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Elastic properties of continental carbonate rocks: controlling factors and applicable model

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Continental carbonates gained interest following the discovery of the supergiant field in the post- and pre-salt deposits in offshore Brazil, as they account for a large portion of the deepwater production. The genesis of continental carbonates is generally associated with physico-chemical and biological precipitation of carbonates, coupled with a strong influence of clastic mineralogical inputs. This results in a complex mineralogical mixing, associated with a wide heterogeneity of pore types due to the intense diagenetic overprint potential of carbonate deposits (cementation, dissolution, recrystallisation, dolomitisation...). With that in mind, we propose insights on the controling factors of elastic properties in a continental carbonate dataset, analogue of the brazilian pre-salt deposits. An applicable model based on the effective medium theory is proposed and discussed regarding the experimental results, and try to account for the wide variability of the elastic properties.
Analyzed samples exhibit large variation of (1) sedimentary texture (coquinas grainstones, muddy facies (mudstones to packtones), travertines and stromatolites, (2) pore types (moldic, intercrystalline, vuggy and micropores) and shapes (aspect ratio values fall between 0.2 and 0.5) and (3) physical properties (porosity, acoustic velocity). Regarding composition, samples are characterized by three major mineralogical assemblages, from pure calcite, dolomite, to quartz/clay mixing. If porosity is clearly the first order parameter controlling P-wave velocities, the mineralogical overprint can be accounted for the wide variability of the p-wave velocities at a given porosity (figure 1). The lower porosity-velocity relationship trend is dominated by samples with low to large quartz/clay proportions, whereas the higher trend is dominated by dolomitized samples.
Two input parameters are extracted from the previous experimental observation: porosity and mineralogical composition of each sample. The pore aspect ratio is used as a fitting parameter, but always takes realistic value, falling closely in the range of the one extracted from the samples. Figure 2 shows that prediction is fairly good. For porosity lower than 20%, the predicted velocity is 9% accurate with an aspect ratio of 0.15. For higher porosity, the prediction is 13% accurate with an aspect ratio of 0.3.
All in all, the used analytical predictions of the acoustic wave velocities are in very good agreements with the experimental data.