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SAPIENZA
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DOTTORATO DI RICERCA
IN SCIENZE DELLA TERRA

Research topic: Burial evolution of sedimentary successions in Lorestan, NW of Zagros Folded Belt, Iran

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Introduction

Amounts and rates of orogenic shortening and tectonic exhumation is a key issue in the study of Lorestan region. To better understanding of this is re-construction of the crustal thickening that any shortening implies. In this case, the thermal evolution of sedimentary rocks is widely used to obtain a quantitative assessment of the tectonic loading that has been partially or totally eroded. These data can be integrated in the structural and stratigraphic modelling of the chain evolution, thereby also reducing the risks in hydrocarbon exploration.

Burial exhumation history of sedimentary successions are inherently integrated when they are deduced from paleotemperature proxies as burial and exhumation magnitudes depend strongly on the paleogeothermal field, which evolves temporally during orogenesis. Information on thermal evolution of

Sedimentary successions in Lorestan region can be provided by techniques such as organic matter petrography and X-ray diffraction of clay minerals. All these techniques allow quantifying the maximum burial of the rocks underwent (Pollastro, 1990); (Mählmann, 2001). These kinds of information are important in oil exploration studies because they provide insights on source rock thermal maturity (Aldega et al., 2014). In particular, I focused on clay- and organic-rich lithologies in order to assess source rock potential. Vitrinite reflectance and illite content in mixed layer illite-smectite (I-S) are useful to reconstruct the thickness of eroded sedimentary or tectonic overburden.

1. mixed layer illite-smectite (I-S)

X-ray diffraction analyses have been done on **< 2µm** grain-size fraction for 20 samples of Huleylan well. These samples are belonging to Garau Formation with shaly limeston lithology and mainly minerals are quarz, calcite, phyrophilite. The results of 8 of them were good. The percentages of Illite in Illite-Smectite mixed layer in all samples are determined. In the samples of 665 and 722 meters depth indicates R1 that a smectite layer is followed by an illite layer and that the order of stacking of layers appears in the interstratification sequence that occur in the temperature range of about 100^0–110^0C and the lower depth can be seen ordered R3 long-range order and that each smectite layer is surrounded by at least three Illite layers on each side occur in the temperature range of about 170^0–180^0C and the minimum heating duration of 2 milion years is generally required. With XRD we can study the illite content in mixed layer illite-smectite (I-S) that are also useful to reconstruct the thickness of eroded sedimentary or tectonic overburden (Moore & Reynolds, 1989). Low content of illite in mixed layer illite-smectite means early diagenesis and low level of maturity. Illite rich composition indicates deep diagenesis. It can be seen that temperature-dependent clay minerals show an incresing of iilite layers in mixed layers I-S as function of stratigraphy age.

X-ray diffraction semiquantitative < 2μm grain-size for the Huleylan well							
Sample	Depth (m)	Formation	XRD analysis < 2μm	I % in I-S	R parameter	Δ2θ	Non clay mineral
HN 2150	655.32	Garau	I_{75} I-S_{26}	75	1	7.6	calcite+qtz+halite
HN 2370	722.37	Garau	I_{84} I-S_{16}	77	1	7/76	calcite+qtz
HN 2630	801.62	Garau	I_{90} I-S_{10}	80	3	7.92	calcite+qtz+halite
HN 2785	848.86	Garau	I_{57} I-S_{31}	80	3	7.84	calcite+quz+halite
HN 2890	880	Garau	I_{17} I-S_{35} kao $_{48}$	82	3	7.89	calcite+qtz
HN 3070	935.73	Garau	I_{14} I-S_{26} kao $_{60}$	77	R1/R3	7.75	calcite+qtz
HN 3450	1051.56	Garau	Pif $_7$ I_{12} I-S_{16} kao $_{64}$	88	3	7.8	Qtz+Calcite
HN 3550	1082.04	Garau	Pif $_5$ I_7 I-S_{15} kao $_{72}$	90	3	7.74	Qtz+Calcite

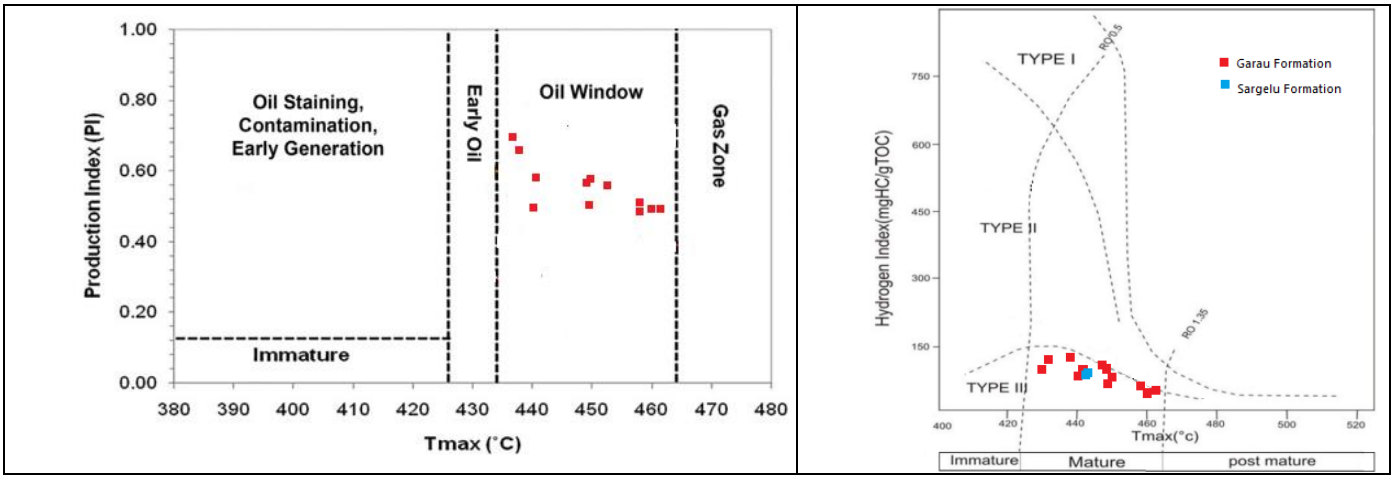
2. Organic matter optical analysis

Vitrinite reflectance (VR_O %) is an optical parameter for describing the degree of thermal maturity of organic matter. On each sample of Huleylan well was performed vitrinite or bitumen unaltered fragments. Mean reflectance values (R_o for vitrinite and Rb for bitumen) were calculated from the arithmetic mean of these measurements. Rb values were converted into vitrinite equivalent reflectance data (Ro_{eq}) using Jacob's equation:

$Rb = Ro_{eq} \times 0.618 + 0.40$

Vitrinite reflectance measurement for the Huleylan well								
Depth (m)	lithology	Formation	Bitumen reflectance (R_{obit}%)	STDEV	R_{oeq}%+s.d.	Jacob, 1989 (R_{oeq}%)[a]	Landis and Castano , 1994 (R_{oeq}%)[b]	Schoenherr et al., 2007 (R_{oeq}%)[c]
477	limestone	Garau	0.446	0.111	0.577	0.675	0.776	0.657
621.79	limestone	Garau	0.489	0.102	0.542	0.702	0.815	0.698
722.37	Limestone shaly	Garau	0.489	0.074	0.576	0.702	0.815	0.698
848.86	limestone	Garau	0.610	0.077	0.641	0.777	0.926	0.814
880	limestone	Garau	0.420	0.076	0.708	0.659	0.752	0.633
935.73	limestone	Garau	0.650	0.076	0.881	0.840	1.020	0.911
1167.38	limestone	Gotnia	0.757	0.065	1.062	0.867	1.061	0.954

The values between 0.5and 1.2 show the potential of producing of oil and in this samples we see the range of oil window. In Huleylan well samples contain organic macerals as vitrinite and bitumen. This shows the mature stage of hydrocarbon generation. Fourteen samples from Huleylan well were provided by NIOC (National Iranian Oil Company) for Rock-Eval pyrolysis and total organic carbon (TOC) investigations. Samples were taken from Garau and Sargelu Formations (two main source rocks) with cretaceous and Jurassic age. Platting of all value on the chart shows the oil window and type III kerogen.

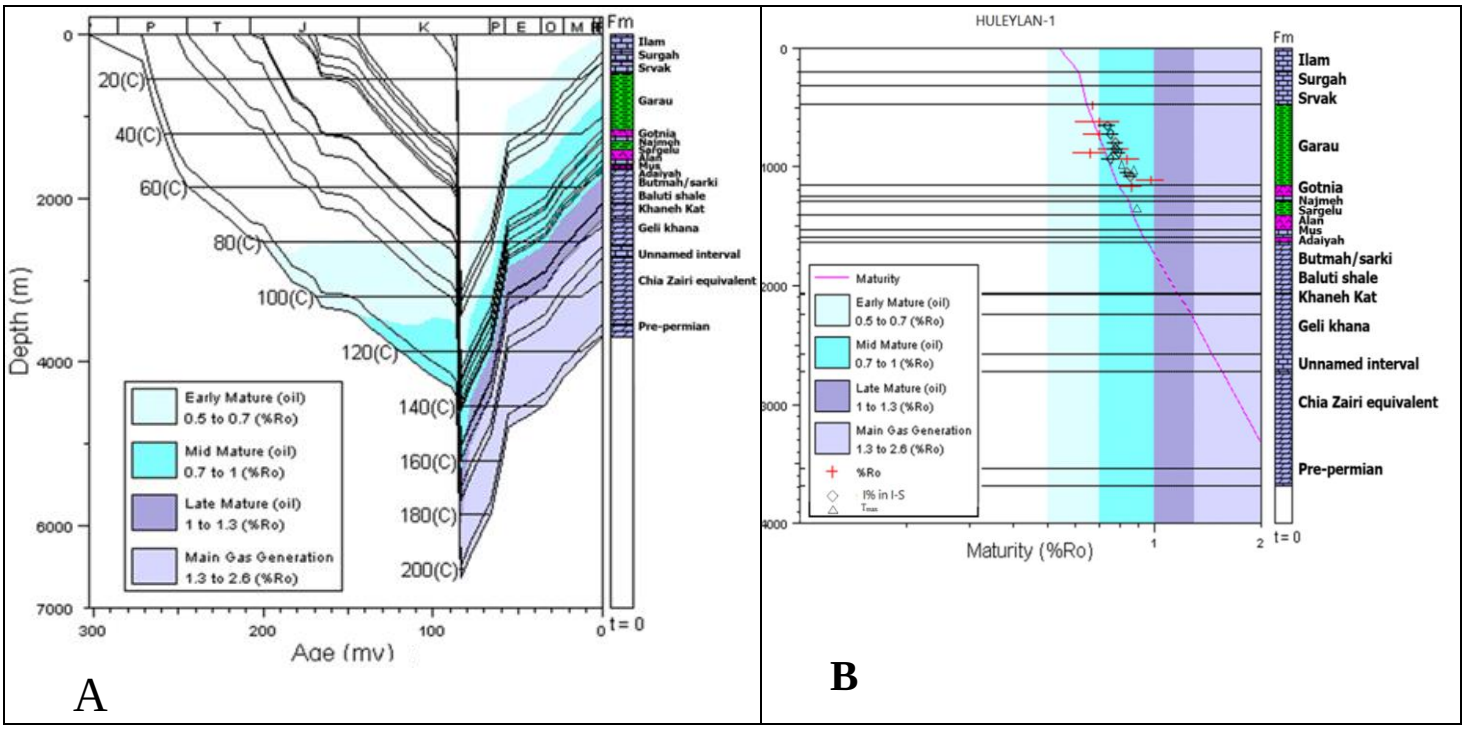


Plot of Production index (PI) versus pyrolysis T_{max} (Al-Ameri and Zumberge, 2012)	Plot of hydrogen index (HI) versus pyrolysis T_{max} (Tissot & Welete 1984)

3. Thermal modeling

Inorganic and organic thermal parameters were used as thermal constraints for reconstructing the burial evolution of the Huleylan well by using Basin-Mod1 software. The stratigraphy of well contains from Ilam Formation in the top and pre-Permian Formation in deep. Geothermal gradient in this area is 30^0C/km. In figure A burial history for Hulaylan well indicate that maximum burial in cretaceous time to depth of 6 km that temperature increases until 200 ^{0}C and stopped in late cretaceous and after this period it starts to exhume . Maximum burial of the Garau Formation is 4.2 km with 130 ^{0}c.

Respect to geology map of this area we can see that the Amian , Tale-zang, Kashkan, Asmari and Razak Formations were eroded in upper part of Ilam and also upper part of Ilam Formation indicates erosion. Eroded part is approximately 3 kilometers. Figure B shows present-day maturity data plotted against calculated maturity curve. As it can be seen the maturity value of samples has best fit with curve and they are in early and mid-maturity level. I prepared 12 samples from Jurassic to pre-Permian to understand if the modeled present day maturity curve may intercept them.



Lab activity

Optical analysis of organic matter for determining vitrinite reflectance

X-ray diffraction of clay minerals

Thermal modelling by using 1D software (Basin Mod 1D)

Also I did X-ray diffraction measurement for 38 samples for Mahidasht well, 11 samples for Baba Ghir well, 20 samples of Bankul well, 18 samples for Darreh Baneh well,5 samples for Shah abad shomali, 10 samples for Samand well, 8 samples for Kabir kuh and 8 samples for Tange haft outcrops that after finishing vitrinite reflectance analysis I will do modeling all of them.