Some Relations of the Shape of Quartz Sand Grains to their Crystallographic Orientation

E. L. LUCAS, University of Oklahoma, Norman

Geologists have long known from microscopic study that quartz grains in both sedimentary and metamorphic rocks show a tendency to be elongated parallel to the c-axis. Many samples of quartz grains were collected for this study and measurements made to observe possible relations between their shape and differential wear or hardness directions.

Sandstone samples were chosen in which the quartz grains exhibit the original crystal forms and also show evidences of appreciable wear. Quartz grains at this stage of wear were selected mainly because their study does not require the use of a universal stage. The grains were carefully disaggregated, boiled in dilute acid, cleaned and screened. Grain samples most convenient for study were taken from the 100-mesh screen having passed the 80-mesh size. Some grains were mounted in Canada balsam and others were studied in immersion oils in order that any secondary growth could be seen and dismissed from consideration.

Some sandstones consist of well-worn quartz grains possessing a high degree of sphericity (Fig. 1). Quartz liberated from granitic rocks by weathering can be expected to be equidimensional rather than elongate, in fact this may be the source of the quartz grains in most sandstones. When such grains have suffered wear through more than one cycle of fluvial or eolian erosion, their shape may be an outward expression of the original equidimensional crystals or fragments. If all crystallographic directions in the grains are equally hard and resistant to abrasion, a near sphere should be the result.

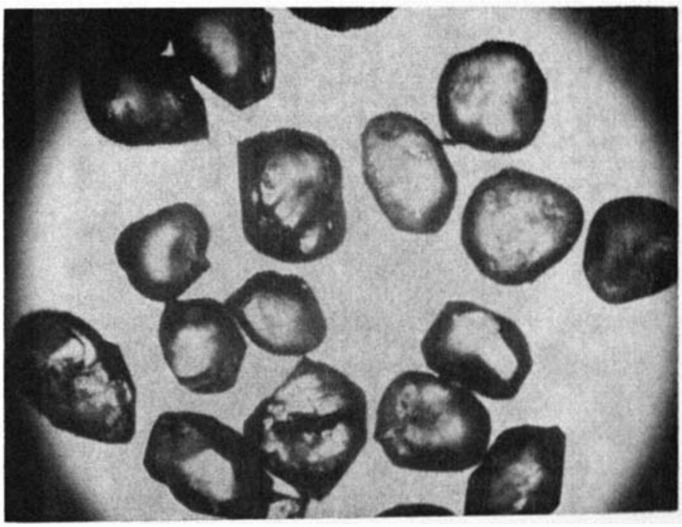

Fig. 1. Ordinary light, X 55. Quartz sand grains with high degree of sphericity.

Quartz has been tested for differential hardness in a number of ways. Sosman (1927) stated that Berndt concluded from experiments that quartz is more difficult to scratch parallel to the c-axis than in any other direction. Sosman also stated that Auerbach found the penetration hardness of quartz to be less in the direction of the c-axis. Gilluly (1937) cited Berndt that the crushing strength is greatest in the c-axis direction. Moreover, recent experiments have not as yet solved the problem of differential resistance of quartz to abrasion.

Many of the grains observed in this study are not perfect spheres, but vary from near spheres to ellipsoidal shapes. Over fifty percent of the later formed by abrasion are very possibly the consequence of greater hardness or resistance to abrasion in the direction of the longer axis of the grains. Since the major axis of most of the quartz grains coincides with the crystallographic c-axis, it seems probable that rounded clastic quartz grains are longer and harder in the direction of the optic axis. Many of the stubby quartz crystals reveal initial rounding at the zones of intersecting prism, rhombohedral and trapezohedral faces. Wayland (1939) stated that actual measurements of grains of the Jordan sandstone show that they are 17.5 percent longer in the direction of the optic axis than normal thereto. This feature suggests that abrasion begins to develop a high degree of sphericity on such equant grains in directions not parallel to the c-axis. Yet, the fact remains that in addition to the effect of the crystallographic aspects, the original somewhat equidimensional nature of the fragments is the chief factor leading to the ultimate spherical shapes.

Other sandstones consist of greatly-elongated quartz grains which may have also suffered mechanical wear during one or more erosion cycles (Fig. 2). The elongated feature of these grains may have been inherited from some vein quartz crystals in which the c-axis was relatively long. However, one has every reason to expect them to be in the minority in the average sandstone. Ingerson and Ramisch (1942) stated that abrasion tests made by them on oriented quartz prisms reveal that the elongation of quartz sand grains is due to the original shape rather than the result of fracture and differential erosion during transportation. Their experiments also show that quartz has no pronounced tendency to fracture parallel to the c-axis. Krynine (1940) has studied quartz grains in sediments from many places in the world which show appreciable elongation parallel to the c-axis. He called these grains schistose quartz, meaning that the elongation is due to the original crystal shape of the quartz in the schist. He concluded that a considerable amount of the quartz in sediments come either from metamorphic rocks or from re-worked sediments containing elongated quartz crystals.

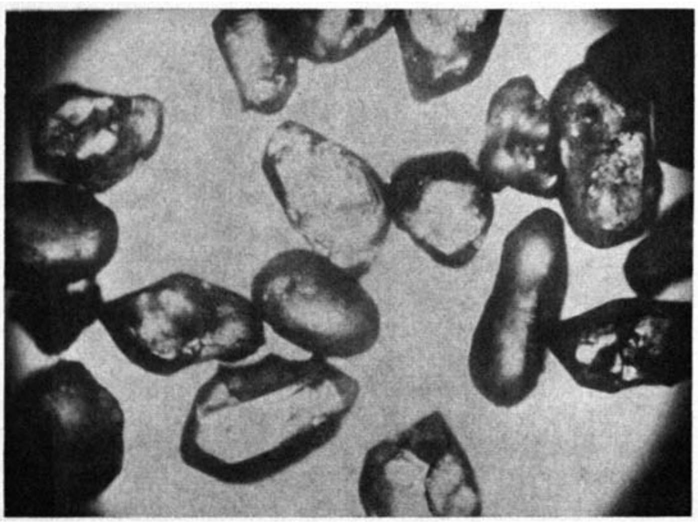

Fig. 2. Ordinary light, X 55. Shows elongated quartz sand grains.

A study of elongated quartz grains shown in (Fig. 2) seem to bear out the idea that the elongated and well-worn grains owe their shape to the external appearance of the original quartz crystals and fragments. The rounding due to mechanical wear begins at the base of the rhombohedron zones and continues until all edges and corners become round.

CONCLUSION

The shape of quartz sand grains made round by abrasion whether exhibiting oblong or spherical forms seem to definitely depend upon the original shape of the quartz crystals or fragments. On the other hand, the tendency for many quartz grains to be longer and harder, in the direction of the optic axis, lends much support to the idea of unequal wear due to differential resistance to abrasion. Therefore, it seems reasonable to expect both factors to be about equally effective in the ultimate rounding of quartz sand grains.

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