THERMAL EVOLUTION OF THE KUH-E-ASMARI AND SIM ANTICLINES IN THE ZAGROS FOLD-AND-THRUST BELT BY MEANS OF ORGANIC AND INORGANIC PALEO-THERMAL INDICATORS

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Introduction

In the Zagros orogen along strike variations in structural style are testified by the development along the front of the fold-and-thrust belt of salients and recesses (McQuarrie, 2004). These variations are thought to be driven by stratigraphic changes along strike (e.g., distribution of Cambrian salt at the base of the sedimentary pile) that may have influenced geometry of thrust faults and related folds. Nevertheless further stratigraphic variations as well as depth of deformation may account for structural differences in folds and associated fracture patterns.

We investigated the depth and paleo-temperatures of deformation of the Asmari Fm (a major reservoir rock in the petroleum system of the Zagros orogen) in two anticlines developed in areas characterized by occurrence (Sim anticline) and absence (Kuh-e-Asmari anticline) of Cambrian salt, in order to contribute to the investigation of the possible factors that control along strike variations in fold style.

With this purpose, organic matter optical analysis and X-ray diffraction of clay-size fraction were performed on samples collected in the field at the top and bottom of this unit to derive organic and inorganic indicators of thermal exposure such as vitrinite reflectance and illite percentage and stacking order in illite-smectite mixed-layers (see Pollastro, 1990; Mukhopadhyay , 1994; Merriman & Frey, 1999)

These paleo-thermal indicators have been integrated in 1D thermal models, with stratigraphic and structural analyses and Tmax data from pyrolysis derived from subsurface samples. This multi-method approach allowed us to define the level of thermal alteration of sedimentary successions in both areas and to constrain their burial and thermal history.

A companion abstract (see Carminati et al., this volume) is dedicated to the reconstruction of the strain associated to the same two anticlines and to the possible causes for the observed differences in fracture density.

Results

Organic matter analysis

A total of twenty-two surface samples have been analysed for organic matter thermal maturity evaluation. Fourteen derive from the Kuh-e Asmari anticline and surrounding areas (e.g., from Katzumi, Gachsaran, Mishan and Agha Jari Fms) and six from the Sim ancline (e.g., from litho-stratigraphic units younger than the Asmari Fm).

Main results concerning optical analyses performed in reflected mono-chromatic light, show that samples from the area of the Kuh-e Asmari anticline are relatively richer in organic matter than those derived from the Sim anticline. This allowed to provide coherent quantitative thermal maturity data for the first structure and only a qualitative evaluation of thermal maturity for the latter one. Nevertheless the integration between organic matter analyses and X-Ray diffraction on pelites provided a satisfactory mach between quantitative and qualitative results.

Furthermore the lithostratigraphic units that are more prone for organic matter thermal maturity studies are the Kazdhumi, Gurpi, Pabdeh, Mishan and Agha Jari with special regard to their poorly oxidized portions (especially for the Agha Jari Fm).

In both anticlines, organic and inorganic thermal parameters measured on surface samples indicate that the analysed sedimentary units fall into the early diagenetic zone and the immature to early mature stages of hydrocarbon generation.

Furthermore in the area of the Kuh-e Asmari anticline, Tmax values of twenty-eight subsurface samples collected at depths higher than 2 km (from Dogger to Lower Cretaceous units) are between about 435 and 450 °C indicating the mature stage of hydrocarbon generations.

XRD analysis on <2μm fraction

A total of twenty surface samples have been analysed for clay minerals characterization. Most of them are marls interbedded within cm-thick carbonatic strata of the Gurpi, Pabdeh, Guri and Champeh Formations and pelites from the Mishan, Gascharan and Mol Formations. Only sample AJ3 from the Agha Jari and GAS2 from the Gascharan Fms are siltstones. To the NE of the Kuh-e-Asmari anticline one more sample has been collected from the Kazdhumi Fm.

In the Kuh-e Asmari observed mixed layer I-S in the Mishan and Gascharan Formation are disordered (R0) structures with an illite content between 12% and 33% indicating early diagenetic conditions according to Merriman and Frey (1999). Samples from the Agha Jari Fm. display mixed layer I-S with a lower amount of expandable layers (hence higher illite content) with illitic layers ranging from 30 to 40%. These latter data are probably related to detrital inputs and therefore their conversion into paleo-temperatures is overestimated. This Formation shows also mixed layer chlorite-smectite with a chlorite content of 55%. The Pabdeh and Gurpi Fms are characterized by R0 I-S structures with an illite content of 50%.

Apart the overestimated thermal maturity of the Agha Jari Fm due to detrital phases, a slight increase of the illite content in mixed layer I-S as a function of stratigraphic age is observed in the surroundings of the Kuh-e-Asmari anticline which is compatible with early diagenesis conditions, only the Kazdhumi Fm. reveals short-range ordered mixed layer I-S (R1) with an illite content of 77% suggesting deep diagenesis.

In the Sim anticline identified mixed layer I-S from the Oligocene-Miocene lithologies are disordered (R0) structures with an illite content between 28% and 52% indicating early diagenetic conditions according to Merriman and Frey (1999).

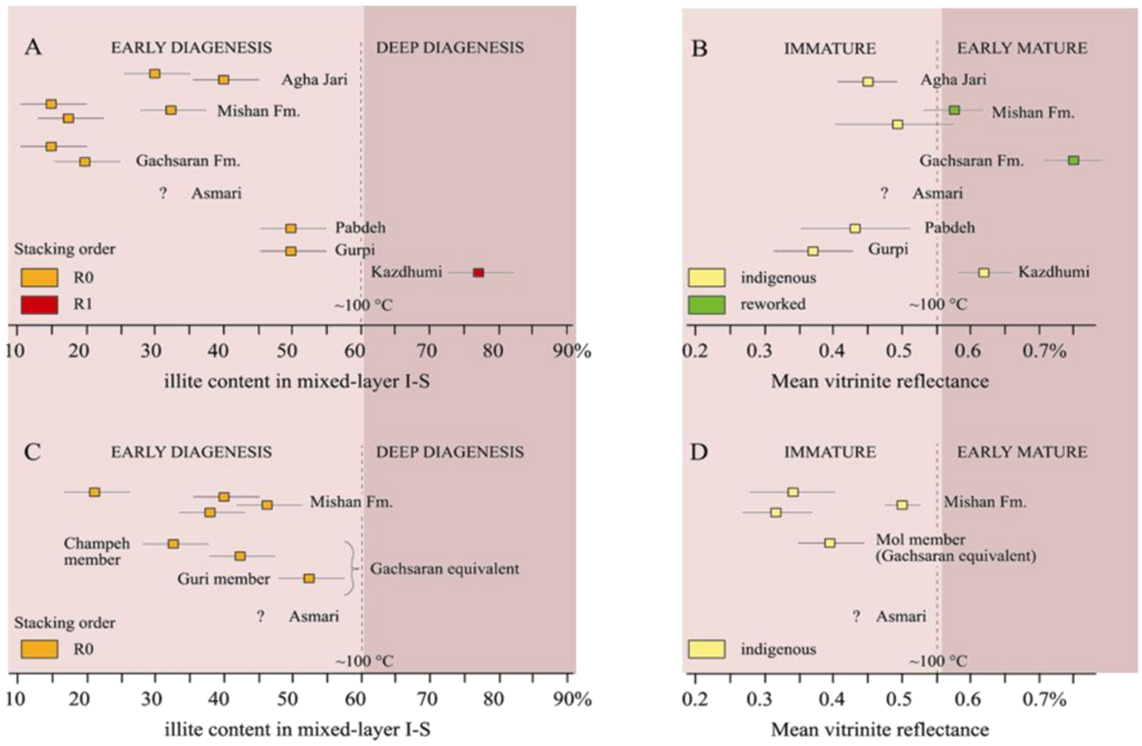

Fig. 1. *Synoptic view of inorganic and organic indicators of thermal exposure in the Kuh-e Asmari anticline (A-B) and Sim anticline (C-D). In detail, to the left: illite percentage and stacking order in illite-smectite mixed layers in the less than 2 μm fraction of sediments; to the right: vitrinite reflectance and equivalent values from bitumen in dispersed organic matter.*

Conclusions

From laboratory analyses on both organic and inorganic fraction of lithostratigraphic units in the area of the Kuh-e Asmari and Sim anticlines, it can be preliminary concluded that in the two structures, showing similar dimensions and shape, the top of the Asmari Fm in the area of the Kuh-e-Asmari anticline was buried at slightly shallower depths and at lower temperatures than in the Sim anticline. This evidence is inferred from modelling of organic and inorganic thermal indicators and may be accounted among the factors that controlled fracture spacing in the two anticlines (see Carminati et al.'s abstract).

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