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FROSTING OF QUARTZ GRAINS BY CARBONATE REPLACEMENT

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Frosting on quartz grains is commonly attributed to abrasion during aeolian transportation. The effectiveness of sand blasting in producing frosted surfaces cannot be questioned, but not all frosting originates in this way. A review of the literature dealing with surface textures of quartz grains reveals several other explanations of frosting, including differential solution of grain surfaces by percolating ground waters, incipient quartz overgrowths, and pressure solution along contacts between adjacent grains. Still another cause of frosting, and one that has received little mention in the literature, is that caused by carbonate replacement of quartz along grain boundaries.

The writer has studied thin sections and insoluble residues of several quartzose limestones and dolomites and finds that calcite and dolomite replacement of quartz is common and that microetching on many peripherally replaced quartz grains produces a surface texture that appears frosted (Pl. 1, figs. 1–4). Frosting of this type is easily mistaken under the binocular microscope for that resulting from aeolian abrasion, and failure to interpret its origin correctly may lead to erroneous conclusions concerning genesis of these carbonate sediments.

Misinterpretation of replacement frosting is most likely to result if the peripherally replaced grains are well rounded, because such grains have what might be considered the ideal shape of wind-transported sand grains. Partially replaced grains in most samples observed, however, are not well rounded because differential penetration of quartz by the replacing carbonates tends to increase grain angularity. The origin of the grain frosting on angular grains might be puzzling to the observer, but it probably would not be attributed to aeolian origin. The writer has seen many examples, on the other hand, in which replacement apparently had only slightly modified the shape of grains that were well rounded when deposited, and these rounded and frosted grains were readily mistaken for aeolian material (Pl. 1, figs. 2, 4).

Frosting observed on grains in most samples is a result of simple marginal replacement of quartz. The shape of the relic grains therefore depends in part on the shape of the original detrital grains and in part on the degree to which carbonates differentially penetrate the grains. Well-rounded and frosted quartz grains of more complex origin, however, have been observed in samples of oölite from the Ordovician Oneota formation near Madison, Wisconsin. The nuclei of the oölites in these samples are well-rounded quartz grains, many of which have secondary quartz overgrowths. The silica of the overgrowths in these samples is more susceptible to replacement than is the silica of the original quartz grains, and replacement tends to halt at the grain boundaries. Selective replacement has removed the overgrowth quartz on most grains and has produced frosted relics which have the well-rounded shapes of the original grains. These grains resemble frosted grains of aeolian origin (Pl. 1, figs. 3, 4). Steps in the replacement that has produced these unusual grains are shown in Figure 5 of Plate 1.

When considering the mechanism of quartz replacement by carbonates, two questions immediately come to mind. To what extent can replacement destroy detrital quartz grains in carbonate sediments, and what happens to the silica that is replaced?

In extreme examples quartz grains in carbonate sediments locally might be replaced completely and might result in a carbonate rock free of detrital quartz. Evidence of such replacement may be preserved as relic outlines of original grain boundaries, or it may be destroyed during the process of replacement or by later recrystallization. Complete replacement of detrital quartz is probably more significant than has been suspected.

The problem of what happens to the replaced silica is important because it concerns the problem of the origin of secondary silica in some sediments. An appreciable amount of silica is released by even partial replacement of quartz, and in those rocks in which replacement has been extensive it furnishes a volumetrically important source of material for secondary silification in associated sediments. After replacement, the silica may not travel far before it encounters an environment favorable for its precipitation. Such an environment might be a change in pH of the migrating solutions which would result in silica deposition by direct precipitation or by replacement (Correns, 1950, p. 53; Newell *et al.*, 1953, p. 162–166). The writer believes carbonate replacement of quartz (and also feldspar) as a local source of silica for secondary silicification has not received the consideration it deserves. In the forthcoming paper the writer will discuss this subject in detail.

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Plate 1.—CARBONATE REPLACEMENT OF QUARTZ

Figure 1.—Dolomite replacement of quartz-grain boundaries. Original well-rounded shape of quarts has been only slightly modified by replacement. Williams Canyon dolomite (Devonian?) near Manitou Springs, Colorado. Plain light, 50×.

Figure 2.—Insoluble residue of sample shown in Figure 1 of this plate. Frosting on grains is due to marginal replacement by dolomite. Sample has been sieved for clarity of illustration; fraction shown is medium sand grade. 15×.

Figure 3.—Selective replacement of overgrowth quartz by dolomite. Dark rings are oölite shells; dark spots are tangential sections. The oölite nuclei were originally surrounded by secondary quartz overgrowths that have been replaced by dolomite (gray mosaic within dark rings). The sequence of this replacement is shown in Figure 5 of this plate. Oneota dolomite (Ordovician) near Madison, Wisconsin. Plain light, 50×.

Figure 4.—Insoluble residue of sample shown in Figure 3 of this plate. Frosting on grains is due to marginal replacement by dolomite. Well-rounded shapes reflect rounding of quartz nuclei in Figure 3. A grain showing a remnant of unreplaced quartz overgrowth is near the center of the photo. Sample has been sieved; fraction shown is medium sand grade. 15×.

Figure 5.—Sequence of selective replacement of secondary quartz overgrowths. Roundness of overgrowths probably is due to abrasion, and indicates multiple cycle sand grains. Oneota dolomite (Ordovician) near Madison, Wisconsin. Plain light, 50×. A. Initial replacement of quartz overgrowths by dolomite. Note that replacement tends to halt at boundary of nucleus. B. Intermediate stage of overgrowth replacement. Dolomite has penetrated the nucleus at lower left but, in most places, has halted at the nucleus boundary. Adjacent clear areas are secondary silica that predates the dolomite. C. Advanced stage of overgrowth replacement. The overgrowth is almost completely replaced by dolomite. Unreplaced remnants remain along the left and upper right sides of the nucleus. Slight penetration of the nucleus is visible at lower left. Further replacement would remove all traces of the secondary overgrowth, and differential penetration of the nucleus would continue.

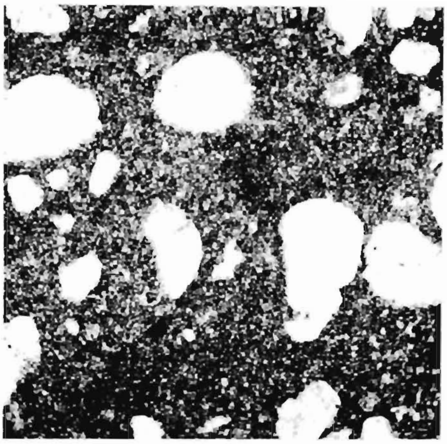

FIGURE 1

FIGURE 2

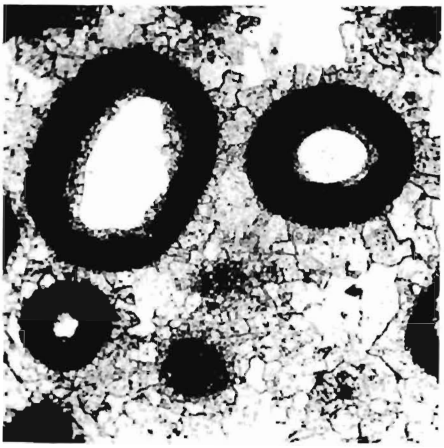

FIGURE 3

FIGURE 4

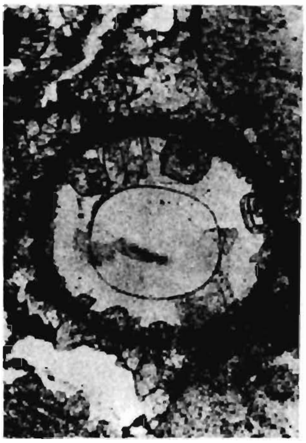

FIGURE 5A

FIGURE 5B

FIGURE 5C

CARBONATE REPLACEMENT OF QUARTZ