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Application of DSI Log in Geomechanical and Petrophysical Evaluation of Carbonate Reservoirs: A Case Study in One of The SW Iranian Oil Fields

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INTRODUCTION

DSI (Dipole Shear Sonic Imager) is one of the newest dipole sonic tools which has been introduced by Schlumberger Company in 1990 [1]. Moreover, it provides new technology for dipole transmitters, along with the latest advances in monopole transmitters within a single system, and it is currently one of the best tools for obtaining compression, shear and Stoneley wave velocities in the formation. The main uses of dipole logs are: calculation of elastic rock parameters, estimation of pore pressure, estimation of horizontal stresses, constructing synthetic seismogram, anisotropy evaluation, porosity estimation, permeability estimation (using Stoneley wave), natural fractures evaluation and lithology determination [2]. In this research, the application of DSI log in rock elastic parameters calculation, estimation of in-situ stresses, anisotropy analysis and permeability measurements in Sarvak carbonate reservoirs of one of the SW Iranian oil fields are evaluated.

GEOLOGICAL SETTING

The studied field is located in southwest of Iran, and it is located in Abadan Plain (in terms of structural geology). Moreover, Sarvak Carbonate Formation is the second largest oil reservoir in Iran (after the Asmari Formation) [3]. The Sarvak Formation is formed in the Upper Cretaceous. The Sarvak Formation, in the Abadan plain, consists of (1) thick limestone layers, (2) dolomitic limestones and (3) argillaceous limestone, with an average thickness of 600 meters.

MATERIALS AND METHODS

In this study, the data obtained from a vertical well have been used to study the Sarvak reservoir. The data of this study are: DSI log data, FMI image logs, conventional well logs and Core permeability. Moreover, elastic modulus are calculated using compressional (DtP) and shear (DtS) waves. By performing Slowness Time Coherence (STC), DtP and DtS logs can be extracted from the waveforms of mode- 4. In addition, one of the methods for estimating horizontal stresses, is the use of poroelastic relationships. For the measurement of anisotropy of the formation, mode-x data are used. In an anisotropic formation, there is a direction in which the formation in this direction is stiffer than other directions; and therefore, the shear waves whose polarization is in this direction are moving faster than other directions. Moreover, Stoneley waves move at the interface between the drilling fluid and the wellbore wall and are of the type of transverse waves. The borehole washouts, the layering surfaces and the natural fractures cause Stoneley waves to be reflected. When Stoneley waves pass through a permeable zone, fluid is pressurized into the formation. This movement transmits some of the energy of these waves into the formation and its attenuation is used to measure permeability.

RESULTS AND DISCUSSION

In Figure 1, the geomechanical parameters extracted using DSI log data in the studied well are shown. In addition, in Sarvak reservoir of the studied field the dominant lithology is limestone, but there is also shale interbeds in some intervals. Moreover, Young’s modulus have decreased in shale interbeds and has been reduced by increasing porosity in limestone layers. In addition, Poisson’s ratio has increased with increasing shale. Furthermore, the pore pressure in the reservoir is low and close to the hydrostatic pressure. Finally, the stress state is also normal- strike slip.

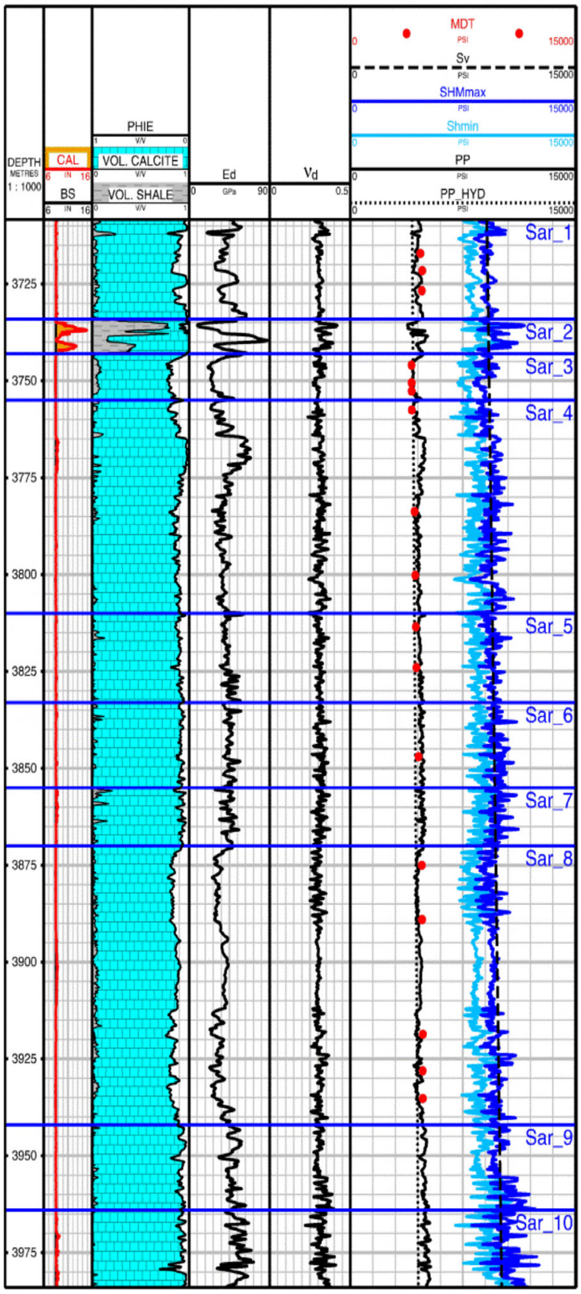

Figure 1: The Extracted Geomechanical parameters using DSI log Data.

The slowness anisotropy has increased in fracture and washouts zones (zones 4 to 7 and zone 2, Figure 2). The slowness anisotropy log is shaded for values greater than 4%, which are increased in line with the fracture and washout zones (Figure 2). The transit-time anisotropy is affected by the washouts (Figure 2).

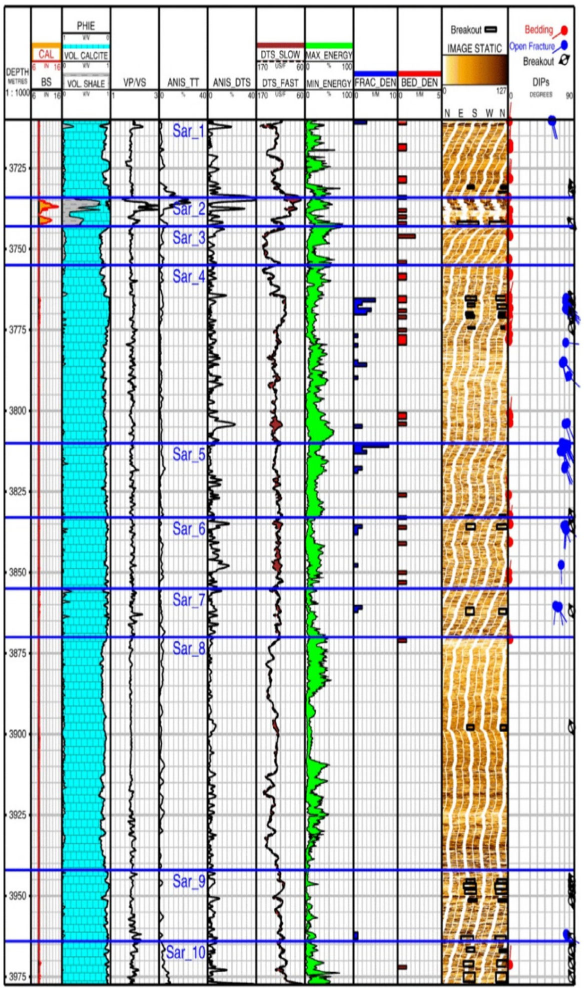

Figure 2: The different anisotropies against the borehole events.

CONCLUSIONS

The stress state in the studied well is normal-strike slip. In natural fracture and washout zones, slowness anisotropy is increased. Moreover, the transit time anisotropy is also affected by washouts. Finally, the permeability of the Stoneley waves is in good agreement with the core permeability, and the difference in some parts is due to the difference in the nature of the permeability measurement in these two modes.

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