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Natural Fracture and Storage Characterization in the Granitoid Basement of Campamento 1, the Oldest Oilfield in the Neuquén Basin, Argentina

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Abstract

Located in Argentina, the paleozoic basement in the Octógono field, Huechulafquen formation, consists of granitoid rocks underlying Los Molles shale which is seal and one of the source rocks altogether with Vaca Muerta formation. The field was discovered in 1918 and produced from shallow reservoirs. Development activity in the basement is a recent upside.

The basement anticline started forming during Early Jurassic. After the rifting, sedimentary units of Cuyo group deposited above the Basement in hemigrabens lately elevated during the tectonic inversion in the Upper Jurassic. Campamento 1 structure is formed due to reactivation of tensional faults in the heights of the rollover. The structure was already formed when hydrocarbon migration started.

All permeability and storage had been originated from fracturing and alteration. Six alteration zones corresponding to the differential weathering can be correlated based on 3D seismic and well logs. The reservoir classifies as type BA (35 % of storage in macrofractures). There is a 300 m thick gas cap and an oil leg up to 450 m thick.

In order to support the characterization of the reservoir, a fracture intensity model was built by a geomechanical approach in which main structural features (faults) interact in a remote stress field generating local strain which is the origin of fracture sets. Each fracturing event, influence and reactivation under successive stress fields was identified, as well as fracture properties of the different families, such as orientation, quality and intensity.

Faults at seismic resolution are mapped in detail as the frame to generate the stress tensor in the Basement and for estimation of strain distribution. Most of faults have northeast orientation dipping westwards and eastwards creating a pop up type structure analogue as which is observed in the Cerro Granito outcrops. Complexity is due to the tectonic evolution during the tensional stages and also as the multi-episodic inversion which started in the Middle Jurassic and was reactivated during Upper Jurassic, Middle Cretaceous and Tertiary, with 90° rotation of main stress direction.

The geomechanical 3D analysis was based in 3D algorithms for the calculation of stress field and deformation on a linear-elastic space using boundary polygons that represent part of a fault surface. Displacement is constant in each element although as a surface is formed by various interacting elements, non-uniform strain can be characterized. The integration of the processed information into a 3D model allows identifying regions where storage capacity is higher. Mapping of fracture intensity helps to orientate the development to sectors where flow capacity is

higher, thus optimizing EUR. The output includes de displacement vector, strain tensor and the Maximum Coulomb Strain Stress (MCSS) in the form of an observation grid.

Regions with high MCSS are expected to have high chances of occurrence of natural fractures. These are showing a north-east trending during the Jurassic, with maximum coinciding with the high storage area in the front of Campamento 1 structure. During Cretaceous the trend is similar than previous but with a different distribution due to a change in the maximum stress orientation from 340° to 290°. During Tertiary the inversion is registered only in the periphery of the Campamento 1 region. The fracture intensity pattern is more homogeneous than during previous stages. Coincidence is good between MCSS and fracture density derived from well data, also with the areas of high storage, proving this method as valuable addition for the characterization.