16. STRUCTURAL AND TEXTURAL CHARACTERISTICS OF DEBRITES FROM THE PHILIPPINE SEA

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ABSTRACT

Some conglomeratic and sandy deposits, cored in the Philippine Sea during DSDP Leg 31, were interpreted as debrites—deposits of debris flows. Core slices were analyzed for grain orientation and inclination, degree of roundness, grain-to-grain relationship, and grain size. The results of all measurements on 50 grains in each of the 23 slices do not show any clear relationship between any of the parameters. In general, the finer grains are less angular than the larger ones. The degree of orientation varies considerably, and only when two distinct groups of orientation (90° apart) exist, were a high number of near-vertical grains found. Comparison with similar measurements on turbidites fails to show any differences.

An overall indistinct macro-graded bedding was observed during visual observations; however, 40% of the slices showed a faint thin bedding during visual or radiographical description. No other sedimentary structures were observed.

The degree of orientation or inclination, as well as the ratio between floating and free grains, seems to depend more upon the viscosity and turbulence of the transporting debris flow or turbidity current than on the other textural parameters.

INTRODUCTION

During DSDP Leg 31 in the Philippine Sea a sediment type was cored at a number of sites that was interpreted as debris-flow deposits. Since little is known about the structural and textural characteristics of debris-flow deposits, a number of vertical and horizontal sample slices was collected and analyzed.

All collected slices were radiographed for an analysis of sedimentary structures. A selected number was then microscopically examined to measure orientation or grain inclination. At the same time the grain-to-grain relationship, or packing, was studied, and the size of each measured grain was determined. A few of the sample slices were thin sectioned to see if real differences exist between sample surface and the thin section sample.

Several studies on such parameters have been made on sandstones and conglomerates. Correctly, Pettijohn et al. (1972) express "At present we have the terminology and a little of the methodology, but we are desperately short of systematic mapping studies" (p. 89). The present authors are of the opinion that time-consuming studies like this have their value, in that empirically derived relationships on debris-flow deposits can be checked experimentally before developing meaningful theoretical-hydraulic theories.

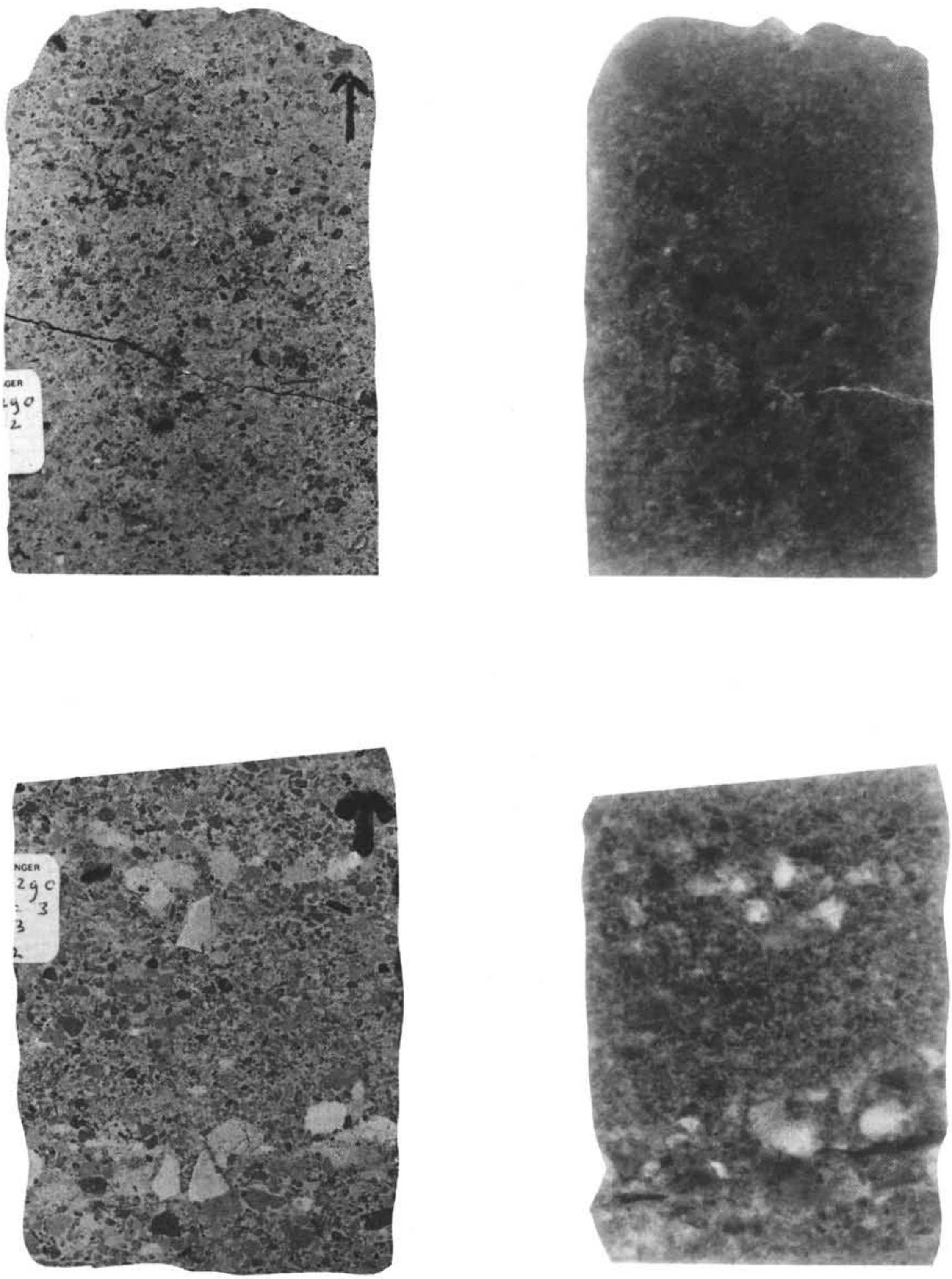
The weakest assumption in this study is the acceptance that these deposits resulted from debris flows. No conclusive criteria are known to make such determinations, but reference to the literature makes this assumption reasonably valid.

A number of successive coarse-grained (gravelly) debris-flow deposits (debrites, Bouma, 1972) were encountered in Core 8 at Site 290, while some coarse and fine-grained deposits were recovered from Site 296. In general the thickness could not be estimated due to interval coring. In the case of all these samples from the Philippine Sea, they were derived from a volcanic source area.

It is possible to interpret them as coarse-grained turbidites or the massive or graded lowest division of the turbidite model (Bouma, 1962, 1972; Walker, 1965, 1967; van der Lingen, 1969). Various authors have indicated that debris flows may represent an intermediate transport step between the initial slump and the turbidity current. Thus, it is likely that these fluxoturbidites (Unrug, 1963) or gravitites (Natland, 1963) are basically synonyms for debrites. Consequently, some thicker turbidites, having massive bedding in their "a" division, may reflect a transport mechanism which was more a debris flow than a turbulent flow. However, in the case of Core 8 from Site 290 no indications of the presence of higher turbidite divisions could be observed.

SEDIMENTARY STRUCTURES

Most of the gravelly debris-flow deposits at Site 290 (Core 8) show a vague graded bedding during a visual observation of the entire core. Although vague, about four to six successive debrites could be seen overlying each other. Some contacts were too vague to indicate whether such a zone was a fluctuation within one deposit or the boundary between two (see photographs



NATURAL SIZE

Figure 1. *Photographs (left) and prints of radiographs (right) of Samples 31-290-8-3, 0-9 cm #1 (top) and 31-290-8-3, 85-93 cm #12 (bottom). The top sample is fine grained and homogeneous; the bottom one is bedded with coarse-grained thin layers.*

and core descriptions in Site Report Chapter 2, this volume). Vertical samples of about 5 cm in height do not reveal any graded bedding. Most of the samples show massive bedding, both visually and by a radiographic analysis, but about 40% show some faint medium and/or thin bedding (see Bouma, Chapter 14, this volume). Figure 1 presents photographs and radiographs from a massive and a thin-layered debrite.

The finer-grained debris-flow deposits are a few centimeters to a few decimeters thick and are completely massive or homogeneous. They are interbedded between finer sandstones of similar lithology, which are massive or contain thin bedding, thin or thick parallel lamination, and/or foreset bedding (Bouma, Chapter 14, this volume). Figure 2 presents an example of two succeeding grain sizes, both without any sedimentary structures.

TEXTURAL CHARACTERISTICS

The following textural characteristics were measured on 23 sediment slices: long axis orientation or inclination (depending on the cut of the sample), grain-to-grain relationship, roundness, and size in millimeters (Table 1). The results are graphically displayed to facilitate the study on possible inter-relationships (Figures 3-5).

Only grains that had a length/width ratio of at least 3/2 were used to obtain orientation or inclination. Orientation of a grain refers to its direction in a horizontal plane, and inclination refers to the variation of the grains in degrees from the horizontal plane. In many cases a horizontal and a vertical slice were cut from the same rock sample, but except for a few cases, no notation was made to relate the direction of the vertical slice to the horizontal slice. In Figures 3-5 all orientation roses are oriented so that the longest vectors are in a horizontal direction. The variation is extremely large, ranging between well-oriented and nearly complete random orientation. In some cases two directions, 90° apart, can be distinguished.

A combination of the visual roundness classifications by Powers (1953) and Pettijohn (1957) was utilized. Very angular and well-rounded grains are exceptional. The majority of the grains fell in the angular, subangular, or sometimes the subrounded classes.

The grain-to-grain relationship or fabric was established according to Pettijohn et al. (1972). The only grain-to-grain relationships utilized were the free and the floating grains. The term free grain is defined by Allen (1962, p. 678) as a grain in which the free margin exceeds the fixed margin. A fixed margin is the part of a grain in contact with another in the plane of section, and free margin is that part of a grain that is not in contact with other grains in the plane of section. A floating grain has completely free margins; that is, it has no contact with other grains in the plane of section and is totally surrounded by matrix.

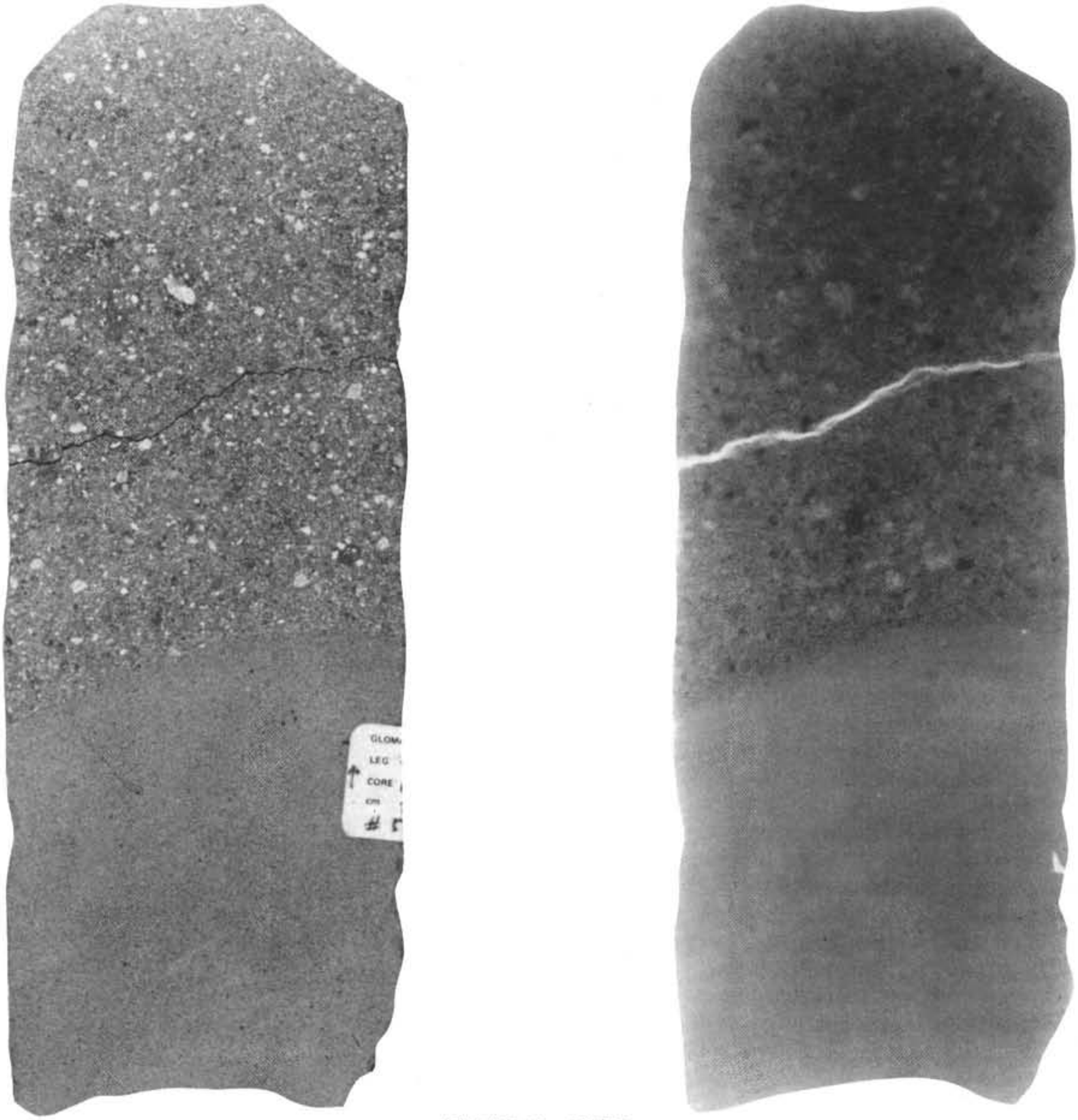
The grain size was measured with a measuring ocular to 1/20th of a millimeter. However, the graphic display (Figures 3-5) is given in 0.5 mm size classes.

In each sample slice 50 grains were examined. The vertical axes for roundness and fabric are the same in Figures 3-5, but for grain size this scale is extended by a factor of 2. In Figures 3-5, 10 samples are presented on which both orientation and inclination have been measured. No clear relationship could be observed between the degree of orientation and the degree of inclination. However, it seems that the number of near-vertical grains increases when the orientation rose presents the longest axes directions in two well-separated groups (90° apart). The best example is Sample 31-296-65-2 (Figure 5).

TABLE 1
Textural Measurement on 50 Grains From Horizontally Cut Sample Slice 31-290-8-1 #5, 123-124 cm

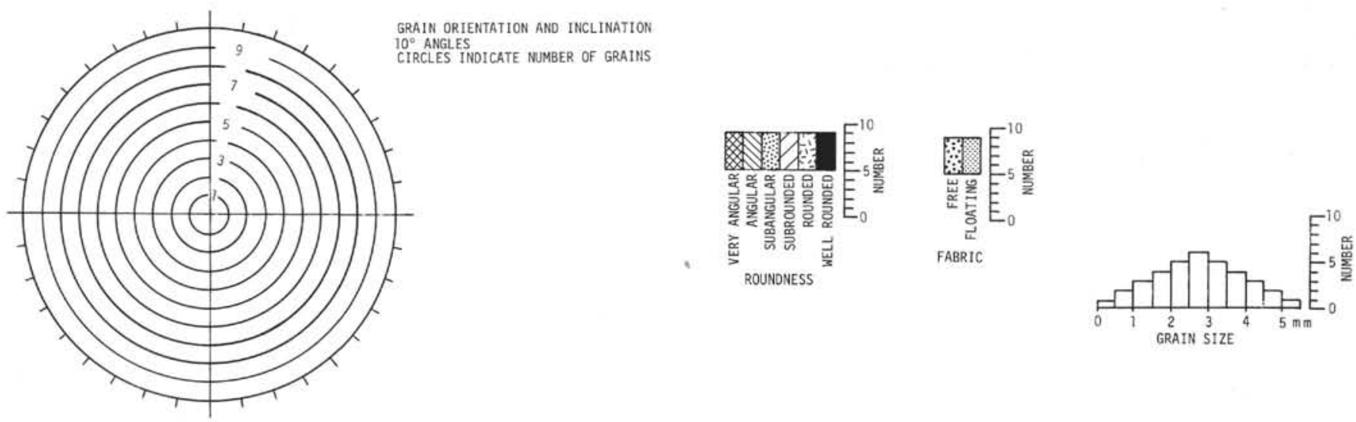
Orientation	Size (mm)	Roundness	Fabric
34.1°	1.9	Subrounded	Free
118.7°	0.9	Rounded	Free
95.7°	0.5	Rounded	Floating
43.0°	1.3	Angular	Floating
6.1°	1.45	Subrounded	Floating
53.8°	3.3	Angular	Floating
22.8°	1.1	Subrounded	Floating
65.2°	1.8	Angular	Floating
63.4°	2.1	Angular	Floating
98.0°	2.3	Angular	Floating
19.0°	1.15	Angular	Free
71.5°	1.9	Very angular	Floating
77.2°	0.65	Very angular	Free
58.1°	1.2	Angular	Floating
58.5°	0.75	Very angular	Free
112.9°	0.75	Angular	Floating
129.8°	0.7	Subrounded	Floating
28.1°	1.35	Subrounded	Free
44.6°	0.65	Subangular	Free
51.2°	1.3	Subrounded	Free
13.4°	0.65	Angular	Floating
172.5°	0.4	Angular	Floating
83.1°	0.45	Rounded	Free
30.5°	1.9	Subangular	Free
71.9°	3.45	Subangular	Free
21.3°	0.7	Subangular	Free
21.6°	0.55	Subangular	Free
4.6°	0.6	Angular	Floating
114.8°	2.0	Subangular	Free
11.9°	0.5	Rounded	Free
40.0°	0.4	Angular	Free
41.8°	1.65	Subangular	Free
25.2°	1.55	Subrounded	Free
135.6°	0.85	Subrounded	Free
53.7°	0.75	Rounded	Free
150.7°	1.0	Subrounded	Free
174.0°	0.65	Angular	Free
36.6°	1.3	Subangular	Free
84.4°	1.0	Subangular	Free
97.3°	0.75	Subrounded	Free
148.0°	0.8	Subangular	Free
108.9°	0.55	Subangular	Free
143.4°	0.9	Subrounded	Free
20.1°	1.1	Angular	Free
129.9°	2.5	Angular	Free
176.3°	1.25	Angular	Free
93.7°	0.45	Subrounded	Floating
85.8°	0.95	Angular	Floating
169.1°	2.45	Subrounded	Free
21.2°	0.4	Subrounded	Free

Note: The data are graphically displayed in Figure 3 and are given in the same order the grains were measured according to a line-counting system. Only grains with at least a length/width ratio of 3/2 were analyzed.



NATURAL SIZE

Figure 2. *Photograph (left) and print of radiograph (right) of Sample 31-296-65-1, 22-38 cm. The top part is coarse-grained, the bottom half fine-grained. No primary sedimentary structure. Both halves are assumed to be deposits of debris flows.*



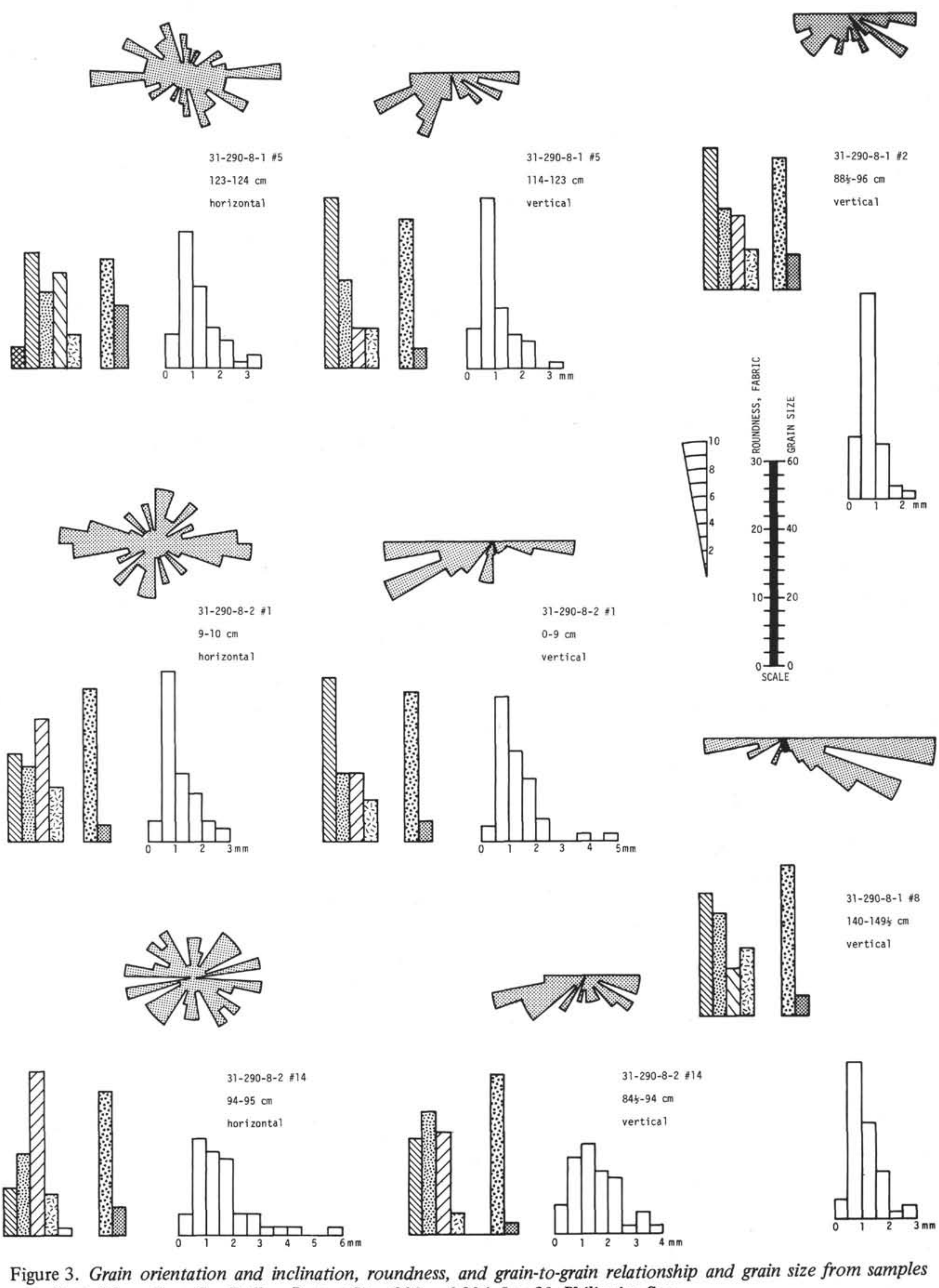


Figure 3. *Grain orientation and inclination, roundness, and grain-to-grain relationship and grain size from samples collected from Deep Sea Drilling Project Sites 290 and 296, Leg 31, Philippine Sea.*

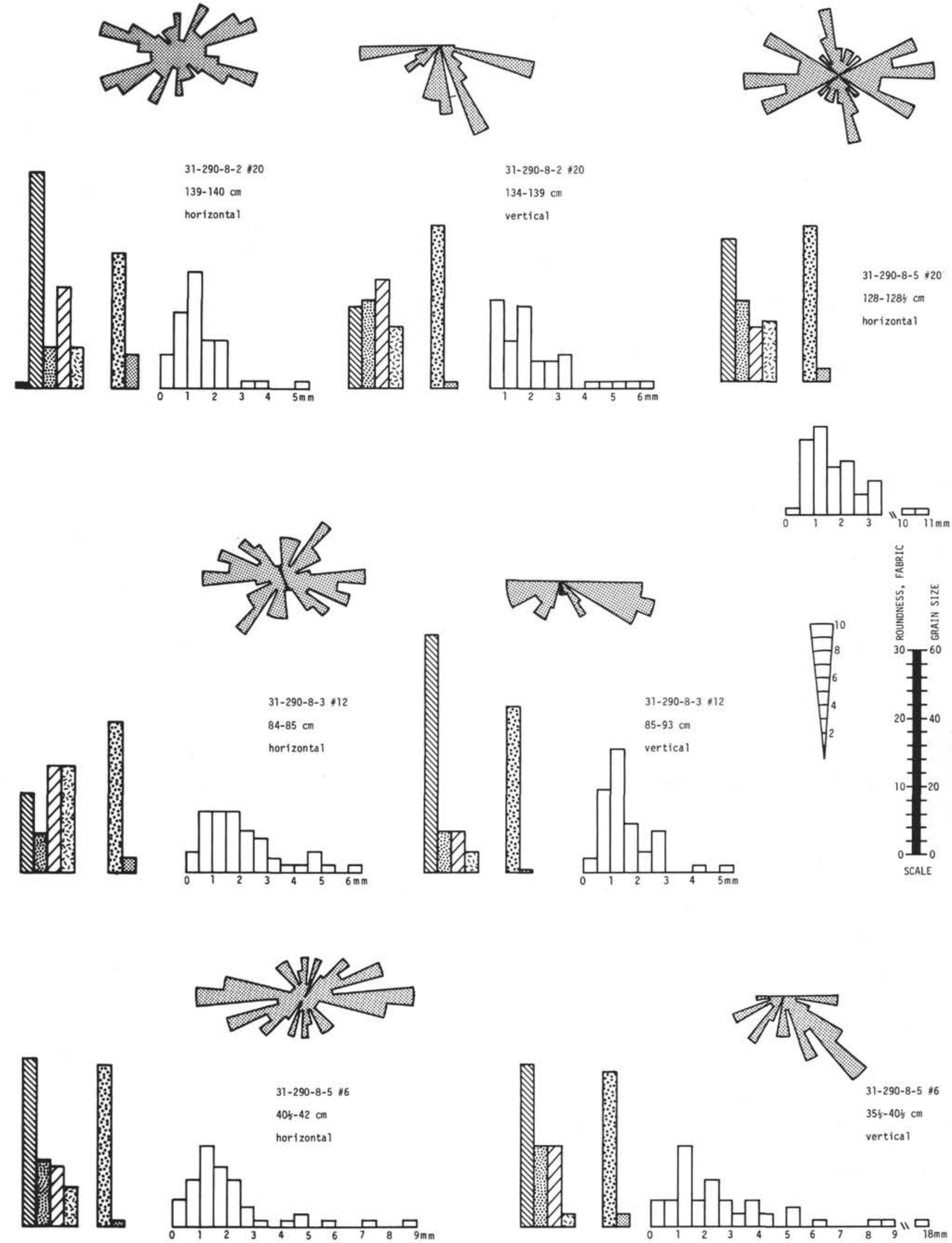


Figure 4. *Grain orientation and inclination, roundness, and grain-to-grain relationship and grain size from samples collected from Deep Sea Drilling Project Sites 290 and 296, Leg 31, Phillippine Sea.*

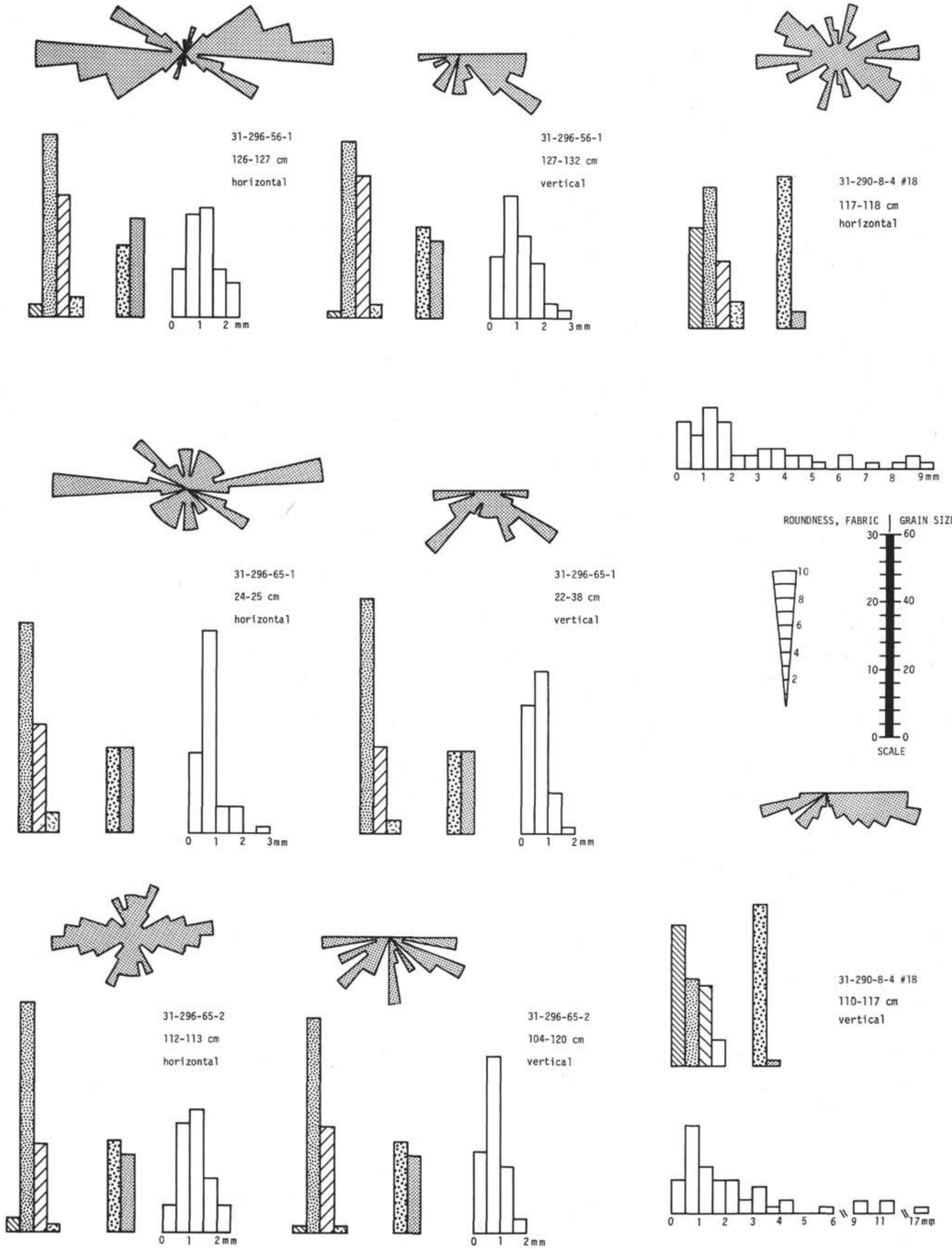
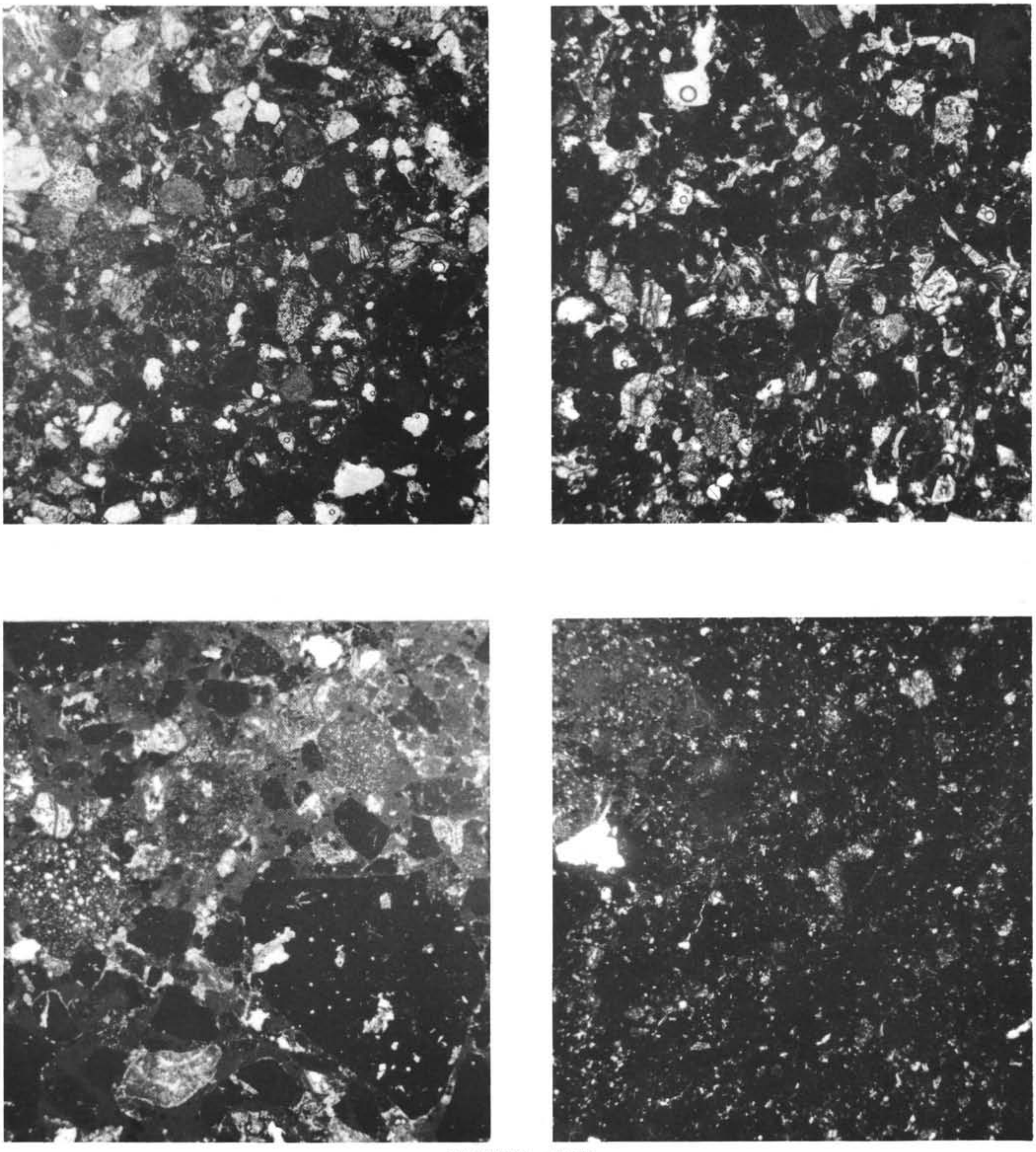


Figure 5. *Grain orientation and inclination, roundness, and grain-to-grain relationship and grain size from samples collected from Deep Sea Drilling Project Sites 290 and 296, Leg 31, Phillippine Sea.*



NATURAL SIZE

Figure 6. *Photomicrographs of thick thin sections from debris flow deposits. Scale: 26 mm on photograph is 6 mm on thin section. Upper row, left: 31-290-8-2 #1 horizontal; right: 31-290-8-2 #1 vertical. Lower row, left: 31-290-8-5 #6 horizontal; right: 31-296-65-1 #5 vertical.*

The finer-grained, and consequently better sorted, debris-flow deposits from Site 296 (Figure 5) tend to be more oriented than the mixtures of coarse- and fine-grained sediments from Site 290. However, it can be observed that within all samples from Site 290, the tendency exists for the degree of orientation to be related to the degree of sorting.

The finer-grained sediments have a much higher floating/free grain ratio than the coarser sediments, which in turn has a minor influence on the degree of orientation. It does not seem to influence the grain inclination.

The present authors feel that not enough data are available to justify the utilization of a computer program to establish relationships. Although the degree of sorting has a major influence when the samples are studied visually, it is believed that the viscosity, velocity, and presumably the degree of turbulence of a debris flow have more influence on the orientation and inclination of grains than the fabric, roundness, and grain size.

The photomicrographs, of which examples are presented in Figure 6, do not reveal much more information than can be obtained from the sample slices. However, the photographs show the grain-to-grain relationship and roundness better. Thinner thin sections may yield better results, but impregnation with a low-viscosity medium has not been attempted.

DISCUSSION

The data obtained from samples of debris-flow deposits on the orientation or inclination of the length axis of 50 grains per sample, together with the roundness, grain-to-grain relationship, and grain size on the same grains, do not reveal any strong relationships. In general, samples with smaller grain sizes, and consequently better sorting, present a more preferred orientation. The finer-grained ones also have more floating grains or a better floating/free grain ratio than the samples which are composed of many size fractions.

Grain inclinations show considerable variation, although there may be a tendency that the ratio of near-vertical grains to near-horizontal grains increases when grains show more orientation in two distinct groups 90° apart.

The finer grains are in general less angular than the coarser ones, but any systematic relationship does not exist between degree of roundness and degree of orientation or inclination.

No significant difference can be observed between these orientation/inclination data and that shown by Bouma (1962, figs. 20, 21), and Spotts and Weser (1964, figs. 5, 6). Consequently, the conclusion seems apparent that debris-flows deposits presently cannot be distinguished from turbidites on the basis of grain orientation and grain inclination.

The grain-to-grain relationship (free/floating grain ratio) and the absence of sedimentary structures, except for some indistinct overall graded bedding and some occasional faint thin bedding, may be used as the strongest criteria to identify a marine deposit as a debrite. It is suggested that the viscosity, the degree of turbulence, and maybe the velocity (horizontal shear stress) of the transporting mechanism have the strongest influence on the orientation, inclination, and grain-to-grain relationship of its deposit.

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