So what is the size of the grains in your sandstone, how do you measure them and why you should care.

Grant Sanden, Yannai Segal, Mikhail Kostousov, Martin Trobec, Britnee J. Beitel and Russell P.W. Stancliffe
Enersoft Inc

Summary

The use of particle size distribution data is common in many parts of geoscience and engineering. However, the two standard methods (sieving and laser/Coulter counting) both have issues with non spheroidal grain shape and lithology variations. A new technology using particle scanning in three dimensions, and data interpretation using computer-based algorithems has lead to each grain being quantified quickly and literally thousands can be analysed to create a large dataset of statistical significance. Sampling of core, Dean Stark retains and chips will lead to a greater understanding of what is in the pay zone and how to successfully recover the entrained hydocarbons.

Background, Theory, Method, Workflow

A common question asked by engineers to geologists concerns the grain sizes found in a pay zone. A standard practice is for the geologist to go out to the core board and sample some core for analysis. The rock fragments are then sent to a lab where a 'determination' is made and the results written up as a report. Often the data is presented in the form of a P10, P50 and P90 distribution and this is sent to the engineers where it disappears into a production forecast model or well completion design. When the well does not perform as expected, engineering blames the geologist for providing incorrect data. Can geoscience do better?

There are two common ways of measuring grain size distributions in oil sand core. The sieve test requires the sediment to be washed, oil removed, sample dried, weighed and then passed through a stack of sieves. Each sieve is weighed to determine what size fractions are present. The data units are normally measured in grams and the technique is effective for grains above 44 microns in diameter. However, there are challenges with repeatability, oval grains, sieve degeneration and poorly sorted sediments. A second technique puts washed samples into a liquid which is then pushed through a small hole. Each grain is illuminated by a laser beam and the diffraction (bending) of the light is measured. The results are related to the particle size and the intensity of the diffraction is a measure of the number of particles with a specific spherical cross-sectional area. Other common technologies for particle size determination include grain settling in a liquid, grain volume, 2D grain dimensions, and thin section analysis. Each grain sizing technique has its issues and strengths, and selection of the best tool should be based on the end application.

A new technique has been developed using optical scanning with computer-based interpretation algorithms to quantify each grain's shape. A sample is washed so that as many grains as possible are separated without breaking the particles. The grains are then scattered on a plate and repeatedly imaged with a high-resolution camera at different focal depths. The data is then analysed using imaging technology to measure each grain in three dimensions, even when the grains are not fully separated. The results are a very large absolute-measurement file which is not derived from, for example, the particle mass, grain settling rate, light diffraction by particles, or Feret's diameter.

Results, Observations, Conclusions

As shown in Figure 1, each grain is scanned, outlined and assigned three dimensions. These can then be binned to ceate 'real' datasets base on size, not on volume or density. The new technology enables the geologist to scan thousands of grains from a sample and for each grain create a 3D image resolving each dimension, and the grain's roughness and angularity. The resulting dataset includes spherical and non-spherical grains with different compositions and is not dependent on using relationship equations such as Stoke's law. Also, it is now possible to repeatedly sample a core for grain size changes as the technique is quick and inexpensive. Furthermore, the data collected is repeatable and statistically relevant for modeling.

Novel/Additive Information

The ability to easily measure the three dimensions of a grain is a break through for geologists and petroleum engineers. Sampling can now be done from Dean Stark retains, chips from intervals along SAGD horizontal well pairs, and strat well cores and chips. Each sample can be scanned for thousands of particles to obtain statistically relevant distributions.

The results will be used by many different specialists including geoscientists who can use the data to determine the presence of sand on sand contacts and the depositional environment. Petroleum engineers use grain size data to determine the choice of slots vs screens completions. The grains also influence the capillary pressure effecting fluids, and how the permeability is determined. Other uses include CHOPS modeling, well bore collapse prevention, gravel pack completion optimisation, fracture propagation modeling and frac sand selection. Construction engineering also uses grainsize data for tailings pond berm creation, and the modeling of sedimentation rates within the ponds.

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Figure 1
A grain cluster imaged on the left is separated into measurable grains in the center using computer algorithms. The image on the right shows the center of each grain used in determining the dimensions.