# Petroleum Reservoir Simulation, Ramin Oil Field, Zagros, Iran

B. Soleimani and F. Nazari, *Member, IACSIT*

***Abstract*—Simulation in petroleum geology is an art to build the structure of the reservoir with the help of geological, seismic, well logs, and petrophysical data which are transferred digitally to the suitable computation software of the reservoir management system. Core analysis, and thin sections petrography are also applied to get more information. In any petroliferous area such as Zagros, reservoir simulation can be also used to predict the best position for drilling projects, and so the reservoir construction is an essential part of the process. The present study is an attempt to construct 3D-structural model using geostatistical method to access in situ oil volume and best position for oil production. The area considered as a case study is the Asmari reservoir of the Ramin oilfield located at Dezful Embayment in SW of Iran. In this oilfield the Asmari reservoir is divided into 4 zones. To make up the model several steps such as griding, kriging and experimental variogram were carried out for all available data. To increase the accuracy and variability of data, selected dimensions was 193×228×1m of each cell in grid model except for zone 4 that it was non reservoir. In this case, for the last zone, dimensions were changed to 193×228×5m. Simulated reservoir model revealed that zone 1 is the main pay zone since it contains about 97.9% of total oil volume in this field. Distribution of the porosity and water saturation indicated that zones 1 and 2 are good candidates for oil production since they have higher porosity% and lower water saturation% than other zones. The best situation for drilling program is in the western part.**

***Index Terms*—Reservoir simulation, ramin oil field, volumetric estimation.**

## I. Introduction

In any petroleum reservoir, understanding of the subsurface structure is an essential part in respect of growing oil and gas demands in the world. Reservoir characterization and modeling are keys to match the production profile and well planning in the oil field. Now, reservoir computational simulation, in spite of its young age, has found a logical and applicable site in scientific research works. With this new window of earth sciences for solving the reservoir problems, researchers have hence begun to report 3D- modeling of fractured reservoir [1]. Three dimensional modeling has been applied in several geological subjects: Structural modeling [2]; Stratigraphic modeling [3]; and Fault modeling [4]. In any case study, it is possible to use each or all cited model above to get a clear position of the subsurface structure if the goal is to reconstruct the structure and estimate in-situ reserve.

To construct simulation model, it is necessary to use geostatistic methods. These are considered as the study of phenomena variation using collection of numerical techniques to describe the spatial continuity [1] by a model in a petroleum reservoir [2]. There are, however, a lot of publications now available that some of them can be cited here as 3D structural modeling [3], certainty of model by computing numerical algorithms [4]), Petrophysical and facies bodies modeling [5], geostatistics for reservoir characterization [6], 3-D definition and flow simulation [7], geometry model [8], outcrop models as petroleum reservoir analogues [9].

In the present research paper, the main objectives are: (1) determine the 3D geometry of the Asmari reservoir, (2) prediction of borehole location for the future oil development and (3) in situ oil volumetric estimation.

## II. Geological Setting

As it is known the Zagros foothill zone is rich in oil and gas reservoirs. This potential was formed by a combination of flexure slip and natural surface folding mechanism [10]-[12]. The fold belt is the result of the Arabo- Iranian plate collision [13]. During the late Cretaceous, the proto- Zagros range developed. It was suggested that the main phase of movement occurred during Miocene– Pliocene time [8]. During the early Oligocene, platform sediments marked by limestone, sandstone and evaporate rocks (Asmari Formation) imply cyclic deposition in shallow restricted depositional setting [9].

The Ramin oil field located at Dezful Embayment in Zagros Frontal fold belt, SW of Iran, consisted of 2 petroleum production reservoirs: (1) Asmari; (Oligocene) and (2) Bangestan (Upper Cretaceous). The last one contains different petroleum production parts such as Ilam; Upper and Lower Sarvak formations. All these accumulations are structurally controlled. It seems logically that the time of oil generation varies towards the thrust and becomes older than the expected time because of higher geothermal gradient/deep buried for the oldest source rocks. This fact is in clear contrast with the idea of [14]. However, their ideas should be tested in appropriate reservoirs.

## III. Methods and Data Collection

To get an accurate structure of the reservoir, at the first it should be studied all available existing geological, structural and petrophysical descriptions to find a general view. In the present case study to do the process of the reservoir simulation, the following steps have done (Fig. 1):

1) Petrographic study was made on 428 thin sections to

Manuscript received August 30, 2012; revised October 8, 2012.

B. Soleimani is with the Geology Department, Earth Sciences Faculty, Shahid Chamran University, Ahvaz, Iran (e-mail: soleimani_b@ scu.ac.ir).

F. Nazari was with Geology Department of Shahid Chamran University, Ahvaz, and now is with the RSS Group of Roxar Lim.Co., Tehran, Iran (e-mail: fatima.nazari@gmail.com).

DOI: 10.7763/IJMO.2012.V2.207

classify the reservoir and its zonation, plot the stratigraphic column and evaluate the reservoir quality; 2) data loading into the software of the reservoir modeling system, organization and visualization processes; 3) calculated horizons based on the underground contour map (UGC) and interpreted horizons, 4) construct structural model; 5) 3D geomodel grid; 6) blocked wells; 7) construct the petrophysical model; and 8) water saturation and porosity distributions and volumetric calculations of the reservoir.

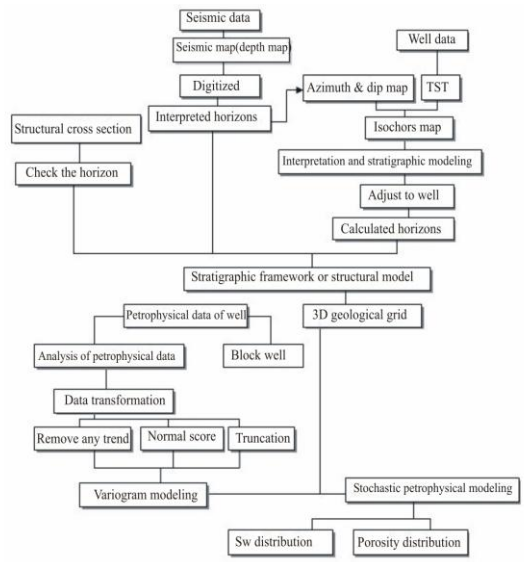


Fig. 1. Schematic flow chart of the petroleum reservoir modeling steps

## IV. Discussion

According to thin sections petrographic analysis, lithologically the reservoir is consisted of limestone, and a less quantity of sandstone. Sparse quartz grains may be observed in limestone as well. The main diagenetic processes are compaction, dolomitization, and anhydritization. Compaction is observed as mechanical and chemical types. The process caused the sediments to solution and compact. Hence, the porosity percentage is going to decrease. Dolomitization and anhydritization are occurred as replacement, cement and pore fillings. Therefore, these are terminated to reduce the reservoir quality and recovery coefficient. Based on petrographic descriptions, the reservoir divided into 4 zones (Fig. 2). It seems that the oil field is deeper than the adjacent oil fields (Fig. 3).

To simulate the reservoir, it is necessary to model structure and petrophysical characteristics as an essential framework. Structural model is the initial points of the reservoir model construction. However, it is possible to put structural planes directly into the model or by help of applicable program that is able to generate these planes.

Stratigraphic model is in fact the production layered cake of different reservoir layers. In this direction, the following maps are generated:

- Structural maps of dip and azimuth of the Asmari Formation top (Fig. 4). It is documented that contours is going to open at the Ilam Formation top and presents a possible new hidden oil field.
- True stratigraphic thickness (TST) calculation in each borehole for all zones.
- Isochore thickness maps by the equation:
  Isochore Thickness = TST/cos (dip) (Fig. 5)
- To plot next structural surfaces by the formula of:
  Next surface=Above Surface + Isochore
- Adjust generated surfaces to borehole location.
- Repeat all above steps for all zones to generate the layered cake model.

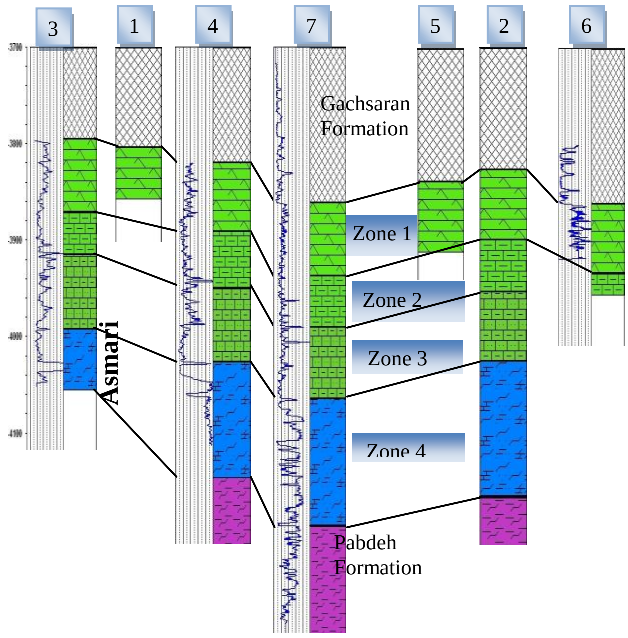


Fig. 2. Stratigraphic correlation chart of the Asmari reservoir zonation in drilled wells.

By considering the depth of each reservoir zone top, underground contour maps (UGC) were plotted (Fig. 6) and then by giving the weight to them structural model and different isochore depth maps (Fig. 7) were made by Reservoir Management Software (RMS). These maps are showing the opening of the last isochore to the south and possible relation to other structure. This matter implies that the possibility of the petroleum migration in the last.

The true strata thickness was calculated in each oil well and plotted as structural map (Fig. 8). According to this plot, the field consisted of two culminations related to the effect of folding compressing stresses.

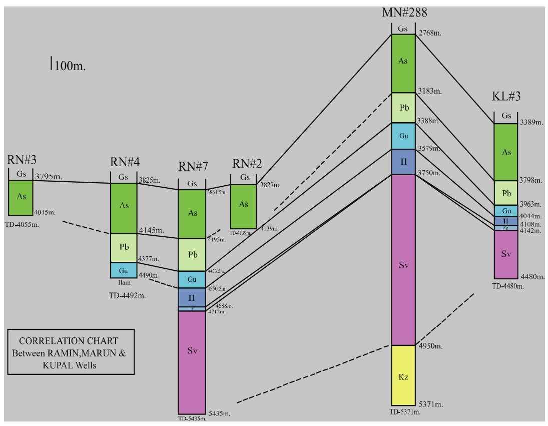


Fig. 3. Stratigraphic correlation chart of the Asmari reservoir in Ramin, Mansouri and Kupal oil fields. Abbreviations are: KL=Kupal; MN=Mansouri; and RN=Ramin

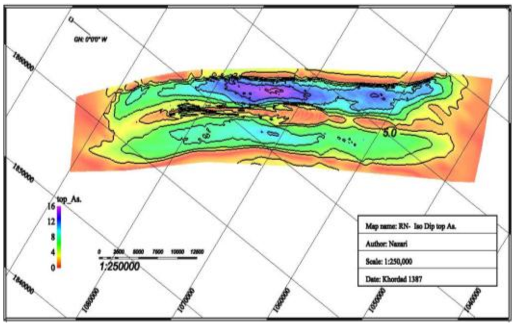


Fig. 4. Isodip map of the Asmari Top.

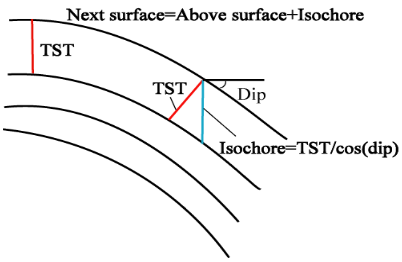


Fig. 5. Schematic chart of isochore and reservoir planes calculation

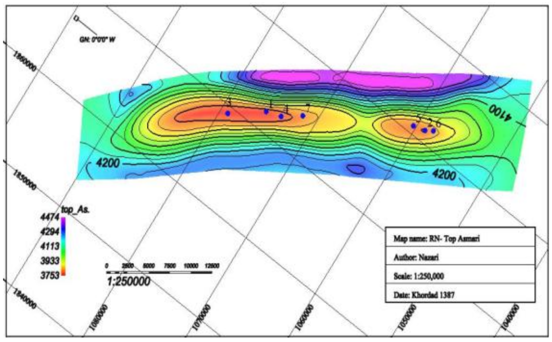


Fig. 6. UGC map of the Asmari formation top

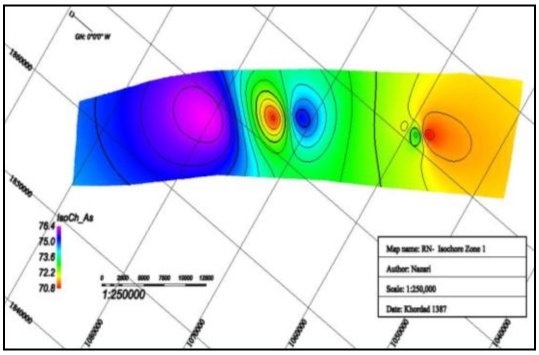


Fig. 7. Isochore depth map of Zone 1.

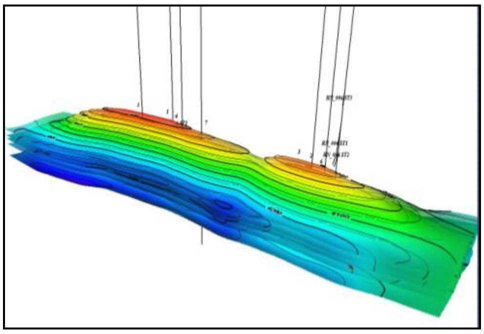

Fig. 8. Structural model with the boreholes positions

Different cross sections were plotted and appeared that the reservoir is smooth and symmetrical but the dip of northern flank is higher (Fig. 9).

The petrophysical model was constructed by data which are taken from well composite logs such as porosity, water saturation, net/gross thickness. Before running the model, it has to do data preparation. Since the modeling process needs to reject data truncate, except marked trends in vertical direction, data transferring to normalize data. Then the variogram model (Fig. 10) and geological grid were made.

Griding is a cell net that other modeling processes are applied in it. To do this, a net of cells with individual dimensions are defined for whole reservoir. Therefore, each cell introduces as a special value that it can be varied as the order of importance. Controlling the geometry and cell dimensions must be done before giving the weight and run in petrophysical modeling. To increase data accuracy, it was selected 193×228×1m dimensions for each cell to consider the space in griding model except for zone 4 that it is non reservoir and thus its cell dimensions was increased.

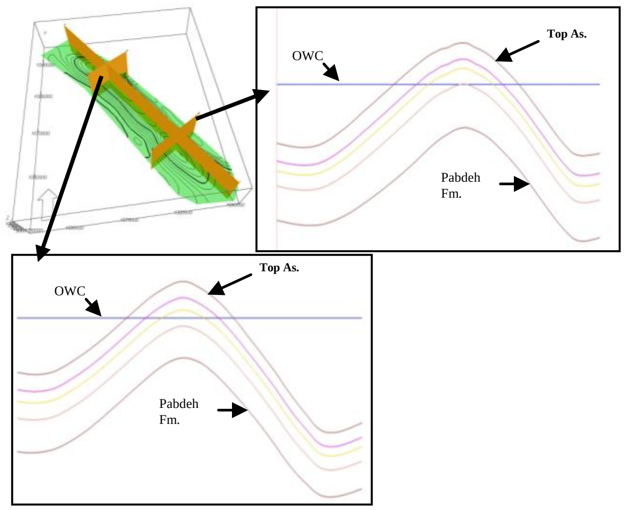


Fig. 9. Different structural latitudinal sections representing a smooth anticline.

Computational data analysis for all zones were made by help of RMS software, 3-D modeling of the average of porosity (Fig. 11), water saturation% (Sw) (Fig. 12) and also net/gross thickness (Fig. 13). These plots revealed that the porosity distribution is not following a special trend but it is related to diagenetic processes which are responsible to increase the reservoir potential such as solution. Therefore as it shown, the areas with high porosity values are concentrated in outer parts. While high water saturation areas are in the central parts. It is supposed that all these characteristics are affected by culminations. It seems net/gross thickness as a positive parameter in petroleum potential is in southern part. Therefore, the extracted data indicated that zone -1 is showing the best reservoir quality in this field. Out put data of the geostatical model are predicted the best situation for future drilling program will be in the western part of the field. Plotting the main reservoir parameters (porosity and water saturation) present that zone 1 (first order) and zone 2 (second order) have higher porosity and lower water saturation from zone 3 and zone 4. It means that zone 1 and 2 have higher oil saturation and are most important parts in hydrocarbon production. It is estimated that accumulated petroleum is 97.9% in the first zone.

Also petrophysical model indicate that water saturation in the upper culmination is higher than lower culmination but zones 1 and 2 in the lower culmination are the best situations of the reservoir for future drillings.

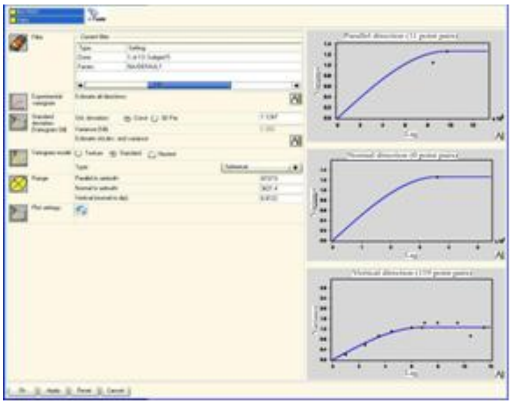

Fig. 10. Variogram prepared by RMS software

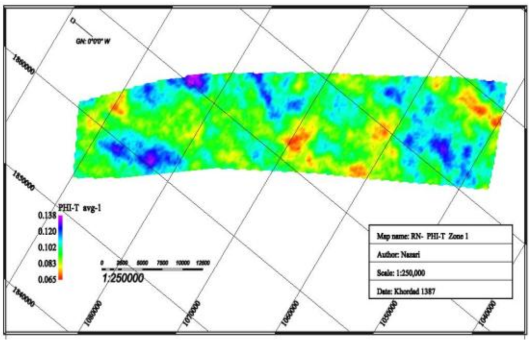


Fig. 11. Mean porosity map of Zone 1

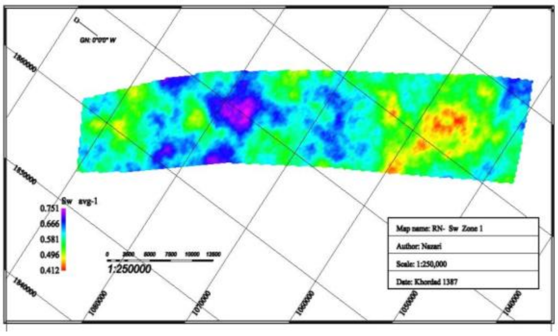


Fig. 12. Water saturation map in Zone 1

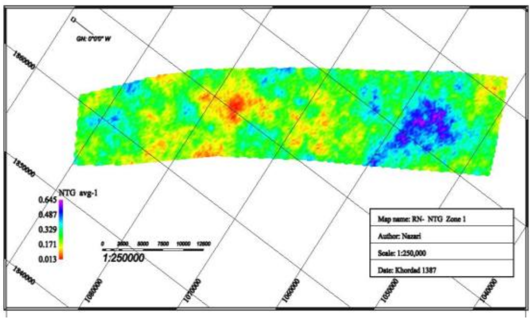


Fig. 13. Net/Gross thickness map in Zone 1

In the present work the in-situ oil volume was made according to structural and petrophysical models. The in situ oil volume is estimated 1 ×108 bbl. Finally, it can be deduced that the Asmari reservoir in Ramin oil field is not a giant oil field. It is possible that its reserve was migrated to adjacent fields.

## V. Results

- Structural model revealed that the Ramin oil field is an elongated anticline with NW-SE trend and extends for 4-40km based on the Asmari Formation top.
- All contours of the reservoir zones are in compatible to the Asmari top contour.
- According to isodip map, the dip of northern flank is higher than southern one.
- It is documented that under ground contours is going to open at the Ilam Formation top which is presenting a new possible hidden oil field.
- It is predicted that the western culmination is the best location for future drilling program due to low water saturation and high net thickness.
- The first zone is indicating merely petroleum potential zone as 97.9% of the present oil is accumulated there.
- The Asmari reservoir in Ramin oil field is not a giant oil field for reasons such as high water saturation, migration of oil to adjacent fields and destructive effects of diagenetic processes.

## Acknowledgment

We are grateful of Dr. Amiri Bakhtiar, Head of Geology Department of NISOC, due to giving the permission of using RMS software and all raw materials. We also express our thanks to Shahid Chamran University authorities. We also express our thanks to the anonymous referees for all friendly critical points.

## References

[1] C. V. Deutsch, *Geostatistical Reservoir Modeling*, Oxford University Press, 2002, 376P.

[2] M. Kelkar and G. Perez, *Applied Geostatistics for Reservoir Characterization*, Society of Petroleum Engineers Inc., 2002, 264P.

[3] R. Labourdette, J. Poncet, J. Seguin, F. Temple, J. Hegre, and A. Irving, "Three-dimensional modeling of stacked turbidite channels in West Africa: impact on dynamic reservoir simulations," *Petroleum Geoscience*, vol. 12, pp. 335-345, 2006.

[4] C. Deutsch and A. Journel, *GSLIB: Geostatistical Software Library and User's Guide,* 2nd ed. New York: Oxford University Press, pp. 369 , 1998.

[5] R. Hauge, A. R., Syversveen, and A. C. MacDonald, "Modeling facies bodies and petrophysical trends in turbidite reservoirs, " *SPE 84053*, pp. 7, 2003

[6] K. Wu, I. J. Marinus, V. Dijke, G. D. Couples, Z. Jiang, M. Jingsheng, K. S. Sorbie, J. Crawford, I. Young, and X. Zhang, "3D Stochastic Modelling of Heterogeneous Porous Media-Applications to Reservoir Rocks, Transport in Porous Media, " *Trans Porous Media*, vol. 65, no. 3, pp. 443-467, 2006.

[7] M. D. Jackson, S. Yoshida, A. H. Muggeridge, and H. D. Johnson, "Three dimensional reservoir characterization and flow simulation of heterolithic tidal sandstones, " *AAPG Bull.*, vol. 89, pp. 507-528, 2005,

[8] J. Lamarche and M. S. Wenderoth, "3D Structural model of the Polish basin, " *Tectonophysics*, vol. 397, pp. 73-91, 2005.

[9] J. K. Pringle, J. A. Howell, D. Hodgetts, A. R. Westerman, and D. M. Hodgson, "Virtual outcrop models of petroleum reservoir analogues: a

review of the current state of the art, " *EAGE*, vol. 24, March , pp. 33-42, 2006.

[10] A. S. Al-Sharhan, and A. E. M. Nairn, "Sedimentary Basins and Petroleum Geology of the Middle East, " *Elsevier Publ*., pp. 963, 1997.

[11] K. A. De Jong, "Tectonics of the Persian Gulf, Gulf of Oman and southern Pakistan region," in *The Ocean basins and margins*, vol. 6: The Indian Ocean, pp. 315-351, Nairn, A. E. M., and Stehli, F. G., eds., Elsevier, Amsterdam, 1982.

[12] H. McQuilan, "Fracture patterns on Kuh-e-Asmari anticline southwest Iran, " *Am. Assoc. Petrol. Geol. Bull.*, vol. 58, pp. 236-246, 1974.

[13] N. L. Falcon, "The geology of the north-east margin of the Arabian basement shield," *British Association for the Advancement of science geology sections*, P.13A15, 1969.

**Bahman Soleimani** was born on 1965 in a village (Khesht) of Fars Province, South of Iran, finished the primary and high school in Bousher Port. He Educated in Geology on 1978-1985 for B.Sc. degree and he finished M.Sc. education in Petrology from Tarbiat Moaalem University, Theran, from 1985 to1989 and also took the scholarship from the Iranian government during this period. On 1992, taken the scholarship from Indian and Iranian governments to continue the education in IIT Roorkee Universiy, Roorkee, U.P., India for Ph.D. The topic was "Subsidence-Uplift History and Petroleum Source Rock Study of Cenozoic Foreland Basin of NW-Himalaya, H.P., India". This period continued up to 1997.

He has joint to Geology Department, Ahvaz University, Ahwaz, Iran from 1992. His interests are petroleum reservoir evaluation, source rock studies, and clay mineralogy in Zagros area.

Dr. Soleimani is the membership of IACSIT, Iranian Crystallography and mineralogy Association, Indian Geologist Congress, Iranian Engineering Organization. Iranian Economic Geologists, and Iranian Petroleum Association. He has presented more than 100 papers in national and international conferences and published more than 15 papers in indexed and ISA Journals.