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Quantitative Determination of Sphericity and Roundness of Pebbles and Sand Grains

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Sphericity and roundness are important shape characteristics for clastic grains, sand, gravel etc. In particular, the suitability of sand used for fracking is defined in terms of sphericity and roundness. The agreed method is the API standard [1] which reproduces the semi-quantitative visual comparison chart of 1951 by Krumbein & Sloss [2]. Historically there were various index numbers proposed for the shape of grains [3] [4]. Some of these are precise but so time consuming as to make them unsuitable for routine use. The quicker methods are subjective and less precise [5] [6].

The limitations of processing time and complexity that made the precise methods impractical in the past apply less today. Modern instrumentation and computer methods allow fast evaluation and more precise results. The proposed method starts with digital photographs of sand and gravel size particles, from which a 2D outline (perimeter or intercept) of the grain is extracted by image processing. Further computation gives the centroid, perimeter, and area of the particle, and the axes: axis a (long axis) and axis b (short/middle axis). From these a number of derived characters e.g. sphericity (Riley [7]), circularity [8] and roughness [9] were calculated and evaluated for usefulness.

Sphericity computed from the b/a aspect ratio of axes correlates well with the API standard, allowing sphericity computed as a simple function of b/a. The computed sphericity matches the nominal sphericity given in the standard visual charts yields within a few percent. E.g. the chart shows a number of particles with a nominal sphericity 0.70. The range of computed sphericities for these is 0.63 - 0.73. Overall STD of estimation is 0.06 through the sphericity range of the standard (0.30 to 0.90).

Roundness is somewhat different. None of the simple measurements approximates the standard roundness as defined by K&S. This should not be surprising as the standard is not defined in terms of simple geometry, and, fractal considerations lead us to believe that it can not be defined so. On the other hand, the usefulness and practical value of this heuristical standard cannot be denied. The chart serving as the base of the standard differs significantly from the more detailed roundness chart of 1941 [10] despite the identical theoretical basis. A view of the charts suggests the use of Fourier analysis [11] [12] and, indeed, a combination of some Fourier coefficients yields a measure reasonably agreeing with the chart. Overall STD of estimation is 0.13. The use of this formula allows reducing both operator error and subjectivity, as well as speeding up processing time.

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