10. PETROGRAPHIC AND SEDIMENTOLOGICAL STUDY OF THE CRETACEOUS-PALEOCENE SEQUENCE OF HOLE 398D

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INTRODUCTION

The aim of this paper is to report the results of a petrographic study of thin sections of Cretaceous and Paleocene sediments of Hole 398D. An important part of the material for this study was provided by different people (Debrabant, Rehault, Sigal). Special attention was directed to certain aspects, such as evidence for biological activity, and the breccias and the gaps in the stratigraphic column. In view of the restricted number of thin sections (about 200), divergences with other studies and omissions are likely to occur. Figure 1 summarizes the petrographic features in thin-sections of the Cretaceous and Paleocene sediments in Hole 398D.

MAIN POINTS AND COMMENTS

Organic Matter; Indexes of Biogenic Activity

The types of organic matter that are or were present in the sediments include vegetal debris and pyritized burrows transformed from organic rich material.

The first organic matter type consists of vegetal debris, which is especially abundant in Cores 131 to 79, but is also present below (Cores 138 to 131) and above (Cores 79 to 56) this interval. These vegetal fragments frequently occur in silty material, and both have a terrigenous origin (Deroo et al., this volume). The size of these vegetal fragments varies, but is comparable in grain size to the silt that contains them. The plant debris is pyritized in some beds. Vegetal debris is also present in the matrix of the debris flows (Cores 124 and 117; see Plate 1), in which sediments of both pelagic and terrigenous origins were mixed during transport.

The second type of organic matter is not directly visible, but may have been responsible for pyritic concentrations, i.e., the contents of many burrows have been diagenetically altered to pyrite. In these cases, we assume that the pyrite is due to the transformation of organic-rich material. The pyritized burrows are abundant in Cores 138 to 56, especially in the less-transported (or "autochthonous") sediments.

Pyritic spherules are generally present in the pre-Senonian sequence, but are particularly abundant in Cores 79 to 56 (Units IV and V of Sigal, this volume), where they form thin layers (Plate 2, Figures 3 and 4). They possibly result from organic matter (transported, sorted, and accumulated on the sea floor), and later transformed into pyrite. They might also be condensed layers or hard grounds, on which the organic matter was concentrated. Whatever their origin, this abundance of pyritic spherules is a characteristic of Units IV and V, perhaps because the terrigenous silty fraction decreases and the pelagic fraction increases in these two units.

Clastic Sediments

Four main types of clastic sediments occur: (1) silt and clay, (2) breccia composed of pelagic limestone pebbles, (3) breccia composed of lithoclasts of platform carbonate origin, and (4) graywacke.

The first type contains the largest amounts of plant debris; it is terrigenous.

The three others are of a different origin and at least two of them (2 and 4) probably result from the erosion of submarine strata. The pelagic limestone pebbles are rounded and show internal flow-structures. They appear to result from the transport by slumping of material that was not completely hardened. Isolated reworked calpionellids in the matrix of Aptian breccias indicate that occasionally such resedimented oozes may be thoroughly mixed with younger sediments.

The presence of the graywacke layers has important implications, because they contain grains of quartz, biotite, muscovite, zircon, tourmaline, feldspar, together with carbonate gravels and radiolarians. The mineral grains obviously resulted from the disintegration of crystalline rocks, probably of Variscan basement. The presence of all these minerals together indicates poor sorting and a short transport history. The bioclastic fraction is of pelagic origin. Such mixed deposits have been described in Alpine sequences (Lemoine, 1967) and were interpreted as being the result of disintegration and erosion of basement rocks, along fault scarps in a deep marine environment (Figure 2). The pelagic limestone pebbles and the platform carbonate debris at Site 398 may be derived from the same outcrops.

Table 1 summarizes the ages of both the reworked elements and the matrix of breccias and graywackes.

Hiatuses: Possible Pauses in Sedimentation

The major discontinuity, in Sample 56-2, 18 cm, is the contact between black, gray, or green middle Cenomanian sediments and Senonian sediments (Sigal, this volume). The latter are composed of fine, red clays, interpreted as autochthonous, and thin, green layers with coarser reworked elements (carbonate gravels, radiolarians. This abrupt change in lithology seems to correspond to (1) a pause in sedimentation (late Cenomanian to early Senonian) or condensed sedimentation dur-

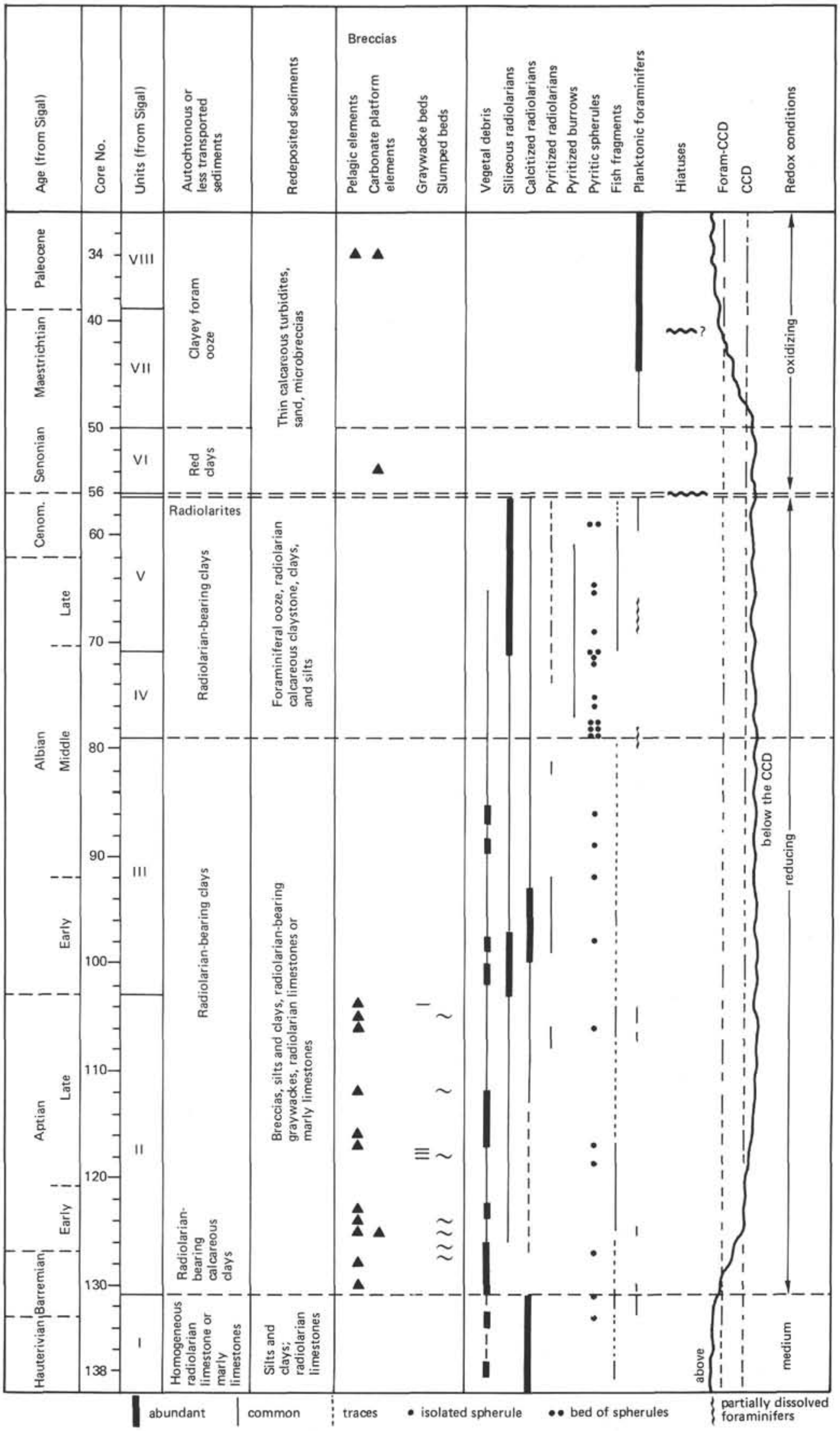

Figure 1. *Leg 47B, Hole 398D petrographic features in thin sections of the Cretaceous and Paleocene sediments.*

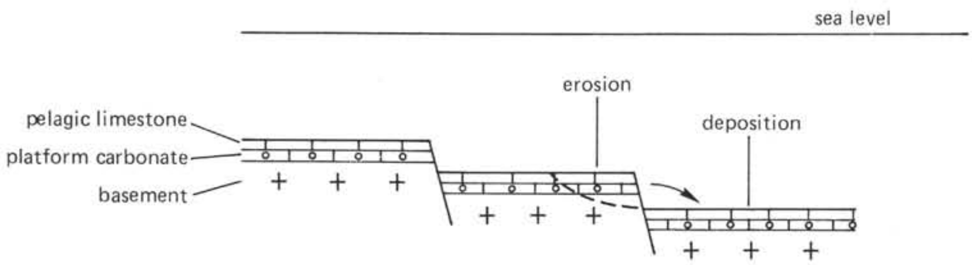

Figure 2. *Deep main erosional and depositional setting for mixed bioclastics in Hole 398D.*

ing the same period; (2) deepening of the bottom (or shallowing of the CCD) based on the fact that the lower, Cenomanian autochthonous sediments contain some organisms (radiolarians), while the younger red clays do not; and (3) a complete change of redox conditions, from reducing before and during the middle Cenomanian, to oxidizing later.

Such a sedimentary discontinuity is well known at approximately the same period at other localities in the Atlantic (Hollister, Ewing et al. 1972) and also in the Tethyan paleo-ocean (Bourbon, in press a). It may be related to a major tectonic (and/or climatic ?) event.

A minor discontinuity may be present at the boundary between the Cretaceous and the Tertiary. The shipboard book describes a strongly burrowed interval at this level, together with a thin clastic bed. I have not studied thin-sections from this interval, but I think it may correspond to a hard ground and a short interval of non-deposition. Such a pause in sedimentation is well established for this period in different parts of the world (Pacific, Atlantic, Tethys; van Andel et al., 1976; Lemoine, 1953; Bourbon, in press b). Nevertheless, this possible hiatus is not perceptible from the micropaleontological study (Sigal, this volume).

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TABLE 1
Petrography and Age of the Main Reworked Facies in Hole 398D

Sample (Interval in cm)	Petrography of Reworked Elements	Fauna in the Elements	Age of the Elements	Age of the Matrix (from Sigal, this volume)	Age Difference Between Elements and Matrix (m.y.)
33, CC	Grainstone with oncolites, pellets	Echinoids, benthic foraminifers, etc.	?	Early Eocene	?
54-1, 127-129	Grainstone with oncolites, pellets	Echinoids, benthic foraminifers, etc.	?	Senonian	?
104-1, 56-58	Graywacke (see below)		Variscan ? (age of the basement)	Late Aptian	150 ?
105-1, 16	Micrite	*C. alpina*	Late Tithonian-Berriasian	Late Aptian	25-35
106-1, 8-10	Micrite	*C. alpina* (dominant) *C. parvula, T. carpathica*	Late Tithonian	Late Aptian	35
106-1, 100-115	Micrite	*C. alpina* (dominant) *T. carpathica, C. boneti*	Late Tithonian	Late Aptian	35
112, CC	Micrite	*C. alpina, T. carpathica* (dominant), *T. longa* *C. simplex* ?, *C. oblonga, A. subacuta* ?	Late Berriasian	Late Aptian	25
116-1, 104-106	Micrite	*C. alpina*	Late Tithonian-Berriasian	Aptian	20-30
117-4, 52-56 117-4, 76-79 118-2, 72-74 118-2, 144	Graywacke : Qz, Feldspar, biotite, Muscovite, Tourmaline, zircon carbonate gravels		Variscan ?	Aptian	150 ?
124-3, 56-72	Micrite	*C. alpina* (dominant) *T. carpathica*	Late Tithonian-Berriasian	Early Aptian	20-30
125-3, 13-15	Grainstone with oncolites, pellets	Echinoids, benthic foraminifers, etc.	?	Early Aptian	?

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PLATE 1

Figure 1	Thin section of calcareous breccia: the pebbles consist of pelagic white limestone with radiolarians; the matrix shows fluidal deformation and consists of marly limestone, with radiolarians and vegetal debris. Sample 398D-128-4, 37-39 cm (Barremian).
Figure 2	Thin section of slumped bed of calcarenite, marly limestone, and silt: the marly limestone and the silt contain vegetal debris. Sample 398D-126-6, 100-102 cm (lower Aptian).
Figures 3, 4	Thin sections of calcareous breccia resulting from slumping: the pebbles are made up of pelagic white limestone with radiolarians; the matrix consists of pelagic marly limestone with radiolarians and vegetal debris. Sample 398D-125-4, 66-68 cm (lower Aptian); Sample 398D-124-3, 56-60 cm (lower Aptian).
Figure 5	Thin section of graywacke: probably slumped and with internal unconformities. Sample 398D-118-2, 144 cm (Aptian).
Figure 6	Thin section of slumped bed of marly and silty limestone with vegetal debris. Sample 398D-112-5, 36-38 cm (upper Aptian).

PLATE 1

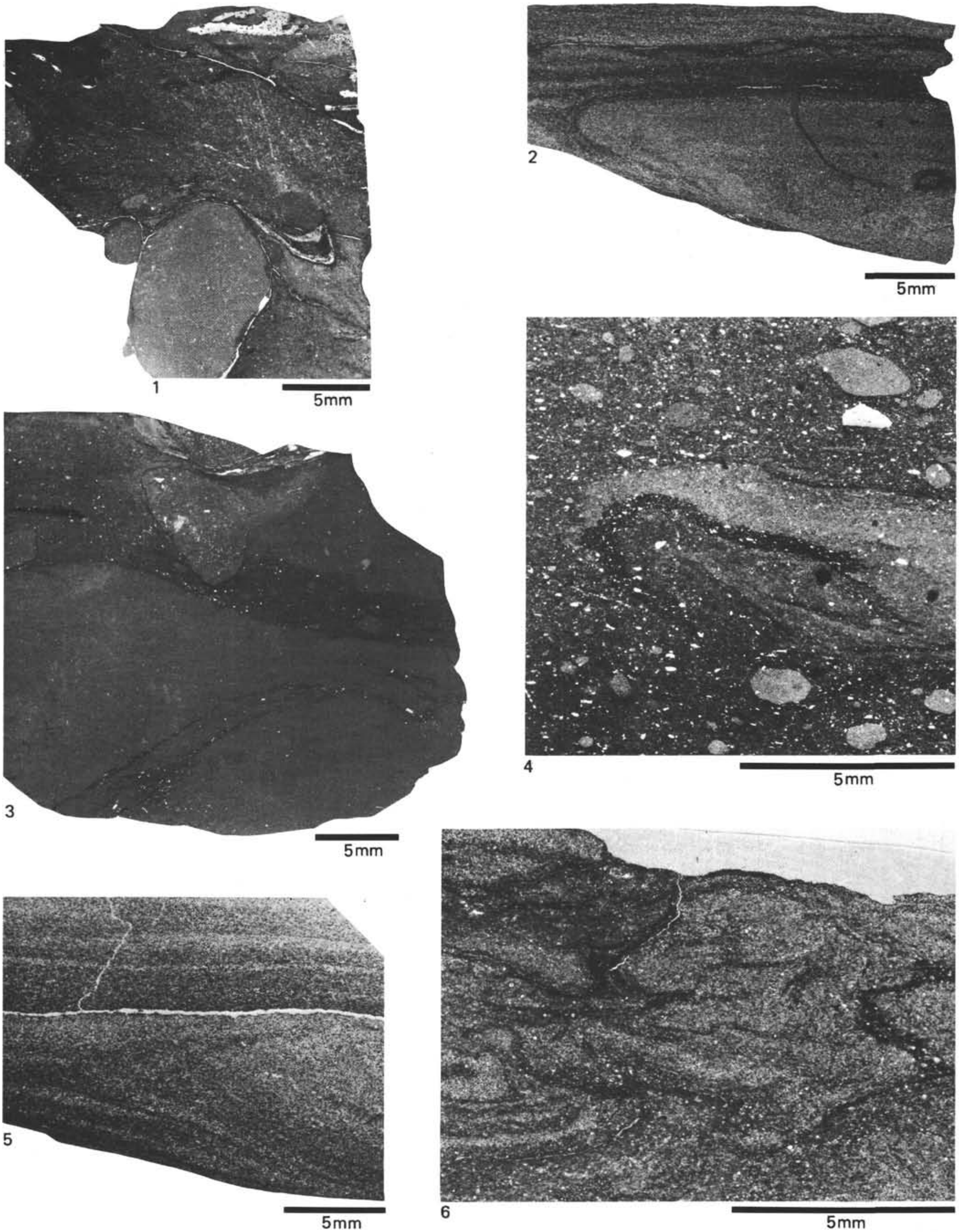
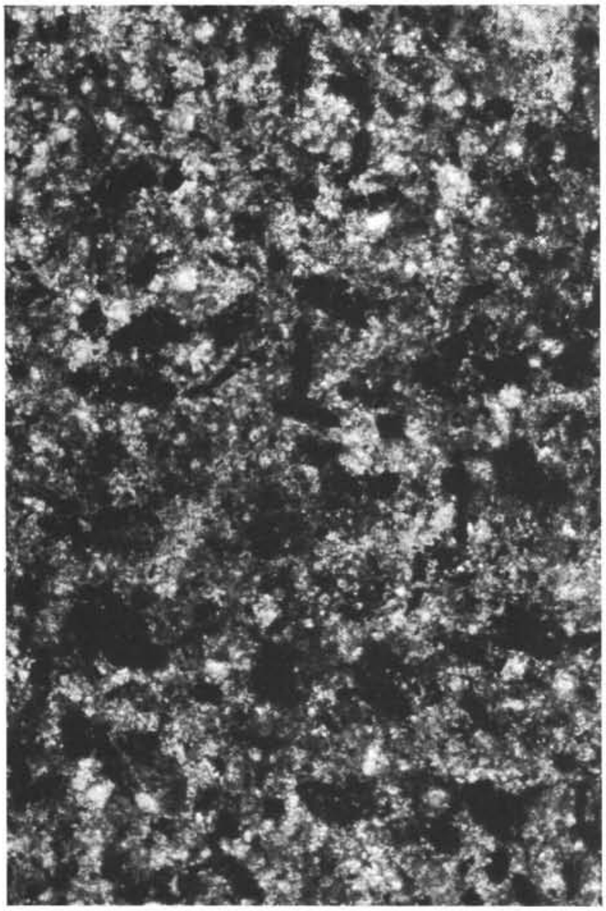


PLATE 2

Figure 1	Thin section showing accumulation of vegetal debris in a pelagic limestone. Sample 398D-129-6, 105-107 cm (Barremian).
Figure 2	Thin section with pyritized burrows, calcitized and partially pyritized radiolarians in a micritic pelagic limestone. Sample 398D-96-5, 76-78 cm (lower Albian).
Figure 3	Thin section showing microspherules or small masses of pyrite, partially pyritized radiolarians and pyritic infilling of foraminifers in a slightly calcareous claystone. Sample 398D-65-7, 8-10 cm (upper Albian).
Figure 4	Thin section of sinuous bed of microspherules or small masses of pyrite in a marly limestone. Sample 398D-92-4, 103-105 cm (lower Albian).
Figure 5	Thin section of siliceous radiolarians or molds of radiolarians in a claystone: bed of pyritic microspherules at bottom of photograph.

PLATE 2



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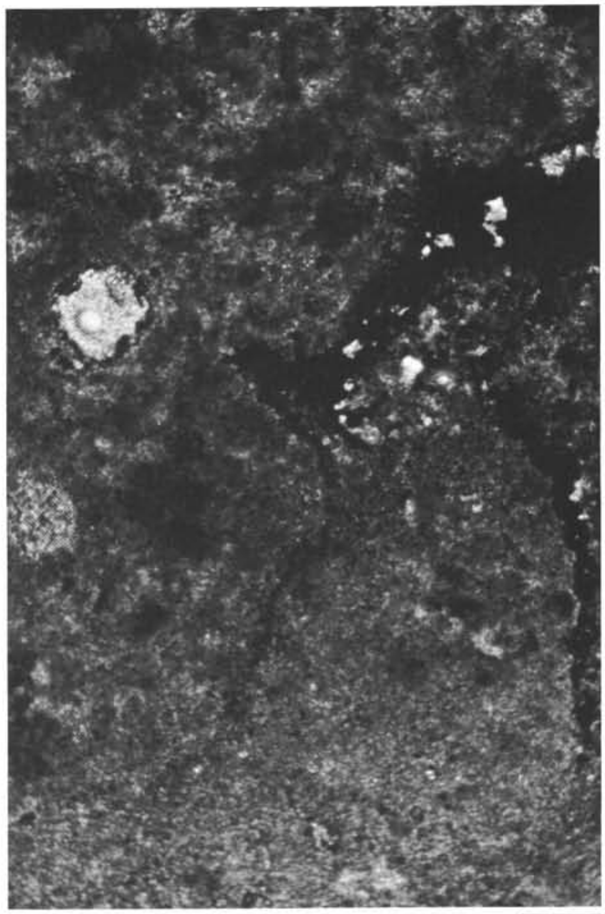

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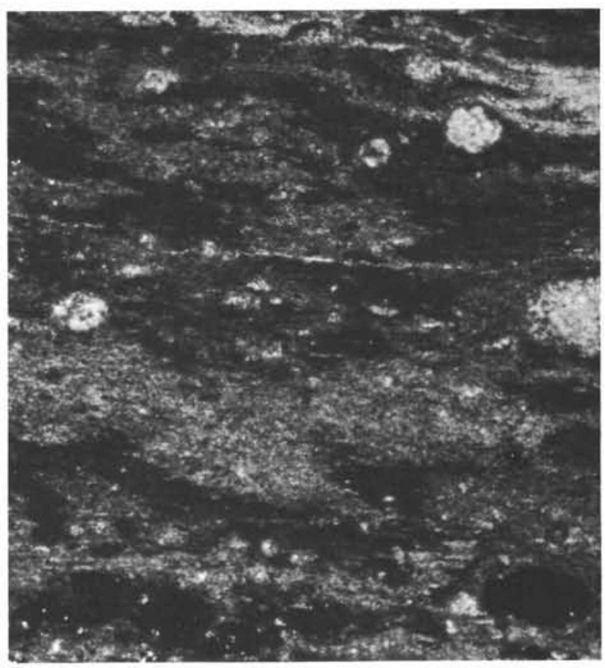

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