Application of Staged Effective Medium Models for the Prediction of Velocities

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A new staged differential effective medium model for acoustic velocities was recently published which allows the mineralogy and texture of rocks to be modeled. The model is based on interpolating between series and parallel additions of inclusions with an effective medium approximation for the host. It was shown to be consistent with critical porosity models and Gassman's equation. The model represents an extension of these ideas in that it allows variations in mineralogy and texture to be included. The development of this model will be briefly reviewed here. What remains to be demonstrated is how the parameters in the model are derived. Several examples are shown for specific lithologies. The model is first applied to a suite of artificial sands. Sand packs were made so that individual parameters could be changed and their influence on acoustic properties measured. Key parameters are derived for variations in packing, sorting, grain size and shape, and framework mineralogy. Suites of samples were measured for increasing ductile grain and feldspar content, for sands having mean grain size of 150 and 300 microns. As feldspar content increases from 3-12 weight percent, the velocity of the sand pack increases with very minimal changes in total porosity. As feldspar content increases above 12%, continuing to add feldspar causes the velocity to decrease. Thin sections cut from 1" diameter plugs of the artificial sands were analyzed using Shell's proprietary image analysis tool. The pattern of changes in measured acoustic properties was tied to changes in contact length and the mineralogy of the contact pairs. Adding small volumes of feldspar causes the overall contact index of the sands to increase because of the lathlike shape of the feldspar grains, although quartz:quartz contacts dominate the elastic properties. Above about 12 weight % feldspar, feldspar:feldspar, and feldspar:quartz contacts begin to dominate the grain pack and exert the primary influence on the acoustic properties. The effects of changing other properties of the sand pack (e.g. sorting) and the influence of more complex mineralogic mixtures on acoustic properties are also discussed. Finally application will be made to real samples both for clastics and carbonates. The dominant mechanisms for carbonates are the texture of the intergranular porosity and the inclusion of vuggy porosity. The field examples of the clastics follow the mechanisms discussed above for sand packs.