Physical Properties of Sandstones Based on Experimental Compaction

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Experimental compaction of loose sands provides a useful database relating rock properties to mineralogical and textural composition of the natural sediments. This study investigates the progressive physical property changes of mechanically compacted well characterized loose sand aggregates as functions of mineralogy, size, shape and sorting of the grains. Sands were categorized using XRD quantitative mineral analysis into quartz arenite, subarkose, arkose, feldspathic greywacke and volcanic arenite. The original samples were separated using sieves to quantify sorting and to obtain coarse, medium and fine grained sands. A total of 29 dry sand aggregates were compacted mechanically to measure rock properties under uniaxial compression. To differentiate sand grain shapes back-scattered electron microscopy image of each sample was quantified using an image analysis software for parameters like sphericity, roundness and aspect ratio.

The strain (compressibility) and velocity (both Vp and Vs) were measured continuously up to a maximum of 50 MPa effective stress. Four end member brine-saturated sands were also tested over the same effective stress range to check the validity of Gassmann fluid substitution of dry sand aggregates. Results of the experimental sand compaction tests showed that at a given stress coarse-grained sands were more compressible and had higher velocities than fine-grained sands when the mineralogy was similar. Poorly sorted samples were highly compressible and quartz-rich samples were the least compressible with lower velocities. The brine-saturated data both from wet measurements and Gassmann brine substitution showed a decreasing Vp/Vs ratio with increasing effective stress. The quartz-rich sands plotted towards the higher side of the Vp/Vs range. Under a given stress the Vp/Vs ratio and porosity decreased, whereas the acoustic impedance increased for sands low in quartz.

Plotting all the Gassmann brine substituted Vp and Vs data together against stress provide a measure of the expected mechanically compacted velocity range of a wide variety of natural sands. Deviations of actual well log data from this range may indicate early cementation, overpressure, uplift, and/or chemical compaction. These data on the relation between mineralogical and textural composition of sandstones and rock properties may help to model velocity-depth trends and to improve the identification of reservoir rock facies from well logs.