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Impact of micrite diagenesis on the elastic properties of microporous carbonates

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In most of the hydrocarbon carbonate reservoirs from the Middle-East, a large proportion of the pore space consists in intercrystalline microporosity within micrite, in intergranular or intragranular position. Quantifying the impact of microporosity on elastic properties of carbonate reservoirs is therefore a major challenge for geoscientists working on fluid detection and porosity prediction from seismic inversion. By integrating ultrasonic velocity and porosity measurements and quantitative mineralogic and petrographic analyses of 75 samples of platform carbonates (Urgonian Limestone, Lower Cretaceous, Provence, SE France) and 45 samples of mixed carbonate-siliciclastic rocks (Upper Cretaceous, Provence, SE France), we can: 1) identify and quantify the parameters controlling elastic properties; 2) demonstrate that micrite can be considered as a porous medium with a low critical porosity (sensu Nur et al., 1998) ranging from 15 to 25%; and 3) relate pore-structure modifications at micrometric scale during diagenetic transformations of micrite, and elastic property changes. In cemented grainstones with microporous micritic grains, velocity-porosity relationships display a steeply decreasing portion for porosities ranging from 0 to 10-15% and a flat portion above 15%. The rate of P- and S- wave velocity decrease with increasing porosity is related to the microtexture of micrite and to the timing of the diagenetic processes (compaction, cementation, neomorphism and dissolution) affecting micrite. The stable values of velocities for porosities greater than 15%, indicates that micrite porosity within grains has reached the critical porosity and no longer controls the effective elastic properties of the rock.

Nur, A., G. Mavko, J. Dvorkin, and D. Galmudi, 1998, Critical porosity: A key to relating physical properties to porosity in rocks: The Leading Edge, 17, 357–362.