39. PETROGRAPHY OF THE SANDY DOLOSPARITE (UNIT 7) IN HOLE 549[1]

R. Borkowski and J. Mazzullo, Department of Geology, Texas A&M University[2]

ABSTRACT

The sandy dolosparite of Unit 7 in Hole 549 consists of large proportions of dolomite, quartz, and calcite, with lesser proportions of clay, hematite, and accessory minerals. The size of the dolomite crystals and that of the quartz-sand grains both increase upsection throughout the recovered unit; in addition, the quartz-sand content increases in a regular manner upsection in the unit. Calcite appears as crystalline inclusions within the dolomite, having formed by dedolomitization. A model for the formation of the unit is proposed in which the unit was deposited during a lowering of sea level and diagenetically altered during a period of subaerial exposure.

INTRODUCTION

A thin unit (Unit 7) of red, sandy dolosparite was penetrated between 664.15 and 673.85 m sub-bottom in Hole 549. The recovered sections of the unit, which total 148 cm in thickness (15% of the unit's total thickness) show a hard, massive, coarse-grained sandy dolomite lithology, stained red and containing black and yellow streaks and lenses of clay and iron minerals. The rock contains few fossils, so its age cannot be accurately determined, but a few poorly preserved foraminifers and the ages of surrounding rocks suggest that Unit 7 is lower Albian (Sigal, this volume). The unit is very distinct from both the underlying Barremian syn-rift sediments and the overlying lower–middle Albian post-rift sediments. It is considered to represent the first in a sequence of post-rift sediments, but because of the paucity of fossils, this conclusion is still tentative.

In this chapter we examine this sandy dolosparite unit in detail, discussing the results of our thin-section and luminescence petrographic studies and X-ray analyses of samples from the unit. From these data we then postulate an origin for the unit and attempt to fit it into its proper stratigraphic and structural setting.

TEXTURE AND COMPOSITION OF THE SANDY DOLOSPARITE

The predominant components of the rocks of Unit 7 are dolomite, quartz, calcite, and hematite; plagioclase feldspar, clay minerals, volcanic rock fragments, foraminifers, and echinoderm plates occur in trace amounts.

Quartz

Thin-section examination shows that most of the quartz is monocrystalline, with both simple and undulose extinction; polycrystalline quartz is present as well, but only in minor amounts. Many varieties of monocrystalline quartz are present: water-clear volcanic quartz with simple extinction and remnants of beta-quartz habit (Fig. 1); heavily vacuolized plutonic quartz with simple extinction (Fig. 2); subrounded undulose grains with parallel Boehm lamellae (presumably of low-grade metamorphic origin; Fig. 3); and sedimentary quartz grains with relict (i.e., source-inherited) overgrowths (Fig. 4; Blatt, 1982). The polycrystalline quartz grains are all plutonic varieties composed of 3 to 7 coarse-grained quartz crystals, each with undulatory extinction, vacuoles and inclusions, and straight or curved crystal contacts (Fig. 5; Young, 1976).

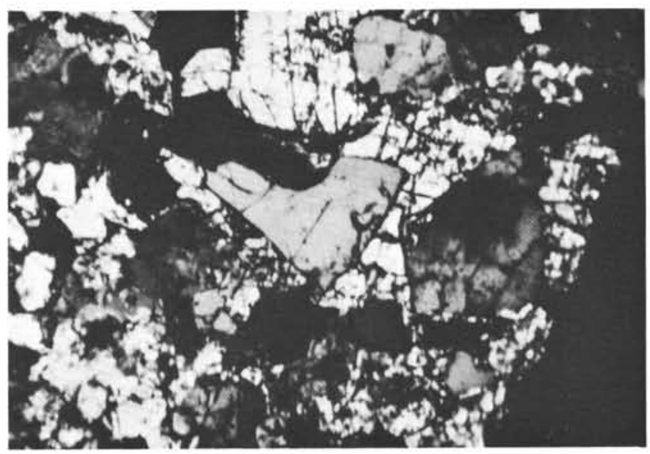

Figure 1. Water-clear volcanic quartz grain with remnant beta-habit, Sample 52-1, 32–35 cm. Note also the well-crystallized coarse dolomite surrounding the quartz grains. Crossed nicols; magnification = 120×.

The proportions of monocrystalline and polycrystalline quartz vary in a regular manner throughout the recovered unit (Fig. 6). In Section 52-1, the lowermost sample (at 126–129 cm) contains only 4% monocrystalline quartz (Fig. 7A). In the next sample above (at 108–111 cm), the monocrystalline-quartz content increases sharply to 26%, and from this point in Section 52-1 upward to the top of the core it increases, albeit erratically, to a maximum of 36% (Figs. 6 and 7B). The polycrystalline-quartz content also increases upsection in Core 52, from 0–1% at its base to 3–4% at its top. In Section 53-1, the proportion of monocrystalline quartz varies between 1 and 13%; no polycrystalline quartz was noted in this section.

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[1] Graciansky, P. C. de, Poag, C. W., et al., *Init. Repts. DSDP*, 80: Washington (U.S. Govt. Printing Office).

[2] Address: Department of Geology, Texas A&M University, College Station, TX 77843.

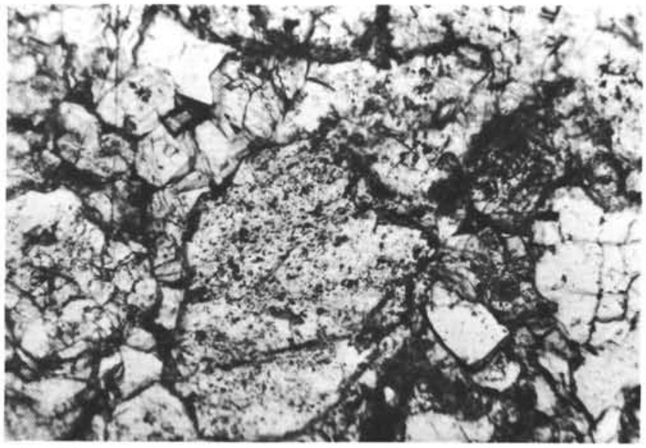


Figure 2. Heavily vacuolized plutonic quartz, Sample 52-1, 20–23 cm. Note also the dark hematite rim around the quartz grain. Plane-polarized light; magnification = 120×.

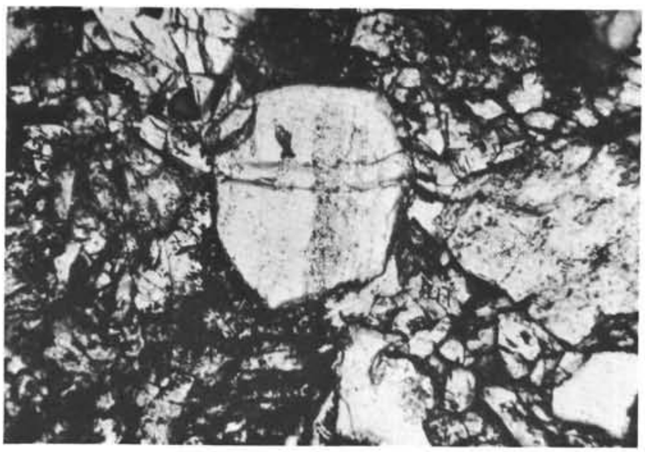


Figure 3. Quartz grain with parallel Boehm lamellae, Sample 52-1, 20–23 cm. Such a feature indicates a low-grade metamorphic rock source. Plane-polarized light; magnification = 120×.

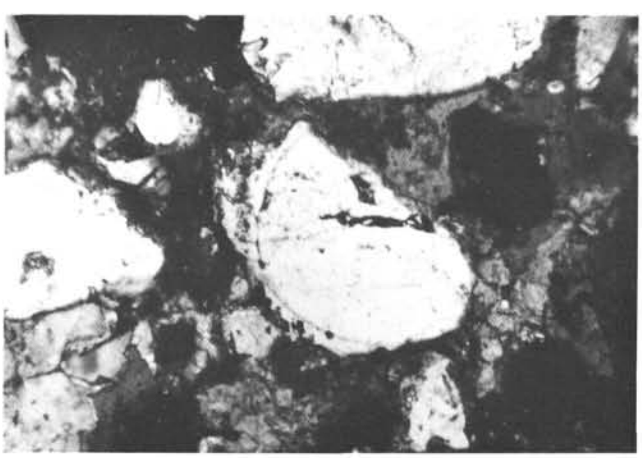


Figure 4. Sedimentary quartz grain with clay or iron stain outlining the detrital core, Sample 52-1, 20–23 cm. Many of the quartz grains in this rock do not show evidence of any post-depositional silica precipitation, so it is presumed that this overgrowth is a source-inherited feature. Crossed nicols; magnification = 120×.

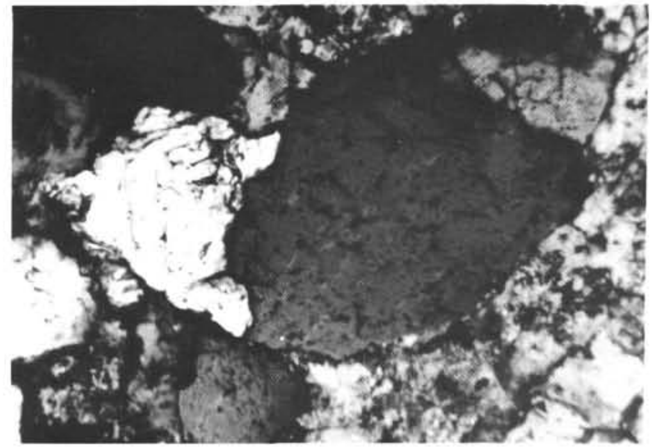


Figure 5. Polycrystalline quartz grain with three large quartz crystals and abundant vacuoles and inclusions, Sample 52-1, 32–35 cm. Crossed nicols; magnification = 120×.

For purposes of quartz grain-size measurements, splits of each sample were boiled in dilute HCl for 30 min. to dissolve all carbonate cements and clasts, and then bathed in dilute HF for 10 min. to remove clays, hematite, and non-quartzose grains. After drying, a split of each sample was mounted in glycerine on a glass slide, and the long axes of 100 randomly chosen quartz grains were measured under the microscope with an optical micrometer. Data were stored and analyzed by using a CROMENCO microcomputer.

The quartz fraction in all the rocks consists of very well sorted fine and medium sand; all grains from all samples average 0.184 mm in long diameter, with a standard deviation (sorting) of 0.084. Mean quartz grain size increases noticeably between the bottom and the top of Section 52-1 (Fig. 6), from 0.14–0.16 mm (fine sand) near the base to 0.26–0.28 mm (medium sand) at the top. This upward-coarsening trend is accompanied by a small but consistent decrease in sorting (Fig. 6), and parallels the increase in quartz content upward in the section.

Dolomite and Calcite

The thin sections were etched and stained with a mixture of potassium ferricyanide and alizeran red-S to aid in distinguishing calcite and dolomite. Examination indicates that euhedral and subhedral dolomite are the major components of this unit, comprising a minimum of 51% of each sample (Fig. 6). The average size of the dolomite rhombohedrons, and the range of crystal size, change upward in the unit from equigranular, fine sand-sized particles in Section 53-1 and in Sample 52-1, 126–129 cm to coarse-to-fine sand-sized crystals in the remainder of Section 52-1. This change in the dolomite crystal grain size and fabric parallels trends in the quartz-sand grain size, and presumably reflects a higher initial porosity in the uppermost coarser sediments.

Hematite and ankerite are associated with both dolomite types in this unit, although they appear to be more abundant in the finer-grained dolomites near the base of

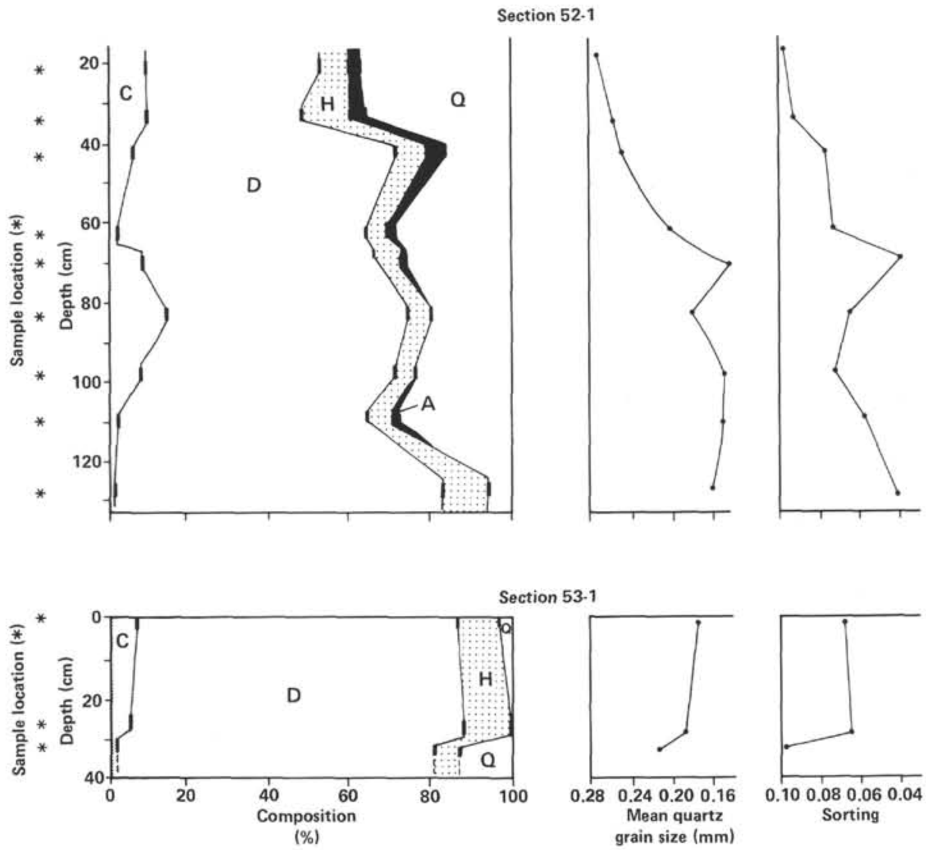


Figure 6. Graphs showing the proportions of components in Unit 7 and grain size and sorting trends. On compositional plots, C = calcite, D = dolomite, H = hematite, A = accessory minerals (feldspar, volcanic rock fragments, etc.), and Q = quartz.

the unit. In addition, many of the quartz grains have been etched by, and to some degree replaced by, the dolomite (Fig. 8), although it is likely that this silica replacement occurred not during dolomitization but in an earlier calcification stage.

Calcite is a minor component in this rock, comprising 2 to 14% of the unit. It can be clearly differentiated from the dolomite by cathodoluminescence: under electron-bombardment it appears as luminescent patches of zoned, coarse, sparry calcite rhombohedrons or minute inclusions of calcite floating within—and presumably replacing by dedolomitization—the dolomite (Fig. 9; Frank, 1981; Evamy, 1981). Together, calcite and dolomite comprise 87 to 99% of the rock in Section 53-1 and in Sample 52-1, 126–129 cm. Through the remainder of Section 52-1, there is a slight decrease in the amount of calcite and dolomite, owing to dilution by detritus, from 72% (108–111 cm) to 60% (20–23 cm).

Hematite

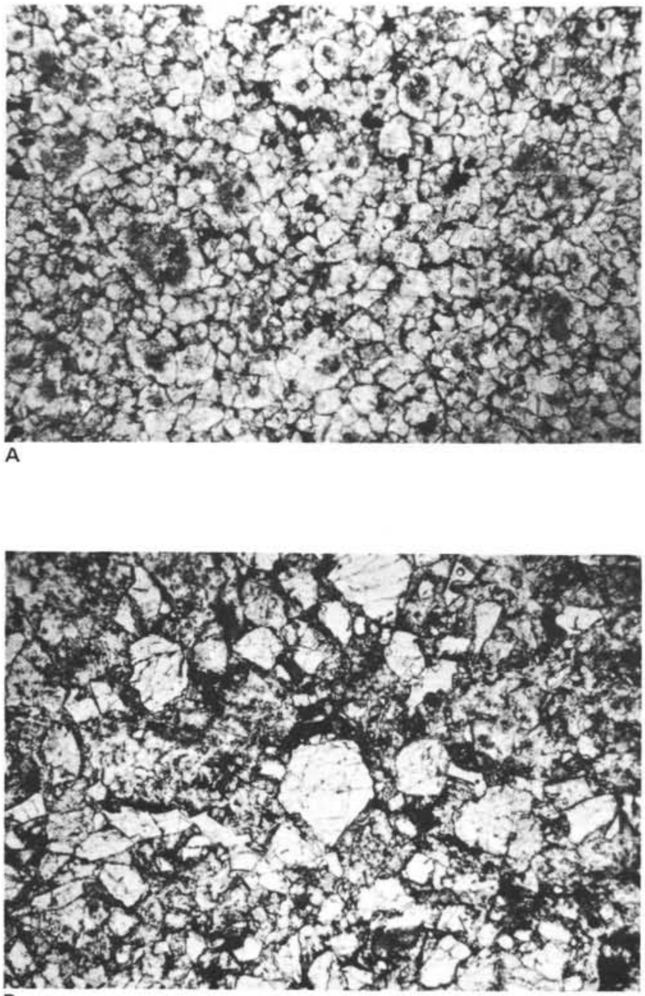
Hematite is a pervasive mineral in this unit, present in fairly substantial amounts (6–13%), and gives the unit its distinctive red color. It occurs as a very fine granular mass lining all dolomite rhombohedrons and quartz grains and filling much of the available pore space, thus eliminating most remnant microporosity (Fig. 8).

Other Components

Clay minerals occur as minor pore fillers and pore liners in the rock of Unit 7. Thin-section and X-ray analyses identify these clays as illite, montmorillonite, and mixed-layer illite-montmorillonite, which are usually associated with marine deposits rather than with continental or paralic deposits. Plagioclase feldspar is present in small amounts (1%) only in the two uppermost samples from Section 52-1. Volcanic rock fragments, either cherty or clayey rock fragments containing feldspar laths, are also present in trace amounts in these two samples. Sand-sized foraminifers and echinoderm plates are present but rare in the samples from Section 52-1.

CONCLUSIONS: DEPOSITION, DIAGENESIS, AND STRATIGRAPHY OF UNIT 7

The mineralogical and textural characteristics of Unit 7 suggest deposition in a shallow marine, sublittoral (upper part) to open marine shelf (lower part) setting during a relative lowering of sea level. Earlier deposition of the unit occurred in an open marine shelf environment, far removed from a clastic sediment source, where sedimentation was dominated by carbonate deposition. As regression and shoaling proceeded, increasing amounts of progressively coarser sand were supplied to the depo-



A

B

Figure 7. A. Sample from 52-1, 126–129 cm, showing the abundance of dolomite and the paucity of quartz. Plane-polarized light; magnification = 25×. B. Sample from 52-1, 32–35 cm, showing abundance of quartz-sand grains found at the top of the unit and the pervasive hematite surrounding all the grains. Plane-polarized light; magnification = 25×.

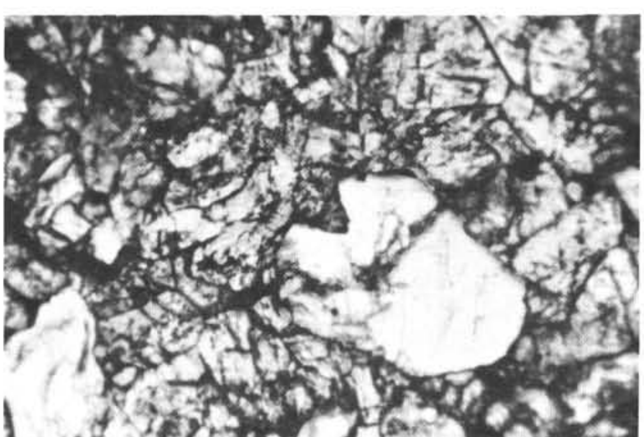


Figure 8. Quartz grain etched by dolomite, Sample 52-1, 20–23 cm. Also note the dark hematite, which lines quartz and dolomite and fills most available pore space. Plane-polarized light; magnification = 120×.

sition site, presumably from the reworking of quartz-rich nearshore sand accumulations. The last stage of sedimentation occurred in sublittoral or inner shelf environments proximal to a shoreline, where the supply of quartz sand was relatively high and where wave energy winnowed out any fine-grained sediment; here deposition of a coarse, mixed clastic–carbonate sand occurred.

During or shortly after deposition, while the sediment was still in an active marine phreatic zone, cementation and presumably neomorphism of skeletal grains resulted in the formation of sparry calcite, which cemented the rock and produced rhomb-shaped etch features on the quartz grains. Subsequently, continued regression and shoaling allowed gradual intrusion of a fresh-water lens into the rock, resulting in lowered pore-water salinity and super-saturation with dolomite. This led to replacement of all the carbonate grains and cement by dolomite, and obliteration of all primary textures and sedimentary structures. Continuing fresh-water intrusion resulted in total flushing of marine water from the pores and its replacement with fresh water; the low (< 1) Mg/Ca ratio in this fresh water initiated some replacement of the dolomite by rhombohedral calcite (Frank, 1981; Scholle, 1971; Evamy, 1981; Churnet et al., 1982). Hematite, a dedolomitization by-product formed by surficial weathering and oxidation of ferroan dolomites, presumably formed at this time as well (Al-Hashimi and Hemingway, 1973). Clay minerals also percolated into any remaining pore space during this period of apparently subaerial exposure.

Overall, then, Unit 7 was deposited in shoaling marine environments and later cemented in brackish and fresh-water paralic and continental environments. It is clearly in unconformable contact with the deep-water sediments of Unit 8 below. It is also apparent from our study, however, that the upper boundary of Unit 7 is an unconformity too, created during a period of subaerial exposure, as evidenced by both the dedolomitization and hematization of the rock. The unconformable contact of the shallow-marine to continental rock of Unit 7 with deeper-water sediments above and below suggests that it was deposited during a time of active tectonism and so should be considered part of the syn-rift sequence in Hole 549—not, as judged earlier, part of the post-rift sequence.

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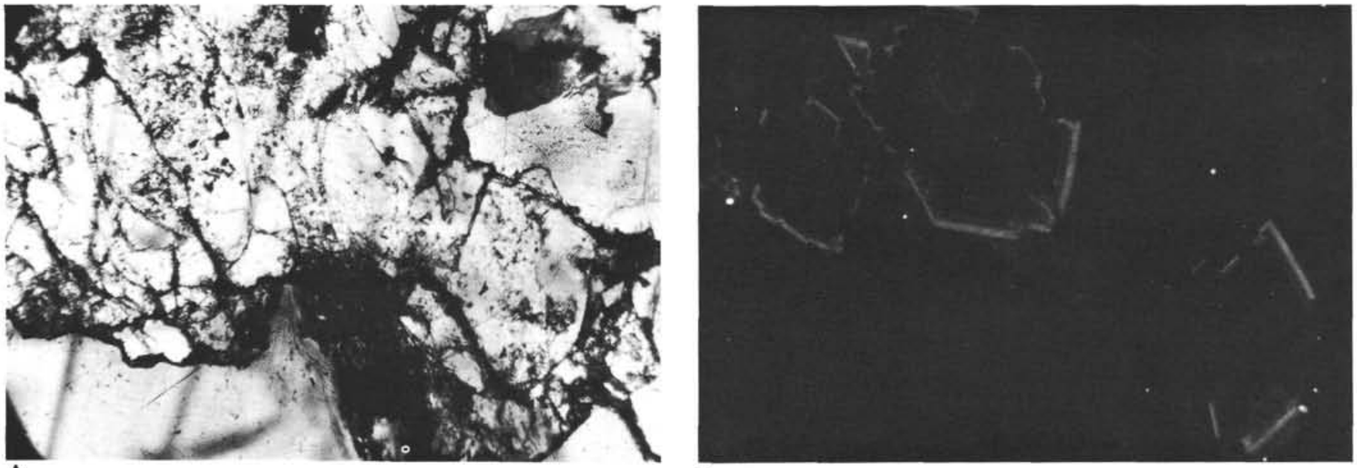

A B

Figure 9. Sample from 52-1, 32–35 cm. A. A photo demonstrating the optically continuous zoning of calcite within dolomite. B. This zoning is only detected optically by using a cathodoluminoscope, as shown here (light gray = calcite; dark background = iron-rich dolomite). Magnification = 200×.