermochemical origin (Fig.2).

The mean δ34S of hydrogen sulfide gases at the studied field is approximately 20‰ lower than the δ34S of Permian anhydrides and may be a consequence of the TSR of Permian anhydrite in deeper areas with appropriate temperature regime (~ 100 °C) for a long period of geological time. The produced H2S then migrated into the upper reservoirs of the Upper Dalan and Triassic-

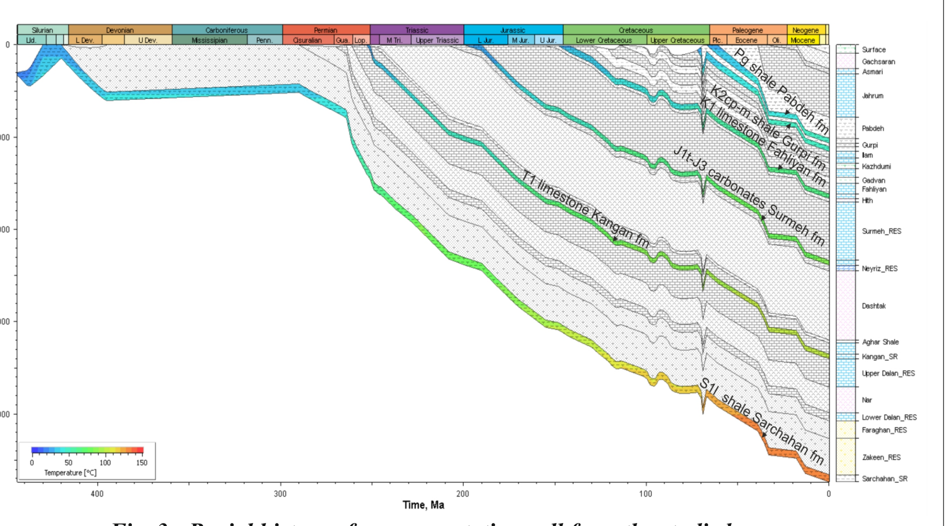

Fig. 3 - Burial history of a representative well from the studied area

The relatively low concentration of H2S is explained by the initial phase of TSR reactions [12].

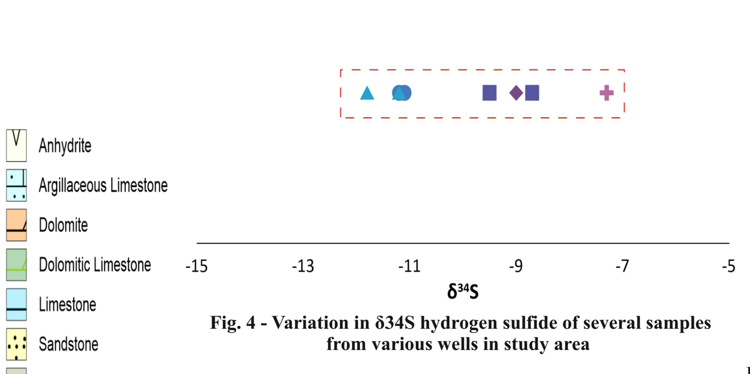

Fig. 4 - Variation in δ34S hydrogen sulfide of several samples from various wells in study area

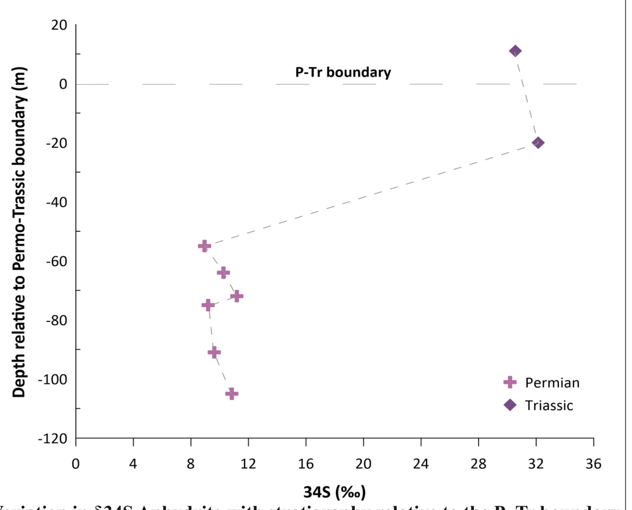

Fig. 5 - Variation in δ34S Anhydrite with stratigraphy relative to the P–Tr boundary

In this study, the molecular and isotopic composition of 12 gas samples in addition to the previously-published results of integrated analyses on rock and condensate, were utilized to trace potential alterations caused by the given phenomenon exhaustively.

Molecular and geochemical analyses

The correlation between the TSR extent and the ratio of aromatic to saturates fraction in condensate shows that saturate fractions are among the primary input components for sulfate reducing and oxidizing reaction.

Direct correlation between the gas dryness index and the extent of TSR, illustrated in fig.7. is consistent with the previous studies on thermochemical sulfate reduction impact on gas chemistry, however the relative low reservoir temperature would not allow methane to get oxidized. Fig.8 shows that with the extent of TSR, the isotope composition difference between methane and ethane gets larger. This trend is against of maturation process, which makes the isotope composition of the hydrocarbon components closer to each other. The increase in isotope composition of ethane versus hydrogen sulfide content in fig.9. indicates that ethane is another hydrocarbon component that has been consumed during sulfate reduction process in the studied area. It can be concluded that in TSR reaction, ethane due to its lower energy of activation gets to the reaction earlier than methane, which in result would increase the dryness index as well.

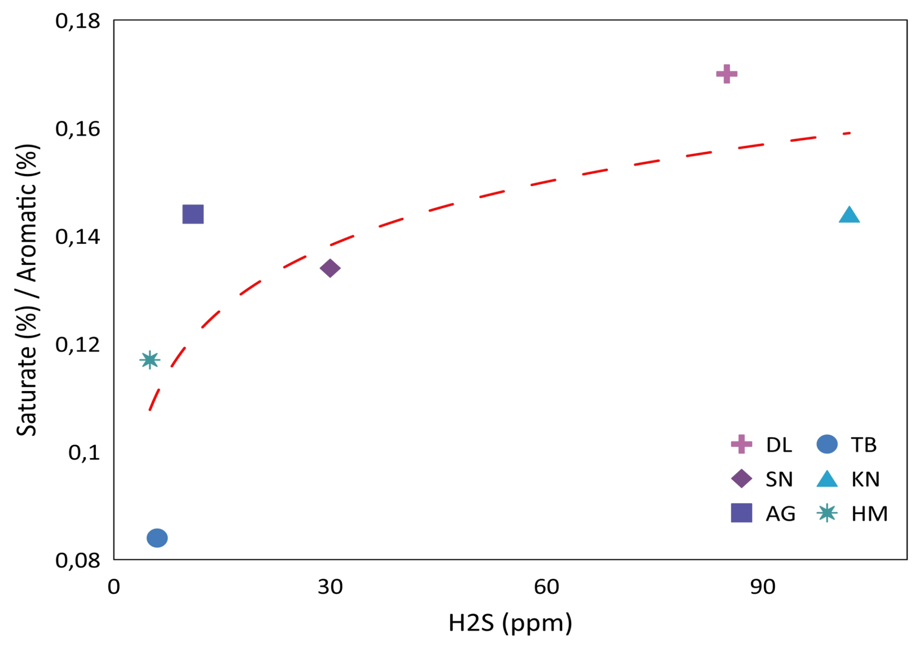

Fig. 6 - Correlation between the Aromatic/Saturates ratios and H2S

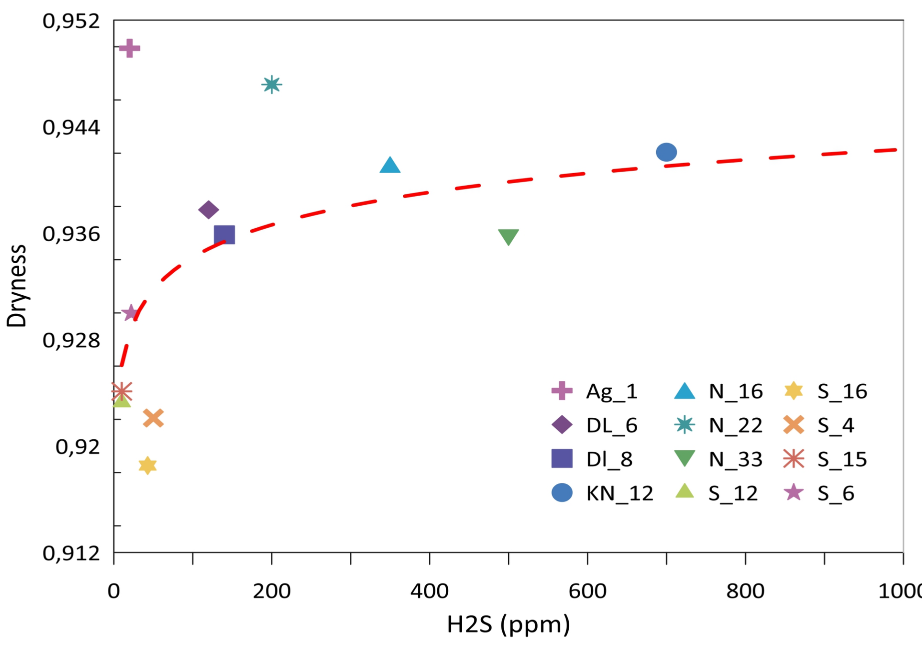

Fig. 7- Correlation between the Aromatic/Saturates ratios and H2S

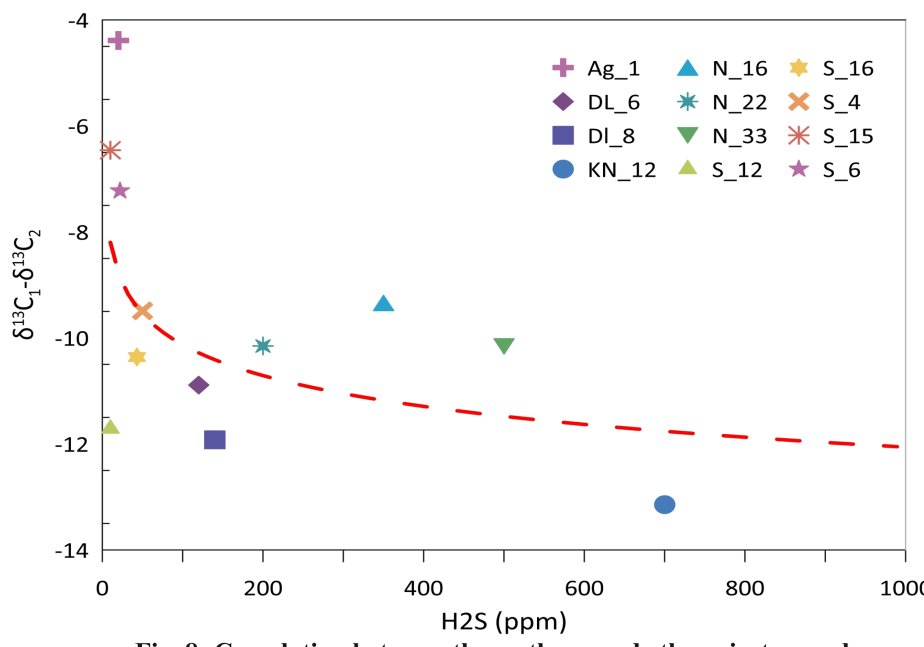

Fig. 8- Correlation between the methane and ethane isotope values difference and H2S concentration

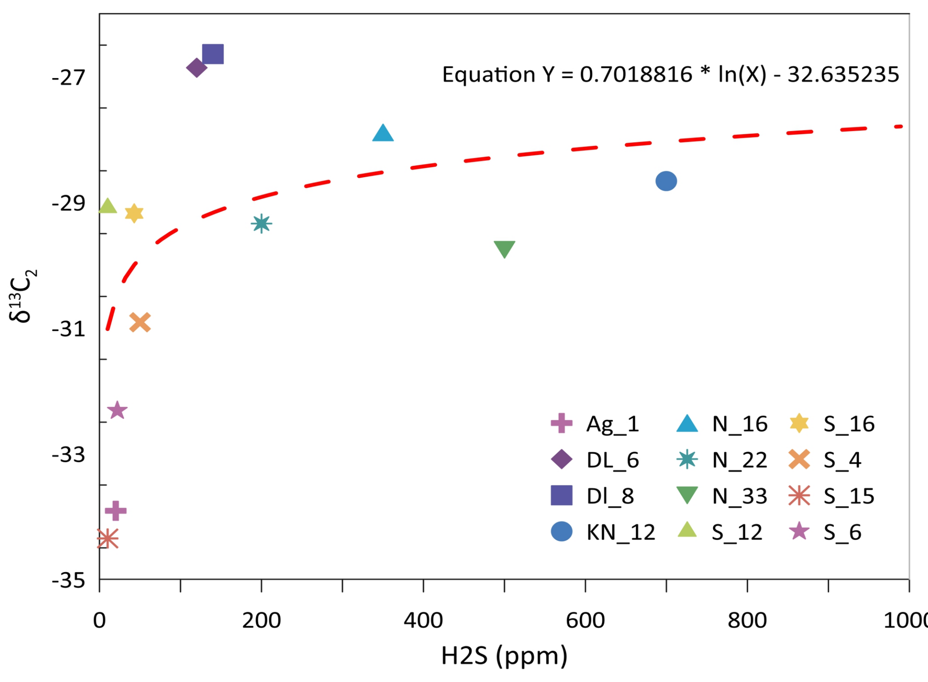

Fig. 9- Correlation between the isotope composition of ethane and H2S concentration

Fig. 10 demonstrates that the studied samples isotope and molecular composition are behaving different that the maturing process. It can be seen that in comparioson to the methane, ethane is preferebally gets consumed in the TSR process.

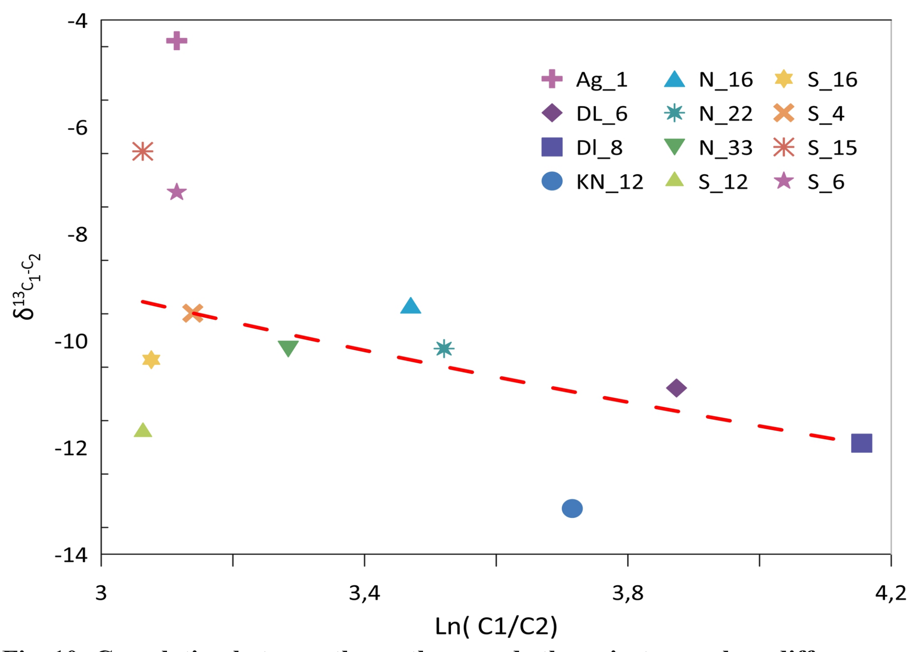

Fig. 10- Correlation between the methane and ethane isotope values difference and methane to ethane content ratio

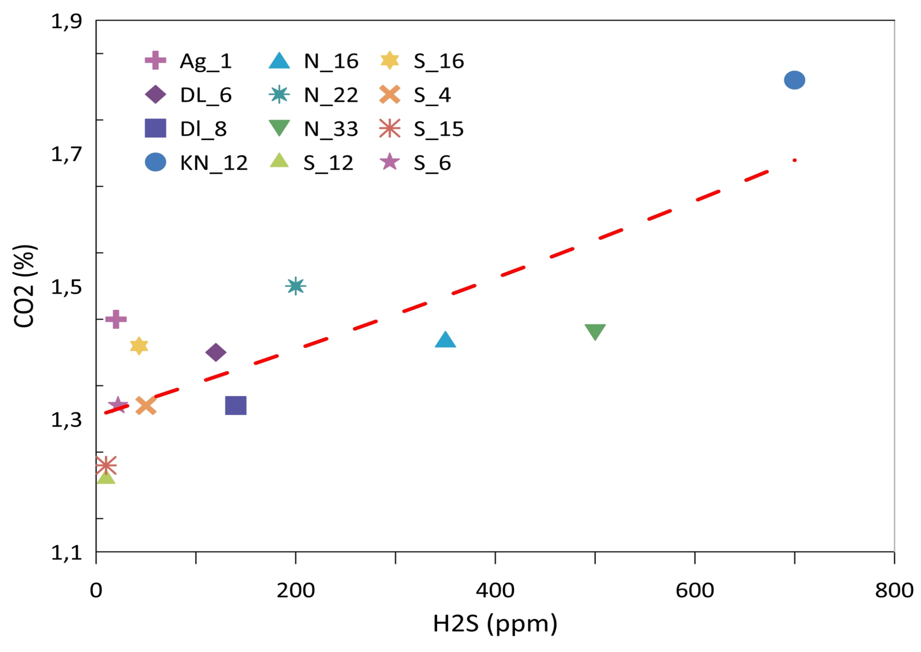

Fig. 11- Correlation between carbon-dioxide content and H2S concentration

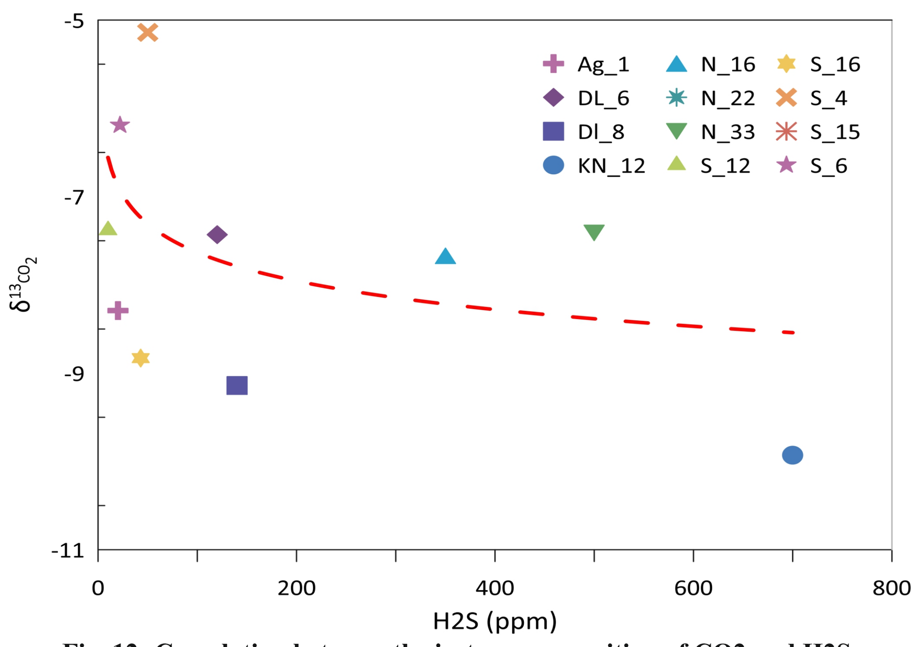

Fig. 12- Correlation between the isotope composition of CO2 and H2S concentration

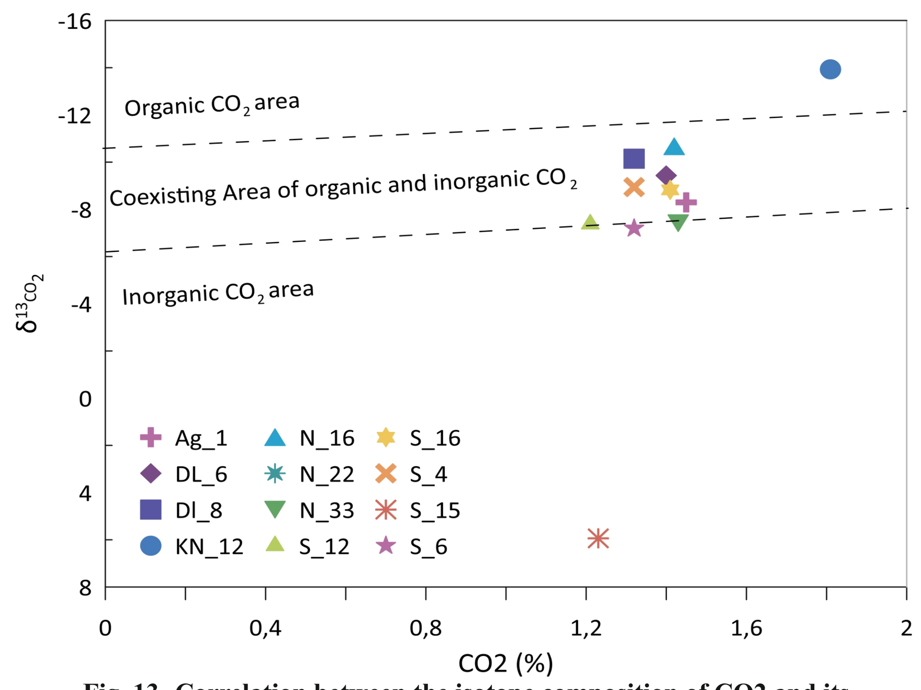

Fig. 13- Correlation between the isotope composition of CO2 and its concentration

One of the main product of the Thermochemical Sulfate Reduction reaction is carbon dioxide. Molecular and isotopic analyses of gas samples of the studied area shows that carbon dioxide has been produced along with H2S in the given area. This can is seen in Fig. 11and 12, where with the extent of TSR, ligher carbon isotopes from the oxidized hydrocarbon components are turning to carbon dioxides. Although the carbon isotope values of the given samples obtained after analyses are too heavy to conclude their organic origin. For this purpose, the isotope values were plotted against carbon dioxide mole fraction to identify their origin. Fig. 13., developed by Dai.et.al. shows that carbon dioxide of the studied area has both organic and inorganic origin. Crbonate lithological structure of the studied reservoir might explain the given phenomenon, where a large portion of the carbon-dioxide are released to the natural gas after carbonate dissolution in the reservoir.

Conclusion

The results of the molecular and isotopic composition of the studied samples from Gavbandi-high region in Iran imply that the thermochemical Sulfate Reduction reaction is the main mechanism for the emergence of the hydrogen sulfide in the studied area. The extent of this reaction is accomponied by the increase in gas dryness, where heavier hydrocarbon components are get into reaction faster. Accordingly, With the increase of hydrogen sulfide content the concentration of ethane drops, and on the conterary the amount of carbon dioxide increases. This is consistent with the increase in isotope value of ethane, where only heavier molecules are left and decrease in isotope value of carbon-dioxide, where ligher molecules of carbon are becoming CO2. Further studies on carbon-dioxide origin in this region, indicate that TSR is not the only reason for their formation. Slight heavy isotope values shows the intrusion of relead carbon-dioxide from carbonate rocks to the natural gas.

References

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