———., 1910. Deuxième note sur le feldspath néogène des terrains sedimentaires non metamorphiques. *Bull. Soc. France Mineral. Cristall.*, **33**, 92.

Kastner, M., 1971. Authigenic feldspars in carbonate rocks. *Amer. Mineral.* **56**, 7 and 8, (in press).

Kastner, M. and Siever, R., 1972. *Authigenic feldspars in sediments* (in preparation).

Siever, R. and Kastner, M., 1967 Mineralogy and petrology of some Mid-Atlantic Ridge sediments. *J. Marine Research.* **25**, 263.

———., 1971. Shale petrology by electron microprobe: pyrite-chlorite relations. *J. Sed. Petrology.* (m. s. submitted).

Von Foullon, H. B., 1891. Ueber Gesteine und Minerale von der Insel Rhodus. Sitzber. Konig. Akad. Wiss. Wien, *Math. Naturw. Kl.* 100 C, Abt. 1, 144.

24.2. EXAMINATION OF SELECTED LITHIFIED ROCKS FROM SITES 121 – ALBORAN BASIN, 125 – IONIAN BASIN, 129 – STRABO TRENCH AND MOUNTAINS, AND 131 – NILE CONE

Joel L. Gevirtz, 27 Prospect Street, New Paltz, New York

INTRODUCTION

Deep-sea cores containing a variety of lithified carbonate and carbonate-clastic sediments were recovered from the Mediterranean Sea during Leg 13 of the Deep Sea Drilling Project.

The purpose of this report is to describe these lithified sediments and to attempt to draw some preliminary generalizations relative to the problem of cementation.

PROCEDURE

Lithified materials were sampled and subjected to textural and mineralogical analysis, using both optical and X-ray diffraction techniques. CuK α radiation was used in all diffraction mineral analyses.

To aid in the optical identification of carbonate phases, staining methods were employed. Where the exact location of a particular phase was desired, acetate peels were made and compared with standard thin sections.

RESULTS

Detailed descriptions of the rocks follow:

Sample 13-121-14-1, 144-148 cm – Alboran Basin.

The sample was taken from a section of core four centimeters long, consisting of a dark gray, well-lithified quartz sandstone. The grains are cemented by anhedral low-magnesian calcite (see also Chapter 30.1), with little pore space left between the grains. Some dolomite rhombs have formed at the expense of the calcite cement, as confirmed by diffraction analysis. Detrital grains consist predominantly of quartz with subordinate amounts of muscovite and biotite micas (see Figure 9 of Chapter 3). Some micritic rock fragments of detrital origin are present. Material resembling rock gypsum was observed, but the mineral was not confirmed by diffraction. The quartz grains range in size from coarse silt to medium sand, and in roundness from subangular to round. All of the genetic quartz types were identified. Organic particles include tests of foraminifera, filled partially or completely with pyrite. Some of these tests exhibit geopetal structure, indicating that they were free of lithic material at the time of deposition. The mica flakes exhibit some coarse form of alignment subparallel to the bedding surfaces. Numerous dark fragments of possible organic origin are present, and these too are aligned subparallel to the bedding.

Sample 13-121-15-1, 131-133 cm – Alboran Basin

The sample was taken from a rather thick unit of dark gray, fairly well-lithified quartz sandstone. This material is similar in appearance and in composition to that described above, although less well lithified. The boundary with the underlying unconsolidated sediment is sharp but irregular. Some of the underlying khaki-colored fine sediment is included in this unit as part of an elliptical structure which may represent a burrow of organic origin (see Figure 16 of Chapter 3).

Low-magnesian calcite, undergoing replacement by dolomite, was confirmed by optical as well as diffraction methods as the grain-cementing material. It occurs as isolated rhombs in the calcite cement. The edges of these rhombs are sharp, precluding the possibility of transportation.

Sample 13-125A-6-1, 137 cm – Ionian Basin

This sample consists of a light gray fragment from a crushed, partly-indurated crust at the contact between Lower Pliocene pelagic oozes (above) and dolomitic and pyritic marls (below) of the Messinian evaporite layer (see Figure 12 of Chapter 7). The piece is roughly cylindrical in shape and somewhat rounded, measuring 1.2 cm long by 0.8 cm in diameter. The mineralogy of the sample is stoichiometric dolomite, having a $\bar{1}\bar{1}0$ reflection peak at 2.98Å.

This fragment is fine-grained and is made up entirely of subhedral and euhedral dolomite rhombs. The subhedral rhombs are rounded at the edges. There is some suggestion of stratification in the fragment. Some of the layers appear to be less well-cemented than the remainder of the rock. No organic remains, such as tests of planktonic foraminifera, are in evidence.

Sample 13-129-1-1, Piece No. 2 – Strabo Trench

The sample was taken from a very friable dark gray quartz sandstone lying just above a buff laminated fine-grained limestone. The contact between these two rock types is sharp and irregular. The upper boundary, with unconsolidated sediments lying above, is sharp and is convex upward.

The rock is composed predominantly of quartz grains ranging in size from coarse silt to coarse sand. All grades of roundness are observed. Subordinate amounts of micas are present as well, and these are aligned parallel to the bedding surfaces. Large pyrite crystals are present. The low-magnesian calcite cement is scarce. Dolomite was identified in the diffractogram, but was not recognized in the thin section examined.

Sample 13-129-1-1, Piece No. 3 – Strabo Trench

The sample was taken from a buff colored limestone exhibiting laminar structures often parallel to the bedding direction, but sometimes resembling convolute laminae (see Figure 13 of Chapter 10). This material lies just below the poorly-lithified quartz sandstone described above. The contact between the two lithic types is sharp but irregular. The lower contact with unconsolidated sediments is sharp and oblique. The rock is well-lithified and consists of low-magnesian calcite. The dominant features of this rock are the prominant laminae which appear to be convolute. The laminae are comprised of concentrations of dark fibrous material within the carbonate matrix.

The rock is cut by numerous veins oriented at various angles to the bedding direction. Stained peels show these veins to be filled with low-magnesian calcite. Some portions of the sample contain filled structures which resemble tracks or trails or organic origin. Examination of the rock in thin section reveals the presence of minor amounts of quartz silt. The mineral was confirmed in the diffractogram.

The rock contains numerous organically derived particles; dominant among these are tests of planktonic foraminifera and single valves of unornamented ostracods. The foraminiferal tests are commonly filled with pyrite, and less commonly with sparry calcite. The matrix of the rock appears to have undergone some process of grain growth, showing visible anhedral grains of calcite in some portions.

Sample 13-129A-2-CC – Strabo Mountains

This sample was taken from a large fragment which had lodged in the core catcher. The sample consists of a light gray fine-grained dolomite, with numerous freckle-like holes filled with similar material appearing on the cut surfaces. The rock is fairly soft and highly porous; the pores are not visible except under high magnification, when they appear along the grain boundaries. Thin section examination of the texture shows the rock to be comprised of rounded and broken dolomite rhombs, of uniform size. No other features of organic particles are present. An insoluble residue indicates the presence of minor amounts of clay-sized material, which X-ray analysis shows to be quartz. The dolomite present is not stoichiometric, but appears to be rich in calcium, as shown by the $\bar{1}\bar{1}0$ reflection occurring at 2.91Å, rather than at 2.89Å as would be expected for stoichiometric dolomite. The predominance of calcium in the lattices would probably lead to some disorder; thus, the mineral is probably a form of protodolomite.

Sample 13-131A-5-1, 130 cm – Nile Cone

The sample consists of four large fragments of a thin brown limestone unit. This unit corresponds to a distinct seismic reflector (see Chapter 12), thus it is probably continuous in the area of the Nile Cone. The fragments are of a soft brown fine-grained matrix, in which are embedded numerous tests of planktonic foraminifera, unornamented ostracods, and larger molluscan shells, quite badly leached. The rock incorporates streaks of darker sediment which are not as well lithified as the matrix. Under the petrographic microscope, the material appears very dense and extremely fine-grained. The fossil tests are often partially or completely filled with sparry calcite. By grinding the section extremely thin, the matrix is seen to be comprised of very fine crystals. X-ray diffraction shows that low-magnesian calcite is present, but the peak generated by the $\bar{1}\bar{1}0$ reflection is very weak.

SUMMARY

The lithified sediments recovered by DSDP Leg 13 in the Mediterranean Sea may be classified into four discrete types, based on texture and composition.

Type I: Calcite-cemented Quartz Sandstones

Three of the samples examined into this category: 13-121-14-1, 13-121-15-1, and 13-129-1-1, 46-48 cm. These rocks are all dark gray quartz sandstones cemented by calcite, differing only in the amount of cement, and contain minor amounts of pyrite, commonly filling fossil tests. All contain some carbonaceous laminae. Differences in lithification between the three samples may reflect post-lithification solution of the calcite cement. The dolomite indicates that at some time in their post-lithification history they were exposed to magnesium-rich brines. This has formed dolomite at the expense of low-magnesian calcite, much like processes of refluxion postulated for recent sediments in carbonate depositional terrains.

Type II: Fine-grained Laminated Limestone

Only one sample properly falls into this category: 13-129-1-1, Piece No. 3. This is a fine-grained buff limestone containing laminae of possible organic origin (i.e., algal filaments).

Type III: Fine-grained Dolomite

Two of the samples examined are members of this group. Stratigraphically, they are assigned to the late Miocene evaporites. The two samples appear to be texturally identical, both comprised of fine subhedral and euhedral dolomite grains. Mineralogically, however, they differ in that one sample (13-129A; 2-CC) consists of a somewhat disordered calcium-rich protodolomite, while the other (13-125A-6-1) is stoichiometric dolomite.

Dolomites having similar textural properties to those described here may be formed by two discrete processes.

1. The dolomite rhombs may be directly precipitated from sea water, either from the overlying watermass or from interstitial water. In the present case, precipitation from the overlying watermass is more probable, because no sediment particles such as foraminiferal tests or detrital grains are included in the sediment.

2. Dolomite may be formed at the expense of aragonite, when the latter is in contact with magnesium-rich brines. The brine necessary for the dolomitization of aragonite—a common evaporite mineral in Dead-Sea-like basins—could occur as dense water enriched in magnesium by prior precipitation of carbonates and sulphates of calcium. The texture of these dolostones indicates that the rhombs of dolomite may have undergone some rounding by transportation. This implies that the rhombs might have been deposited under conditions quite different from those prevailing at the time they were formed. The problem cannot be solved with certainty at this time, due to the lack of stratigraphic information.

Type IV: Well-lithified, Poorly Crystallized Limestone

The only sample in this group is the sample from the eastern Mediterranean Sea: 13-131A-5-1. The age of this material is late Pleistocene, and it occurs in the distal portion of the Nile Cone. Due to the unusual nature of this material, conclusions regarding genesis are premature.