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Estimating V_{sand} and reservoir properties from seismic attributes and acoustic impedance inversion: A case study from the Mansuri oilfield, SW Iran

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ABSTRACT

This study integrates 3D seismic attributes and well log data to determine V_{sand} and reservoir property distribution of the Oligo-Miocene Asmari Formation in the western Dezfol Embayment, SW Iran. The rocks consist of complex geology with siliciclastic and carbonate lithology. Hence, it creates the need for a precise interwell estimation of lithology and reservoir properties. For this purpose, first the acoustic impedance was obtained by a model-based inversion algorithm. Then, the acoustic impedance attribute and other sample-based seismic attributes were integrated with sand volume and petrophysical data by using multiple attribute regression and neural networks in order to predict V_{sand} and reservoir property. In the next stage, cross-validation was used to estimate the reliability of the derived multi-attribute transforms. Based on the results of neural networks, the highest cross-correlation was observed between seismic attributes and the observed target logs at seven wells in the study area. After validation, and making a comparison between different available techniques for sand volume, effective porosity and water saturation estimation, multiple regression transform and neural network were used for the first two and latter, respectively. The derived sand volume and reservoir property maps for the Asmari reservoir indicated that high-porous and high-sand volume parts were laterally more continuous in the central and east part of the area under study. In addition, high-porosity zones were more related to high sand volume parts. Based on the result of interpretation and the relationship between core and acoustic impedance, variations in acoustic impedance were related to variations in geological characteristics of Asmari reservoir in the field. Therefore, seismic inversion as a powerful tool can facilitate the detailed studies of sedimentary facies and lithology in the reservoir which contribute to understand the subsurface reservoirs heterogeneities and drilling strategy of future drilling campaigns in the study area.

1. Introduction

Water saturation, lithology and the associated porosity of the rocks are regarded as the most important elements in estimating reserves, characterizing reservoir and developing models in order to extract the hydrocarbons efficiently. In heterogeneous reservoirs, lateral variations of lithology and reservoir property cannot be delineated from the measurements made at sparsely located wells, due to the presence of high complexity and heterogeneity. In order to overcome this problem, the integration of 3D seismic attributes and well logs is essential for providing different models of geology and reservoir properties for the inter-well regions(Adekanle and Enikanselu, 2013; Pramanik et al., 2004; Saltzer et al., 2005).

The application of seismic attributes is widely used for decreasing the spatial uncertainty of the geology and reservoir parameter prediction. Nowadays, inversion and interpretation of AVO pre-stack data are both most of the approaches for this purpose. However, post-stack data are still common due to their availability, and an inexpensive and fast processing (Leite and Vidal, 2011). Through accurate estimation of volumes and reservoir characteristics by using seismic attributes, the spatial distributions of geology and reservoir property are obtained, which can be used to guide the drilling strategy for development and exploration of

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Fig. 1. Location map of the Mansuri Field in southwestern Iran. The major Cenomanian and Tertiary oil fields in the region are also shown.

hydrocarbons recovery (Ogiesoba, 2010).

In recent years, seismic attributes have been successfully used for different purposes in reservoir characterization (Farfour et al., 2015; Hart and Balch, 2000; Iturrarán-Viveros and Parra, 2014; Kadkhodaie-Ilkhchi et al., 2009; Na'imi et al., 2014; Pramanik et al., 2004; Raeesi et al., 2012). Among this, acoustic impedance (AI) is a rapidly growing field, due to its relationships with geological and petrophysical data from wells. Acoustic impedance, as the product of rock density and compressional (P-wave) velocity, is obtained from the inversion of seismic data. Seismic inversion is a technique which was first used by geophysicists (Lavergne and Willm, 1977; Lindseth, 1976). Then, many geoscientists and geophysicists in the petroleum industry used this technique for subsurface interpretation, especially in settings where a close relationship was established between AI and rock properties like lithology, porosity and pore fluid. A number of approaches are available for seismic inversion. However, in the present study, the model-based inversion was used to obtain the cube of full band acoustic impedance.

Seismic attributes extracted from 3-D seismic data in combination

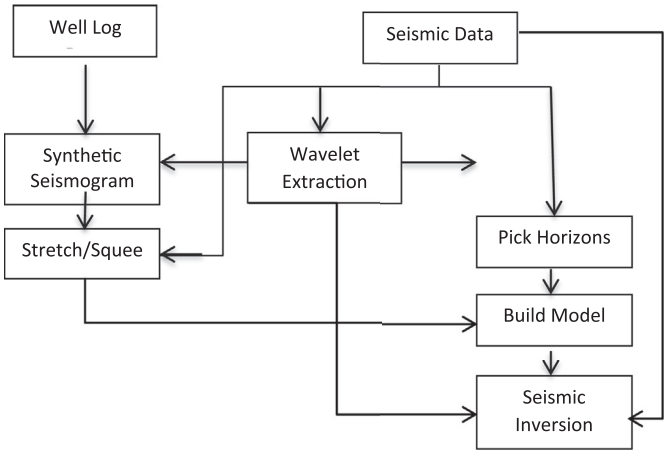

Fig. 3. Generalized flow-chart for model-based inversion.

with statistical methods and intelligent systems have been successfully employed in reservoir lithological prediction, hydrocarbon potential prediction, as well as reservoir property estimates. In addition, several researchers focused on predicting porosity (e.g., Kadkhodaie-Ilkhchi et al., 2014; Khoshdel and Riahi, 2011; Leite and Vidal, 2011; Naeem et al., 2015; Ogiesoba, 2010; Pramanik et al., 2004) and water saturation (Kadkhodaie-Ilkhchi et al., 2009; Na'imi et al., 2014) from various post-stack seismic attributes by using multi-linear regression, neural network analysis and fuzzy system. Based on the results, certain seismic attributes were directly sensitive to the reservoir or desired lithology property. In conclusion, we are able to predict some interesting properties in this regard.

In the present study, sand volume, effective porosity and water saturation were predicted from seismic attributes, along with seismic inversion by using multi-attribute regression analysis and neural network in Asmari reservoir, mansuri field. In addition, in order to reach sedimentary facies and its expansion in the reservoir, a correlation was established between seismic data and core data in wells, based on the seismic inversion results.

2. Geological setting of the studied area

The present study focuses on Oligo-Miocene mixed siliciclastic-carbonate deposits of the Asmari Formation in the Mansouri Oil Field, located in Dezful Embayment, parallel to the general trend of Zagros fold and thrust belt (Fig. 1).

Asmari Formation is considered as the main proliferous reservoirs in SW of Iran (Fig. 2). In the NW-SE trending Dezful Embayment, the Asmari

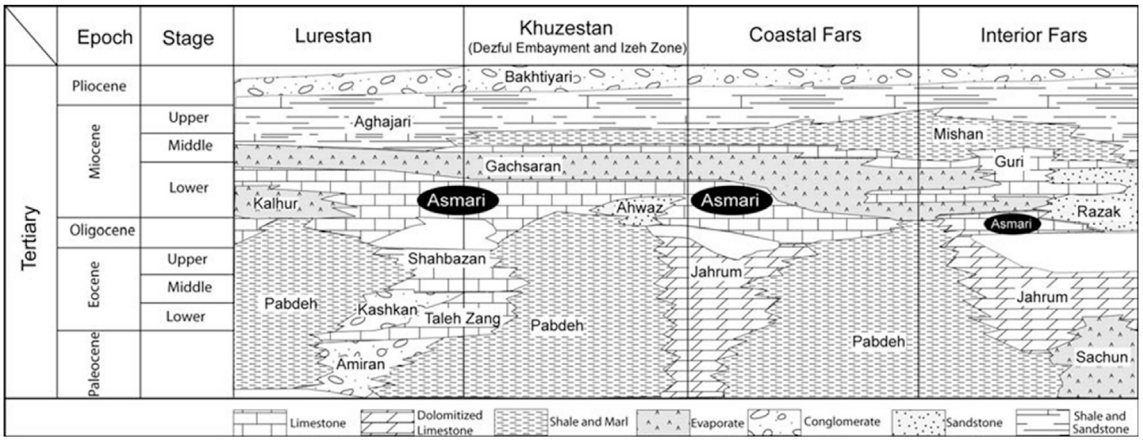

Fig. 2. Cenozoic stratigraphic correlation chart of the Iranian Sector of the Zagros Basin, adopted from James and Wynd (1965).