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Variations of the petrophysical properties of rocks with increasing hydrocarbons content and their implications at larger scale: insights from the Majella reservoir (Italy)

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Crustal processes such as deformations or faulting are strictly related to the petrophysical properties of involved rocks. These properties depend on mineral composition, fabric, pores and any secondary features such as cracks or infilling material that may have been introduced during the whole diagenetic and tectonic history of the rock.
In this work we investigate the role of hydrocarbons (HC) in changing the petrophysical properties of rock by merging laboratory experiments, well data and static models focusing on the carbonate-bearing Majella reservoir. This reservoir represent an interesting analogue for the several oil fields discovered in the subsurface in the region, allowing a comparison of a wide range of geological and geophysical data at different scale. The investigated lithology is made of high porosity ramp calcarenites, structurally slightly affected by a superimposed fracture system and displaced by few major normal faults, with some minor strike-slip movements.
Sets of rock specimens were selected in the field and in particular two groups were investigated: 1. clean rocks (without oil) and 2. HC bearing rocks (with different saturations). For both groups, density, porosity, P and S wave velocity, permeability and elastic moduli measurements at increasing confining pressure were conducted on cylindrical specimens at the HP-HT Laboratory of the Istituto Nazionale di Geofisica e Vulcanologia (INGV) in Rome, Italy.
For clean samples at ambient pressure, laboratory porosity varies from 10 % up to 26 % and P wave velocity (Vp) spans from 4,1 km/s to 4,9 km/s and a very good correlation between Vp, Vs and porosity is observed. The P wave velocity at 100 MPa of confining pressure, ranges between 4,5 km/s and 5,2 km/s with a pressure independent Vp/Vs ratio of about 1,9. The presence of HC within the samples affects both Vp and Vs. In particular velocities increase with the presence of hydrocarbons proportionally respect to the amount of the filled porosity. Preliminary data also suggest a different behaviour at increasing confining pressure for clean and-oil bearing samples: almost perfectly elastic behaviour for oil-bearing samples and more inelastic behaviours for cleaner samples. Thus HC presence appears to contrast the increase of confining pressure acting as semi-fluids, reducing the rock inelastic compaction and enhancing its elastic behaviour.
Trying to upscale our rock-physics results, we started from wells and laboratory data on stratigraphy, porosity and Vp in order to simulate the effect of the HC presence at larger scale, using Petrel® software. The developed synthetic model highlights that Vp, which is primarily controlled by porosity, changes significantly within oil-bearing portions, with a notable impact on the velocity model that should be adopted. Moreover we are currently performing laboratory tests in order to evaluate the changes in the elastic parameters with the aim of modelling the effects of the HC on the mechanical behaviour of the involved rocks at larger scale.