A NEW ANALYTICAL METHOD FOR CHARACTERIZATION OF FRACTURED RESERVOIRS

ZOHREH MOVAHED

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Specially dedicated to *my mother*

I really miss you

Al-Fatihah

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ABSTRACT

Structural delineation is the main issue in the evaluation of carbonate reservoirs in structurally complex areas. Permeability is a critical reservoir parameter that influences well and/or reservoir performance and it is even more challenging when the reservoir is fractured. Oil Based Mud Micro Imager - resistivity of invading zone (OBMI-Rxo) is a high resolution curve that is sensitive to fluid mobility near the borehole wall and indicates invasion. However most operators are not using an accurate Rxo curve of OBMI for reservoir and petrophysical applications. After drilling it is important that the borehole stays in good shape, morevere, borehole instability will reduce the working life of the well. The main aim of this study is to design a workflow in order to establish an advanced formation evaluation in a carbonate fractured and clastic reservoirs. The entire workflow involved incorporating borehole images, petrophysical logs, Modular Formation Dynamics Tester tool (MDT), Xpress Pressure Tool (XPT) and cores in characterizing fractured and non-fractured reservoirs. Image log data are processed and interpreted in the computer using a Geoframe software. The bedding, deviation survey and image logs are imported into the Bortex software and the heterogeneity analysis of reservoirs from borehole images is computed based on the same resistivity contrast principle than the layer delineation. Respectively, the Formation Micro Imager (FMI) and OBMI images are used to examine permeability and index mobility in conjunction with open hole logs. As a result, the answers provided by the FMI tool helped in understanding the reservoir structure, identify and evaluate fractures, visualize the rock texture, and complement coring programs. Single-well permeability distribution was demonstrated by the use of advanced image analysis. OBMI-Rxo helped to identify zones of higher permeability when combined with conventional induction logs and porosity logs. In addition, working on advanced borehole shape analysis improved information about the well condition.

ABSTRAK

Struktur delineasi menjadi isu yang utama untuk penilaian reservoir karbonat di kawasan berstruktur rencam. Ketertelapan merupakan parameter reservoir kritikal yang dapat mempengaruhi pelakuan telaga dan/atau reservoir dan ianya didapati lebih mencabar apabila reservoir mempunyai rekahan. Pengimbas Mikro Lumpur Dasar Minyak – kerintangan zon serbuan (OBMI-Rxo) adalah lengkuk beresolusi tinggi yang sensitif kepada pergerakan bendalir berhampiran dinding lubang telaga dan yang menunjukkan penyerbuan, kebanyakan operator didapati tidak menggunakan lengkuk OBMI-Rxo dengan betul pada reservoir dan bagi aplikasi petrofizik. Selepas penggerudian dijalankan, adalah penting untuk memastikan lubang telaga dalam bentuk yang baik. Tambahan pula, ketidakstabilan lubang telaga akan mengurangkan jangka hayat telaga tersebut. Tujuan utama kajian ini adalah untuk merekabentuk carta alir kerja tetap bagi penilaian formasi lanjutan untuk reservoir karbonat rekah dan juga klastik. Secara keseluruhannya, carta alir kerja ini untuk tujuan pencirian reservoir rekah dan bukan rekah adalah merangkupi imej lubang telaga, log petrofizik, ‘modular formation dynamics tester tool’, ‘Xpress pressure tool’ dan teras. Data log imej diproses dan diterjemah dengan menggunakan komputer dengan perisian ‘Geoframe’. Data dari lapisan, survei deviasi dan imej log diimport ke dalam perisian ‘Bortex’ dan kemudiannya pengiraan analisis keheterogenan reservoir daripada imej lubang telaga dilakukan berdasar kepada prinsip perbezaan kesamaan resistiviti berbanding deliniasi lapisan. Berkaitan log lubang telaga terbuka, pengimbas mikro formasi (FMI) diguna untuk menilai ketertelapan, manakala imej OBMI diguna untuk menilai indeks mobiliti. Sebagai kesimpulan, hasil yang diberi oleh alatan FMI didapati dapat membantu dalam penelitian struktur reservoir, mengecam dan menilai rekahan, memapar tekstur batuan, dan pelengkapan program penerasan. Taburan ketertelapan telaga tunggal telah dipapar dengan menggunakan analisis imej lanjutan. OBMI-Rxo membantu untuk mengenal zon ketertelapan tinggi apabila ianya digabungkan dengan log induksi konvensional dan log keliangan. Berkaitan kestabilan lubang telaga, kajian ini juga didapati dapat menambah baik maklumat tentang keadaan telaga apabila dijalankan analisis lanjutan bentuk lubang telaga.

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LIST OF ABBREVIATION

BS	-	Bit Size
C1	-	Caliper Pair 1-3
C2	-	Caliper Pair 2-4
CGR	-	Gamma Ray (Corrected)
CKH	-	Core Horizontal Permeability
COND.CONNECTED.SP	-	Conductive Connected Spots
COND.PATCHES	-	Conductive Patches
COND.ISOLATED.SPOT	-	Conductive Isolated Spots
CPOR	-	Core Porosity
CS	-	Cable Speed
DEVI	-	Borehole Deviation Angle (deg)
DYNAMIC	-	Sliding Window Normalization
EMEX	-	Measurement Control Voltage
FMI	-	Full bore Formation Micro Imager Tool
FRACTURE APERTURE	-	Aperture of Fractures
FARCTURE DENSITY	-	Number of Fractures Per Meter
FRACTURE POROSITY	-	Porosity of Fractures
GEOLOG	-	Geological Lithozones
GPIT	-	General Purpose Inclinometry Tool
HAZI	-	Borehole Deviation Azimuth (deg)
HC BEDDING	-	High Confidence Bedding
HDRS	-	Deep Resistivity
HGR	-	Gamma Ray
HMRS	-	Shallow Resistivity
ILD	-	Deep Resistivity (Deep Induction)
ILM	-	Shallow Resistivity (Shallow Induction)
LQC	-	Log Quality Control

LC BEDDING	-	Low Confidence Bedding
MDT	-	Modular Formation Dynamics Tester Tool
NPHI	-	Neutron Porosity
OBMI	-	Oil Base Mud Imager
P1AZI	-	Pad 1 Azimuth (deg)
PE	-	Photoelectric Factor
PEFZ	-	Photoelectric Factor
PERM	-	Permeability from FMS
PERM.INDEX	-	Raw FMI Permeability Indicator (Mobility)
PEX	-	Platform Express
PHIS	-	Secondary Porosity
PHIT_FMI	-	Average High-resolution Porosity from FMI
PIGE	-	Shale Corrected Log Porosity
POR_HIST	-	Porosity Histogram
PP	-	Pad Pressure
RES.SOPTS	-	Resistive Spots
PES.PATCHES	-	Resistive Patches
RHOZ	-	Formation Density
RLA3	-	Shallow Resistivity
RLA5	-	Deep Resistivity
SPOR	-	Secondary Porosity from FMI
STATIC	-	Fixed Window Normalization
TENS	-	Tension
TNPH	-	Porosity from Neutron Log
UBI	-	Ultrasonic Borehole Imager tool
WALL	-	Borehole Wall
XPT	-	Xpress Pressure Tool

LIST OF SYMBOLS

Symbol		**Dip Classification**
	-	High Confidence Bedding
	-	Low Confidence Bedding
	-	High Confidence OBMI Bedding
	-	Low Confidence OBMI Bedding
	-	High Confidence UBI Bedding
	-	Low Confidence UBI Bedding
	-	Minor Open fractures
	-	Major open fractures
	-	Medium open fractures
	-	Closed fracture
	-	Continuous open fractures
	-	Discontinuous open fractures
	-	Fault

CHAPTER 1

INTRODUCTION

1.1 Introduction

Outcrop study of the target formations/ reservoirs have a great importance to understand the possible geological (structural and sedimentological) and reservoir characteristics of the reservoir. These features are studied at different scales to determine their lateral and vertical extent and distribution. This is mainly achieved by various technologies, such as, Brunton compasses/Inclinometers, topographic maps, aerial photographs, and satellite images. A similar approach is needed for delineating and characterizing the reservoirs in the subsurface. The large scale subsurface features are delineated with the surface seismic (2D and 3D) techniques. However, the coarse resolution (generally greater than 10 m) of these techniques does not allow for feature identification of smaller scales (for instance, cross bedding, bedding, fractures, and vugs/moulds) that are very useful for detailed characterization of reservoir rocks.

Borehole images are very useful in cases where information on geological (structural and sedimentological) and reservoir features are required. Structural dip by definition is the present day formation dip used to build the structural cross section. It is also a record of the post-depositional structural alteration and may indicate the tectonic history of the sequence. It is not an average dip for all the bedding planes. Apart from structural analysis, the investigation of fractures is the main application for image logs in Dezful Embayment, Iran. Information on fractures is important to know because of their higher permeability, hence their biggest influence on reservoir producibility. Schlumberger provides high quality borehole images in wells drilled with all types of mud; water based mud and oil based mud. These images can be acquired in wells of all geometries ranging in deviation from 0.0 degrees to more than 90 degrees. It is now possible to get resistivity of the invaded zone (Rxo) in the wells drilled with oil-base mud using the state-of-the-art imaging tool called the Oil Base Mud Imager (OBMI) (Schlumberger, 2005). By using advanced interpretation, it can compute permeability from the borehole images in carbonates.

This study highlights the importance of data integration and borehole images in the domains of geology, petrophysics, geomechanics/drilling, reservoir and production engineering in different oil fields of National Iranian South Oil Company (NISOC). Borehole images logged in Asmari and Sarvak reservoirs from the NISOC fields like Lali, Gachsaran, Marun, Mansuri and Pazanan are discussed (Figure **1.1**).

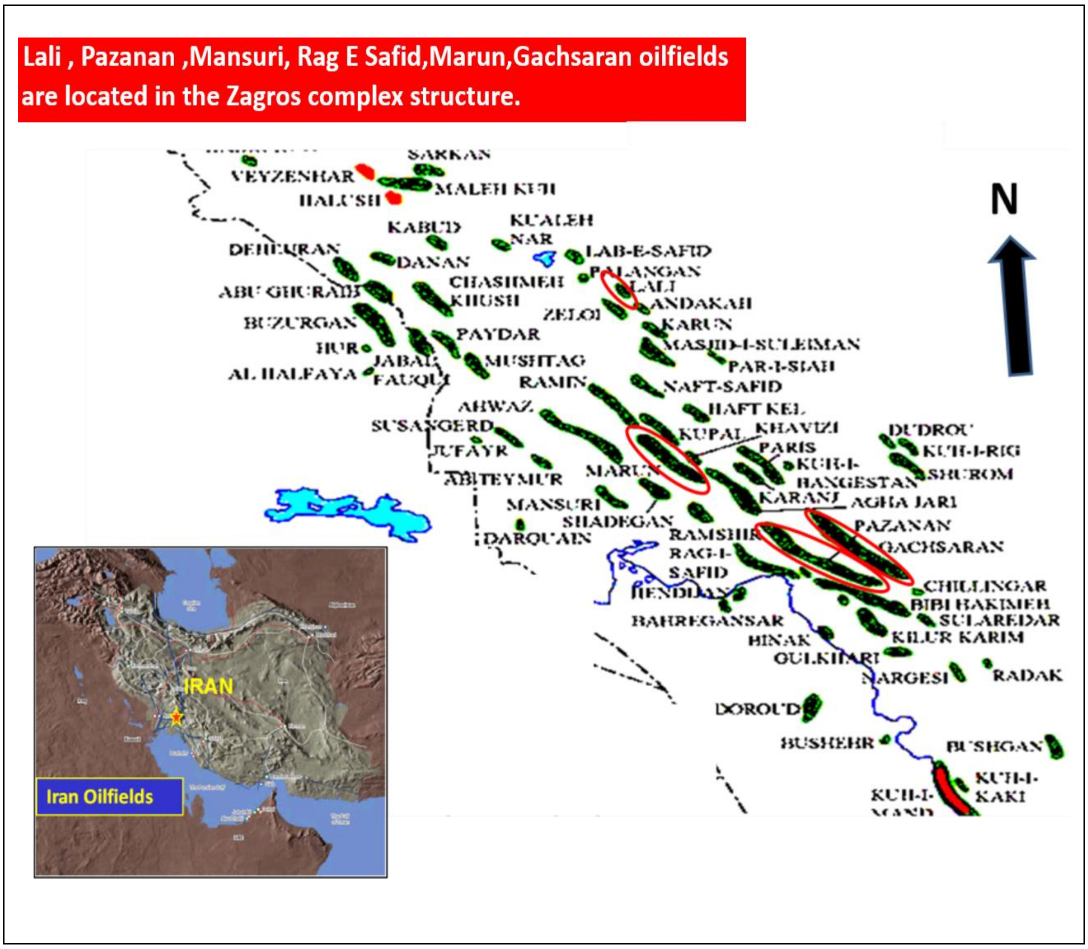

Figure 1.1 Studied oilfields (red colored) in Dezful embayment.

The Asmari formation consists of limestones, dolomitic limestone, argillaceous limestone, and anhydrite and the lithology of Sarvak formation is limestone and it lies below Ilam reservoir (Motiei, 1993) (Figure **1.2**). Our research establishes a technique to increase the reservoir explanation of the Asmari and Sarvak reservoir by using a new application of image logs.

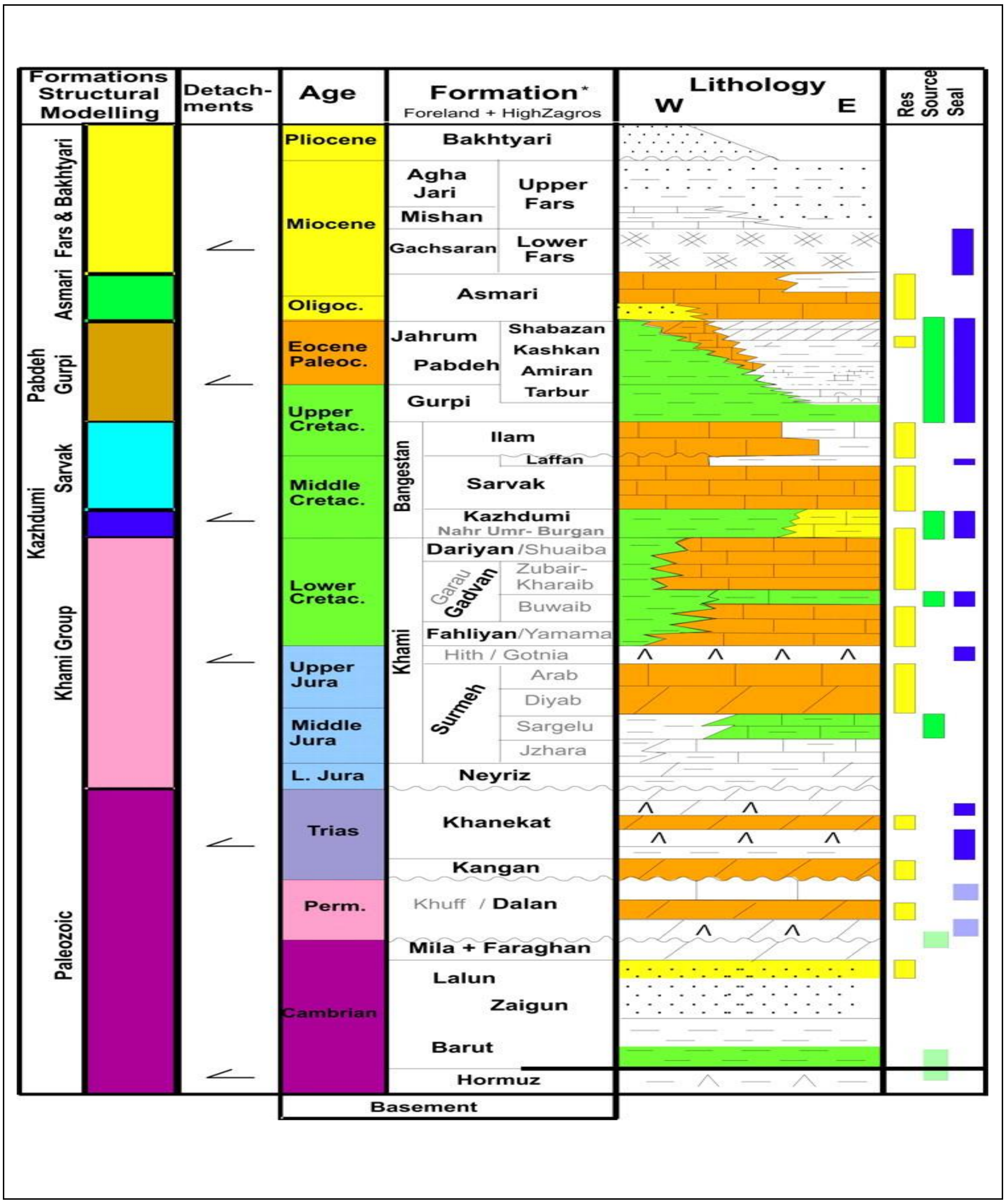

Figure 1.2 Asmari and Sarvak reservoirs in Iran (Bosold et al., 2005).

1.2 Problem Statement

The crossing Asmari reservoir is not so easy in some cases due to structural complexities, where there is a thick pile of evaporates of Gachsaran formation over the reservoir. In some wells, higher than the expected thickness of formations is found. Dip classification based on a geological log has the advantage of providing a direct representation of structural origin and identify Asmari fault and fracture systems and its influence on production and resolve structural complexity.

Fracture intensity and deep rooted fractures extensively increase risk of unexpected water production. So, it is vital to know, whether reservoir is fractured or not. If it is fractured then what is the kind of fractures (open or closed) and what is their intensity? Do they occur as a single set or multiple sets and what orientation is their dominant strike? Solutions to questions like these support geologists and reservoir engineers increase oil production (Movahed et al., 2014) and in this study the borehole imaging tools, like the Formation Micro Imager (FMI), Oil Base Mud Imager - Ultrasonic Borehole Imager (OBMI-UBI) are interpreted to find solutions for fracture systems and fracture attributes.

Permeability analysis of dual porosity systems with heterogeneous distribution of dissolution fabrics can evaluate by using the FMI, but NISOC is not using permeability from FMI in a case when there are no any formation testing data in the well for fracture and reservoir modeling. In this study, image logs provided the most representative measurements in geological and petrophysical heterogeneous formations and present a method to measure permeability from FMI in Asmari and Sarvak reservoirs.

OBMI-Rxo is a high resolution curve that is sensitive to fluid mobility near to the borehole wall and which indicates invasion and indirectly lithology, but NISOC is not using an accurate Rxo curve of OBMI for reservoir and petrophysical application. This method using resistivity classes is used to show how the high resolution OBMI curves can be used. The result of this research demonstrates the new analytical method to evaluate a fractured carbonate and clastic reservoirs from Iran.

The most wells drilled in Iran suffer from geomechanical hazards owing to the high in–situ stress related to the proximity of the Zagros Mountain and it is not always possible to acquire wireline log data because of the borehole condition (Movahed et al., 2014). In this study, advanced borehole shape analysis by using FMI and UBI helped regarding borehole instability and improved information about the well condition.

1.3 Objectives of the Research

The objectives of the research are given below:

1. To develop an accurate structural model for Asmari reservoir.
2. To characterize fractures in the borehole.
3. To compute reliable index mobility from OBMI and index permeability from FMI.
4. To evaluate the borehole condition in order to reduce drilling risk and avoid potential well bore damages.

1.4 Scopes of the Research

Borehole images were integrated with other data (petrophysical, reservoir, and geophysical) to understand the various characteristics of the Asmari both in oil based mud and water based mud systems. In this study, borehole images are used to solve different issues in geology, petrophysics, reservoir engineering, production engineering, sedimentology, geomechanic and drilling in NISOC oil fields that is explained in the following:

1. Image log data are processed for a number of factors that may affect the quality of the images in Geoframe. Such factors include: variation in speed of the tool relative to the drill-pipes, or cable speed; sticking of the tool. Additionally, image logs are equalized and normalized to improve the information of features in it. Interpretation typically started with hand picking dips using sinusoid techniques on image log presented at 1:20 or 1:10 scale so that the geological features are easily visualized. Once dips have been picked they have to be classified into bed boundaries and fractures.
2. Interpreting structural dip resolved structural complexity, thus provided the exact location of the well in the Asmari reservoir, which could not reach the lower contact of Asmari by interpreting FMI images and petrophysical logs in wells LL-26.
3. The structural dip from PZ-126 was used as input for permeability analysis and it was imported into the Bortex module and computed reservoir heterogeneity from FMI used to extract heterogeneities and layer details from images. In addition to formation heterogeneities, the software also calculated index permeability of the reservoir. Fracture properties (open or closed), occurrence, orientation, spacing, and porosity were interpreted by using Image log and imported as indirect input for permeability analysis.
4. The OBMI structural dip data is imported into the Bortex software in the MN-322.OBMI tool was used to identify zones of higher permeability when combined with conventional induction logs and porosity logs. Separation between Rxo curves (one from each of four OBMI pads) and induction logs, due to invasion of oil in the mud, indicated higher permeability.
5. The borehole cross sections are interpreted to give a very detailed account of the in-situ stress conditions by using UBI.

REFERENCES

Aadnoy, B. and Bell, S. (1998). Classification of Drilling-Induced Fractures and Their Relationship to In-Situ Stress Directions. The Log Analyst, v. 39, no. 6, November-December, pp. 27-42.

Akbar, M. (1993). Finding Fractures in Tight Reservoirs. Schlumberger.

Akbar, M., Petricola, M., and Watfa, M. (1994). Classic Interpretation Problems: Evaluating Carbonates. Oilfield Review, Vol. 7, no. 1, pp. 38-57.

Akbar, M. and Sapru, A. (1994). In-Situ Stresses in the Subsurface of Arabian Peninsula and their Effect on Fracture Morphology and Permeability.6th ADIPEC, ADSPE 99, Abu Dhabi, U.A.E.

Akbar, M. , Petricola, M.,Watfa, M., Badri, M., Charara, M., Boyd, A.,Cassell, B. (2001). Porosity Analysis from FMI, Schlumberger.

Alavi, M. (2004). Regional Stratigraphy of the Zagros Fold-thrust belt of Iran. American Journal of Science, Vol.304, pp. 1-20.

Bell J.S. (1990). Investigating Stress Regimes in Sedimentary Basins Using Information from Oil Industry Wireline Logs and Drilling Records. Geological Applications of Wireline Logs, Geological Society Special Publication No. 48, London, pp. 305-325.

Borbas, T., Wendt, B., Jacques, R., Tabanou, J.R., Cheung, P., Liu, C. B., Hansen, S., Lavigne, J., Omeragic, D. and Pickens, T. (2002). Thinly Laminated Reservoir Evaluation in Oil-Base Mud: High Resolution Versus Bulk Anisotropy Measurement, a Comprehensive Evaluation. SPWLA 43rd Annual Logging Symposium. 2-5June. Paris, France.

Bosold, A., Schwarzhans, W., Julapour, A., Ashrafzadeh, A.R.and Ehsani ,S.M. (2005). The structural geology of the High Central Zagros revisited (Iran), RWE Dea AG, Ueberseering 40, D-22297 Hamburg.

Bram, K., Harjes, H. P., Dürbaum, H. J., Gebrande, H., Gebrande, H., Hirschmann, G. , Janik, M., Klöckner, M., Lüschen, E., Rabbel, W., Simon, M., Thomas, R., Tormann, J., and Wenzel, F. (1995). Origin and Nature of Crystal Reflections. Results from Integrated Seismic Measurements at the KTB Superdeep Drilling Site.

Bratton, T.,Canh, DV.,Van Que, N., Duc, NV., and Gillespie, P. (2006). Naturally Fractured Reservoirs, Oilfield, Schlumberger.

Cheung, P., and Laronga, R. (2001). Field Test Results of a New Oil-Based Mud Formation Imager Tool. Transaction of the SPWLA 42nd annual logging symposium, Houston, Texas.

Cheung, P. , and Laronga, R. (2002). Oilfield Review. Schlumberger.

Costain, J. K., and Çoruh, C. (1989). Tectonic Setting of Triassic half-grabens in the Appalachians. Seismic data acquisition, processing, and results: American Association of Petroleum Geologists Memoir 46, p. 155-174.

Cox, J. W. (1983). Long-Axis Orientation in Elongated Boreholes and its Correlation with Rock Stress data. Transactions of the SPWLA 24th Annual Logging Symposium, Calgary, Canada.

Dauod, M. (2010). Advanced Field Scale Modeling. Schlumberger.

Daungkaew S., Fujisawa, G.,Chokthanyawat, S.,Comrie-Smith, N.,and Thaitong, T. (2012). Is there a better way to determine the viscosity in waxy crudes? SPE Asia Pacific Oil and Gas Conference and Exhibition, APOGCE.

Haller, D., and Porturas, F. (1998). How to Characterize Fractures in Reservoirs Using Borehole and Core Images. Case Studies. Geological society, vol. 136. Special Publications, London, pp. 249 259.

Jacques, W. (2010). The Handbook of Groundwater Engineering, Second Edition. Taylor & Francis. p. 7 in chapter 2. ISBN 978-0-8493-4316-2.

Jeffreys, P. (2005). Hole shape and In-situ stress from Geological Images from Iran. Schlumberger

Khoshbakht. F., Memarian, H., and Mohammadnia, M. (2009). Comparison of Asmari, Pabdeh and Gurpi formation's fractures derived from image log. Journal of Petroleum Science and Engineering 65 -74.

Lehne, K.A. and Aadnoy, B. (1992). Quantitative Analysis of Stress Regimes and Fractures of Logs and Drilling Records of a North Sea Chalk Field. The Log Analyst, pp. 351-361.

Ma, T. A. (1993). Natural and Induced fracture, classification using image analysis. Viewed 8 of February 2012 <www.onepetro.org>

Mitra, S. (2002). Fold Accommodation Faults. AAPG Bulletin, v. 86, no. 4, pp. 671-693.

Motiei, H. (1993). Stratigraphy of Zagros in Hushmandzadeh. Treatise on the Geology of Iran: Tehran, Geological Survey of Iran, 536 p.

Motiei, H. (1995). Petroleum Geology of Zagros. Geological Survey of Iran with cooperation of Deputy Ministry of project and planning, no. 25.

Movahed, Z., Junin, R., Safarkhanlou, Z., and Akbar, M. (2014). Formation Evaluation in Dezful Embayment of Iran using oil-based-mud Imaging Techniques, Journal of Petroleum Science and Engineering121 (2014)23–37 37.

Movahed, Z., Junin, R., and Jeffreys, P. (2014). Evaluate the Borehole Condition to Reduce Drilling Risk and Avoid Potential Well bore Damages by using Image Logs, Journal of Petroleum Science and Engineering122 (2014)318-330.

Mount, V.S. and Suppe, J. (1987). State of Stress near the San Andreas Fault: Implications for Wrench Tectonics. Geology, 15, pp. 1143-1146.

Nimmagadda, Shastri, Dreher and Heinz (2010). Ontology based Warehouse Modeling of Fractured Reservoir Ecosystems For an Effective Borehole and Petroleum Production Management. P 490 - 496

N.I.S.O.C, Statoil and RIPI (2003). Sedimentology and Stratigraphy and Reservoir Quality of the Asmari formation in the Marun field.

Nelson, R. A. (2001). Geologic Analysis of Naturally Fractured Reservoirs. Houston, Texas: Gulf publishing company. Pp. 322.

Newberry, B. M., Grace, L. M. and Stief, D. (1996). Analysis of Carbonate Dual Porosity Systems from Borehole Electrical Images.

Park, R. G. (2005). Foundation of Structural Geology (reprint of the 1997 Chapman and Hall edition) Routledge, Abingdon, England, page 9, ISBN 978-0-7487-5802-9.

Prensky. S. E. (1999). Advanced in Borehole Imaging technology application.

Rezaeei, M.R. (2006). The book of petroleum Geology, alavi propagation; 472p.

Richards, J., Wilkinson, D. and Ullrich,T. (2006). Geology of the Sari Gunay Epithermal Gold,Department of Earth and Atmospheric Sciences, doi: 10.2113/gsecongeo. 101.8.1455 *Economic Geology* December 2006 vol. 101 no. 8 1455-1496

Russell, S. D., Akbar, M., Vissapragada, B. and Walkden, G. (2002). Rock types and permeability prediction from dip meter and image logs. AAPG Bulletin, 86 (10), 1709-1732.

Sadler, R (2002). Integrated characterization of fractures and faults of the Shu'aiba reservoir, Shaybah field, AJGS, v. 7, no. 2, p. 291-292.

Sahin, A. and Ali, A. Z. (2011). Comparison of patterns of permeability anisotropy distributions in Jurassic and Cretaceous carbonate reservoirs, AJGS, v. 16, no. 2, p. 209-210.

Schlumberger (1999). Borehole Image Measurements. Schlumberger documents.

Schlumberger (2002). UBI- Advanced borehole imaging independent of mud type, SMP-5871.

Schlumberger (2005). Stratigraphy and Geology of Iran, Reservoir Symposium.

Sembiring, P., Bashir, N., and Danardatu, H. (2005). Oil Based Mud Micro Imager (OBMI) Application in Sangatta Field. SPE-92779-MS, SPE Asia Pacific Oil and Gas Conference and Exhibition, 5-7 April.

Sepehr, M. (2004). The Structural Framework of the Zagros Fold–Thrust Belt, Iran, DOI: 10.1016/ j. marpetgeo.

Shang, R. , Tang, D. (2005). Fracture Pattern and Associated Aperture Distribution: Example from The Foothills, SPWLA, Paper AA.

Shariatinia, Z., Haghighi, M. ,Feiznia, S., Hall, D., Levresse, G.,Dehghani, A. , and Rashidi, M. (2013). Paleofluid analysis from fracture-fill cements in the Asmari limestones of the Kuh-I-Mond field, SW Zagros, Iran, Arabian Journal of Geosciences, 2013: 6 (7):2539-2556, Springer, ISSN: 1866-7511.

Shawky, I. (2006). Application of Most Recent Borehole Geophysical Logging for Aquifer Characterization, Proceedings of the 5th International Symposium on Management of Aquifer Recharge, Berlin, Germany, 11-16 June 2005, UNESCO, Paris, p. 467-473.

Soliman, Osama M., Saad Aba, A.,and Bader, A. (2010). Tectonic and Climatic Controls of Post Glacial Terminal Fluvial Systems, Permian Unayzah Reservoir.

Sorkhabi, R. (2014). How Much Oil in the Middle East? Vol. 11, No. 1 – 2014.

Stocklin, J. (1968). Structural History and Tectonics of Iran. AAPG, Bull.52, pp. 509-526.

Stroble, R. (2009). The Value of Dipmeter and Borehole Images in oil sands Deposit. A Canadian Study.

Szabo, F. and Kheradpir, A. (1978). Permian and Triassic stratigraphy, Zagros Basin, South West Iran. Journal of Petroleum Geology, 1,2, pp. 57-82.

Tatar, M., Hatzfeld, D., and Ghafory-Ashtiany, M. (2004). Tectonics of the Central Zagros (Iran) deduced from micro-earthquake seismicity, Geophysical Journal International, v. 156, pp. 255-266.

Tingay, M., Reinecker, J., and Müller, B. (2008). Borehole Breakout and Drilling-Induced Fracture Analysis of Image Logs, World Stress Map Project.

Watts, N.L. (1983). Microfractures in Chalks of Albuskell Field, Norweigan sector, North Sea, possible origin and distribution, AAPG bulletin, v. 67, No. 2, p 201-234.

Wazeer, F., Ismail, F., and Standen, E. (1990). Fracture Geometry and Hydrocarbon Productivity in the Basement Rocks of the Zeit Bay Field - Gulf of Suez, Egypt, EGPC exploration and Production Confertingayence.

Yang, J., Gou, X., Hilmi, N., and Xia, R. (2012). Identify Fracture Features and to Classify Fracture Types. Fractured carbonate reservoirs.

Zhang, J. (2013). Borehole Stability Analysis, Accounting for Anisotropies in Drilling to Weak Bedding Planes. Int. J. Rock Mech. Min. SCI. 60,160-170.