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Accepted for publication February 1966

A note on the interpenetration of detrital quartz grains during the formation of sedimentary quartzites

BY

HARALD CARSTENS

(Norges Geologiske Undersökelse, Postboks 3006, Trondheim)

Abstract. It is suggested that contrasting degrees of quartz interpenetration in a small sample of sediment are due to non-uniform wetting of the grains by pore water.

Compaction of sand grains because of increasing pressure occasioned by burial results in a volume reduction of the sediments. Slight burial tends to rearrange the sand grains to give higher packing density and lower pore volume resulting in a permeable sandstone in which the quartz grains have mutual, tangential contacts. This is achieved by the grains sliding over one another. With increasing depth of burial,

processes occur which decrease the centre-to-centre distances between grains allowing further reduction in volume. Tangential contacts are thereby progressively replaced by interlocking boundaries described as long, concavo-convex, and sutured (stylolitic) showing increasing

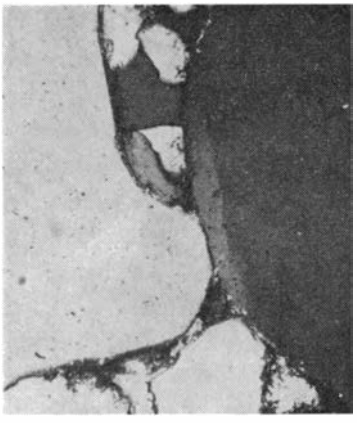

Fig. 1. Strain in quartz at points of grain contact. × 122.5.

Fig. 2. Recrystallization of quartz related to strained contacts. × 122.5.

degrees of interpenetration. This process may proceed to a stage where individual grains eventually loose their identity. Thus, destruction of the primary point-to-point contacts ultimately results in a quartzite with little or no cement. In contrast to the orthoquartzite which contains essential amounts of cementing quartz, this type of sedimentary quartzite has been termed pressolved quartzite (SKOLNICK 1965). The name is derived from the process believed to be involved in the interpenetration of quartz grains. It is generally agreed that sintering occurs by transfer of material from points of contact because of compressive stress, the driving force being the increased chemical potential at the contacts.

There is, however, no consistent, unequivocal relationship between depth of burial and interpenetration boundaries, and sometimes all kinds of contacts are found in the same thin section. A quartz grain may, for example, have deeply interpenetrated boundaries on one side and tangential contacts on the opposite. A close inspection of tangential contacts associated with interpenetration boundaries discloses that those parts of the grains that are adjacent to the point contacts are

strained. A number of observations[1] show that undulatory extinction in the quartz grains is related to stress at these contacts. (Fig. 1). It may also be inferred that the strain level reached a considerable magnitude because the strained quartz has often recrystallized (Fig. 2). No crushing or fracturing of the quartz grains which occur in experimentally compacted sands (MAXWELL 1960) was observed. The important conclusion to be drawn from the above observations is that stress relief at grain contacts variously occurs by pressure solution and plastic deformation. We may now ask why quartz reacts so differently when subjected to stress? A prerequisite for pressure solution to occur is that the grains be separated by a thin water film. Quartz may then go into solution at the stressed contacts and diffuse into open voids and precipitate there or be transported away by percolating water. Thus, if $\gamma_{SS} < 2\gamma_{SL}$,[2] the dihedral angle is zero and the quartz grains form solid-to-solid boundaries, and, because of the slow diffusion in the solid state compared with liquid diffusion, tangential contacts are preserved. Coating on grain surfaces may have a marked influence on the grain-water interfacial energy, which therefore probably varies considerably along the surfaces of detrital quartz grains. Variations in the grain boundary energy (γ_{SS} may, of course, contribute to the wetting ability, but is in all likelihood of little significance.

The catalytic effect of coating material (LERBEKMO and PLATT 1962) in the pressure-solution of quartz is another factor which may accentuate the contrasting behaviour of the detrital grains during the diagenesis.

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Accepted for publication February 1966

[1] The material used in this study, sandstones from the Precambrian of South Norway (Trysil) and sandstones from below the Hyolithes zone of Finnmarken, North Norway, was supplied by state geologists Skålvoll and Gvein.

[2] γ_{SS} = grain boundary energy. γ_{SL} = solid–liquid interfacial energy.