FILE.

INTERNAL DOCUMENT 170

# I.O.S.

PRELIMINARY REPORT ON THE PHYSICAL PROPERTIES
OF SEDIMENTS FROM LEG 86 OF THE DEEP SEA
DRILLING PROJECT

P.J. Schultheiss

Internal Document No. 170

October 1982



NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF
OCEANOGRAPHIC
SCIENCES

INSTITUTE OF OCEANOGRAPHIC SCIENCES

Wormley, Godalming,
Surrey GU8 5UB
(042-879-4141)

(Director: Dr. A. S. Laughton, FRS)

Bidston Observatory,
Birkenhead,
Merseyside L43 7RA
(051-653-8633)
(Assistant Director: Dr. D. E. Cartwright)

Crossway,
Taunton,
Somerset TA1 2DW
(0823-86211)
(Assistant Director: M. J. Tucker)

# PRELIMINARY REPORT ON THE PHYSICAL PROPERTIES OF SEDIMENTS FROM LEG 86 OF THE DEEP SEA DRILLING PROJECT

P.J. Schultheiss

Internal Document No. 170

October 1982

Work carried out under contract to the Department of the Environment



Institute of Oceanographic Sciences,
Brook Road,
Wormley,
Godalming,
Surrey, GU8 5UB

Introduction

Leg 86 of GLOMAR CHALLENGER left Honolulu on May 5th 1982, and arrived Yokohama on June 19th 1982, after sampling six sites in the western North Pacific. The primary objectives of the leg were to unravel the palaeo-oceanography of the North West Pacific, collect evidence of Cenozoic aeolian and authigenic deposition preserved in 'red clay' sections, and hydraulically piston core (HPC) the Cretaceous-Tertiary boundary at the location of DSDP Site 47 on Shatsky Rise.

The primary objective of my participation as 'Physical Properties Specialist' was to obtain undisturbed samples for laboratory permeability and consolidation tests especially from the 'red clays'. Although 'red clays' cover large areas of the Pacific sea-floor they are relatively scarce in the Atlantic. However, their importance to the study into the feasibility of disposing of high-level radioactive waste beneath the sea-floor is in the fact that they lie at one end of the pelagic sediment spectrum (coarse carbonate oozes lie at the opposite end). Many of the geotechnical properties of 'red clays' probably represent the limit that is found in deep sea sediments for having high plasticities, low grain size and probably the lowest permeabilities.

To date at IOS a wide range of near surface N. Atlantic sediment samples have been tested in the laboratory. In particular the permeabilities have been measured at decreasing porosities by applying a uniaxial load in a back-pressured consolidation cell. The consolidation characteristics of the sediments are also measured at the same time. The uniaxial load simulates the progressive increase in overburden pressure caused on the sea-floor by pelagic sedimentation. Consequently, predicted permeability/depth profiles are obtained from tests on these near surface samples. However, the rapid increase in load in the laboratory experiments are not comparable with the rate of loading imposed by the slow accumulation of sediment on the sea-floor. A load equivalent to 100 metres of sediment is normally applied over a period of 10 days; compare this to the 5-50 million years in which 100 metres of sediment would take to accumulate in the deep sea.

GLOMAR CHALLENGER Leg 86 provided a unique opportunity to obtain relatively undisturbed HPC samples from a continuous section of 'red clay' to a depth of 55 metres (Site 576), and to greater depths 170 metres (Site 578) but without continuous 'red clay' deposition. Consolidation and permeability tests on samples obtained from these sites are currently taking place at IOS which will enable the predicted consolidation/depth and permeability/depth profiles to be directly compared with the measured profiles. This will allow the assumptions that are made in laboratory experiments to be directly tested. In addition to this, the cores from Hole 576A (from which most of the samples were obtained) were transported back to the USA without being split and they have now been sub-sampled by a geotechnical consortium who intend to perform an extensive range of other geotechnical tests. This means that the consolidation and permeability data will be supported by a suite of geotechnical characteristics that together will define this sediment section in more detail than has previously been obtained on any other deep sea sediment.

Apart from obtaining the samples discussed above a range of other physical properties measurements were performed on board ship, at all the sites cored, which will help in the broader understanding of the differences which exist for various sediment types in the deep sea. Measurements included seismic wave velocities (P and S), vane shear strength and bulk density on sediments, which ranged from red clays to bio-siliceous and carbonate oozes. Details of this work are included in the physical properties site reports together with some of the shipboard data.

SITE SUMMARY

| HOLE | LATITUDE | LONGITUDE | WATER DEPTH (metres) | PENETRATION (metres) |
|---|---|---|---|---|
| 576 | 32°21.36'N | 164°16.54'E | | 69.2 |
| 576A | 32°21.38'N | 164°16.52'E | 6217 | 65.7 |
| 576B | 32°21.37'N | 164°16.52'E | | 74.8 |
| 577 | 32°26.51'N | 157°43.40'E | | 118.8 |
| 577A | 32°26.53'N | 157°43.39'E | 2675 | 123.4 |
| 577B | 32°26.48'N | 157°43.39'E | | 113.9 |
| 578 | 33°55.56'N | 151°37.74'E | 6010 | 176.8 |
| 579 | 38°37.68'N | 153°50.17'E | 5737 | 17.9 |
| 579A | 38°37.61'N | 153°50.28'E | | 149.5 |
| 580 | 41°37.47'N | 153°58.58'E | 5375 | 155.3 |
| 581 | 43°55.62'N | 159°47.76'E | 5476 | 352.5 |

SITE 576

## G. PHYSICAL PROPERTIES

### Introduction

The following table summarizes the physical properties measurements made and samples taken from the three HPC holes 576, 576A and 576B.

| | | 576 | 576A | 576B |
|---|---|---|---|---|
| Shear strength: | hand operated vane | x | - | x |
| | motorized vane | x | - | x |
| Compressive strength: | hand held penetrometer | x | - | x |
| Wave velocity: | shear wave | x | - | x |
| | compressional wave | x | - | x |
| Water content/bulk density: | shipboard analysis | x | - | - |
| | laboratory analysis | x | - | x |
| Bulk density by 2-minute GRAPE | | x | - | - |
| Consolidation and permeability | | - | x | - |

### Techniques

In general the above measurements or samples were taken at 1.5-meter intervals throughout the core (one per section). However, highly disturbed regions were seldom measured and more measurements were taken at lithologic changes. The techniques used are largely described in the DSDP physical properties handbooks.

Shear strengths were measured on split sections perpendicular to the core axis using both the 'Torvane' hand held device (large and medium size vanes were used) and the modified Wykeham Farrance Vane Apparatus (springs 1, 2 and 3 were used).

Unconfined compressive strengths were measured perpendicular to the core axis on the split sections using the 'Soiltest' penetrometer. A large (one inch diameter) tip was used for most of the measurements. Both the

'Torvane' and the penetrometer were initially used parallel to the core axis at the ends of each section as they were cut. However, the rotational disturbance caused by this procedure was not appreciated by those interested in magnetic properties and was suspended after Core 3 in Hole 576.

Compressional wave velocities were generally measured perpendicular to the core axis through the liner using the Hamilton Frame Velocimeter at 400 kHz after calibration of the system through the various velocity standards. A few measurements were taken parallel to the core axis using bulk samples. Shear wave velocity measurements made on this leg are not normally conducted on DSDP cores. The technique employed piezoelectric bender elements as transducers which were inserted into the split core at a separation of 25.5 mm both parallel and perpendicular to the core axis. The rising edge of a 10 v square wave was used to drive the transmitter and the received signal was high pass filtered at about 1 kHz to remove extraneous noise. The onset time of the received pulse was then measured using the delayed time base of the oscilloscope.

Water content/bulk density samples were taken by inserting metal cylinders of a known volume (referred to as 'Boyce cylinders') into the split section. A d.c. voltage (20-25 v) applied between the cylinder (cathode) and a platinum anode was used to minimize the disturbance caused by the sampling technique. This results from the electro-osmotic effect which continuously lubricates the steel cathode with water, preventing the sediment from sticking to the sampling cylinder. Wet and dry weights of these samples allow the volumetric and weight relationships for the sediment to be calculated; bulk density, water content, porosity, void ratio and grain density. The samples taken for shipboard analysis were also subjected to a 2-minute GRAPE test for calibration of the gravimetric methods with the continuous GRAPE records of the whole sections.

Samples were taken from the unsplit cores at Hole 576A for consolidation and permeability testing back in the UK laboratory. These samples were taken from 10 cm sections which had been cut from the ends of alternate 1.5-meter sections from each core. Sub-sampling was achieved by inserting a stainless steel cylinder (50 mm in diameter and 20 mm high) internally coated with PTFE into the section and trimming with an electro-osmotic knife. These samples were stored under water for transportation back to the laboratory for testing.

Data

Some of the calculated data are presented in Figures G-1, -2, -3 and -4 which show profiles of shear strength, shear wave velocity, compressional wave velocity, water content, bulk density and porosity in Holes 576 and 576B. A detailed discussion of these data is not appropriate here but the following points are worth noting.

1) The correlation both in trends and magnitude of shear strength obtained from the hand held and motorized vane test is remarkably good (Figs. G-1 and -3).

2) Shear strengths and shear wave velocities in the carbonate layers (Fig.2) are generally much less than in the brown clay. This does not necessarily mean that the *in situ* strengths vary by this amount; it may be caused by different forms of stress disturbance in the different lithologies.

3) Where there is a large amount of visual disturbance, the shear strength in the brown clay is markedly reduced (Fig. G-1, flow in), whereas the shear wave velocity is only slightly reduced.

4) The large increase in the shear strength and shear wave velocities in the brown clay below 65 meters in Hole 576B may be indicative of the onset of diagenesis (Fig. G-3).

5) The offset in the shear strength and shear wave velocities between Cores 2, 3 and 4 in Hole 576 (Fig. G-1) may be indicative of non-visual coring disturbance.

6) The compressional wave velocity profile shows no obvious trend through the brown clay section and is always less than the water velocity. Peaks in the compressional wave velocity occur for ash and carbonate layers.

7) The uniformity of shear wave velocities measured parallel and perpendicular to the core axis indicate a total lack of anisotropy within any of the lithologies (Fig. G-2).

8) There is a marked increase in water content up to 220% between 11 meters and 20 meters in the brown clay unit before it gradually decreases to 110% at 50 meters. The cause of this is not known but a change in mineralogy, similar to that found in GPC3, is suspected. The increase in water content is consistent with a decrease in shear strength around 16 meters as shown in Figure L-1.

9) Figure G-5 is an e-log P plot of the brown clay unit using data from Hole 576. In contrast to the typical laboratory consolidation curve, Figure G-5 illustrates the geotechnical complexities caused by what may appear to be only subtle changes in the brown clay. The compression index

lies between 1.2 and 4.2 which compares favorably with available laboratory data from GPC3 (2.8-4.4).

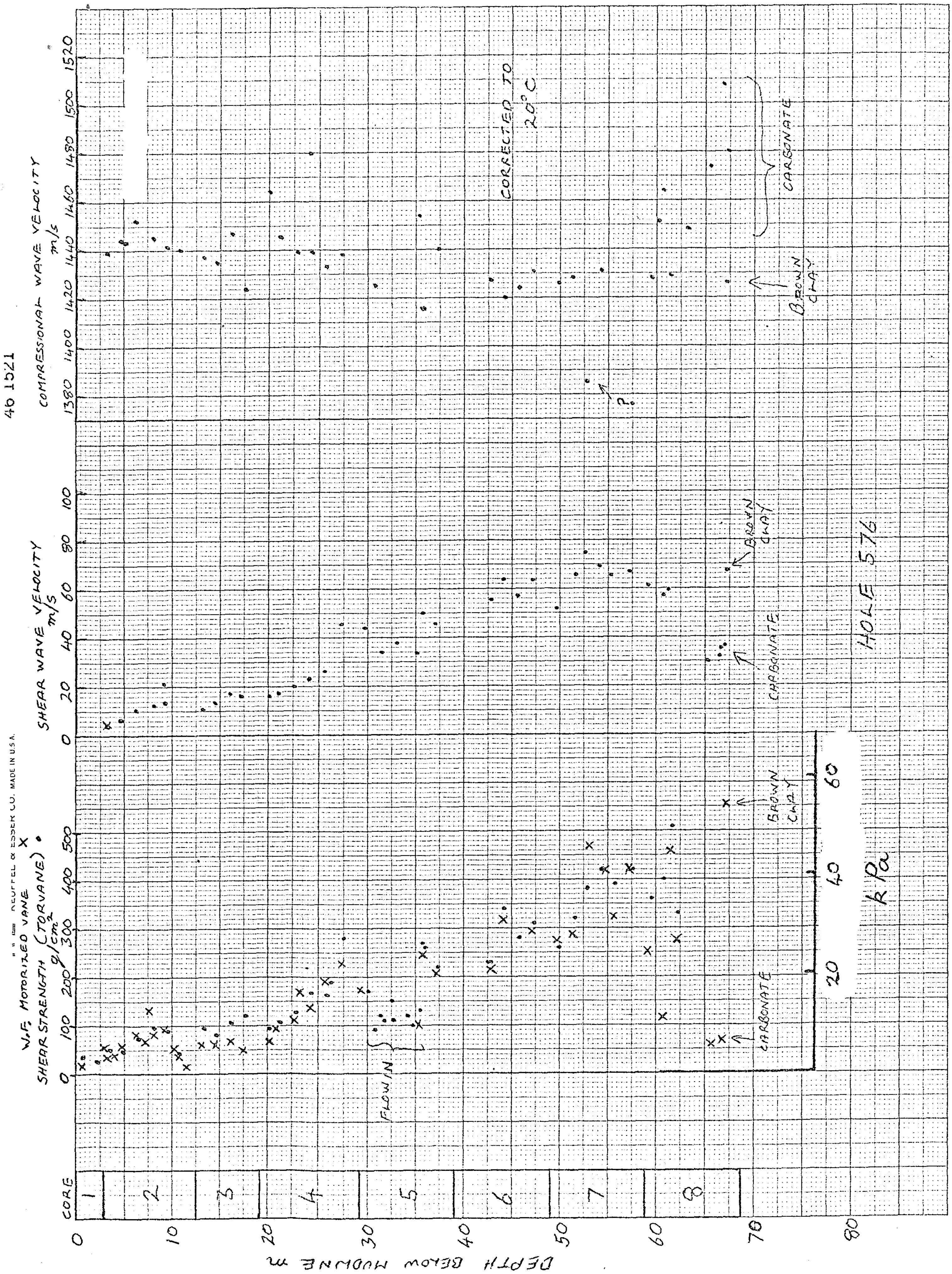
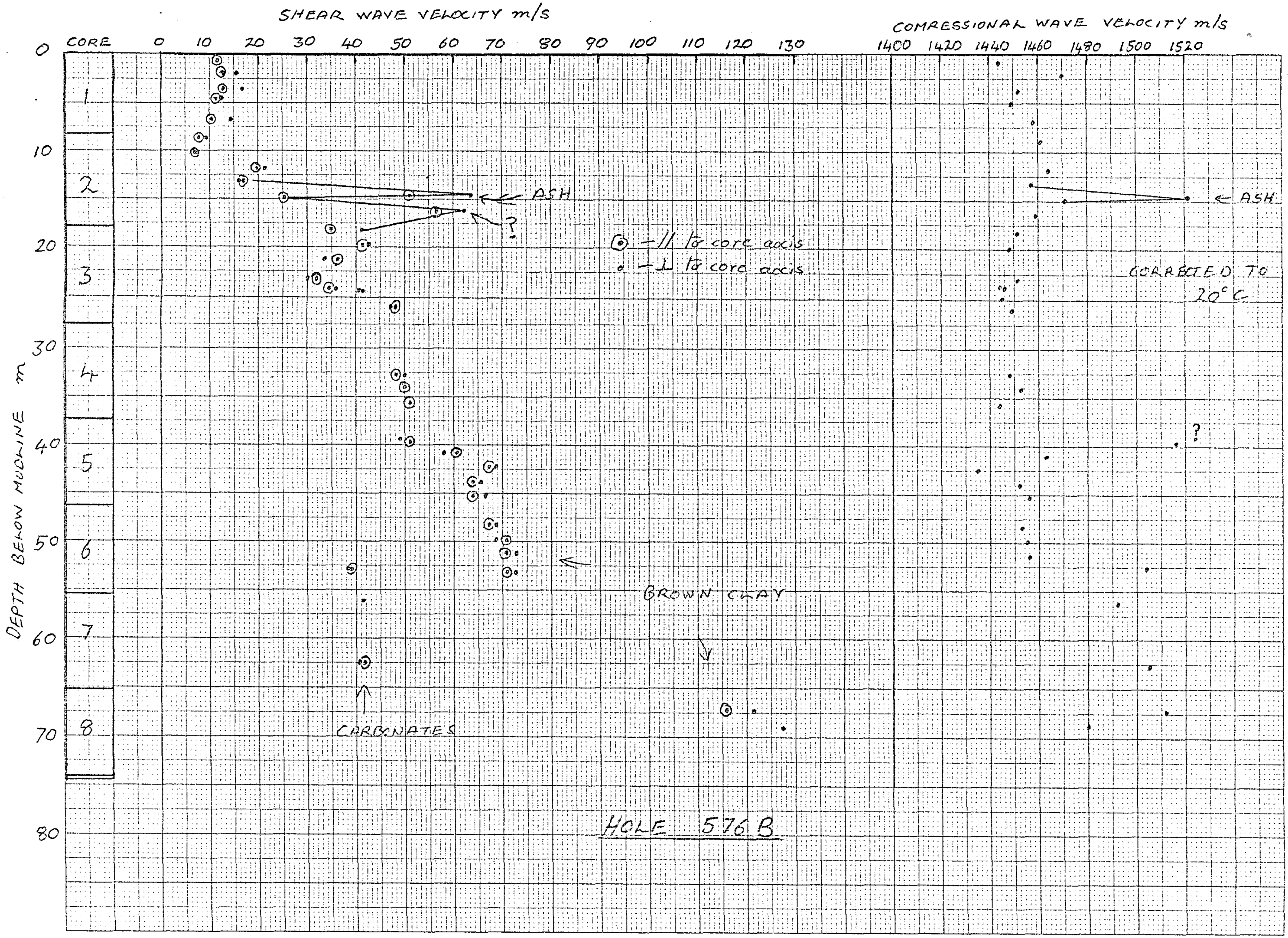

46 1521
COMPRESSIONAL WAVE VELOCITY m/s
1380
1400
1420
1440
1460
1480
1500
1520
CORRECTED TO 20°C
CARBONATE
BROWN CLAY
?
SHEAR WAVE VELOCITY m/s
0
20
40
60
80
100
CARBONATE
BROWN CLAY
HOLE 576
KEUFFEL & ESSER CO. MADE IN U.S.A.
W.F. MOTORIZED VANE X
SHEAR STRENGTH (TORVANE) •
g/cm²
0
100
200
300
400
500
FLOW IN
CARBONATE
BROWN CLAY
20
40
60
kPa
CORE
1
2
3
4
5
6
7
8
0
10
20
30
40
50
60
70
80
DEPTH BELOW MUDLINE m

Figure 1



SHEAR WAVE VELOCITY m/s
COMPRESSIONAL WAVE VELOCITY m/s
CORE
0 10 20 30 40 50 60 70 80 90 100 110 120 130
1400 1420 1440 1460 1480 1500 1520
DEPTH BELOW MUDLINE m
0 10 20 30 40 50 60 70 80
1 2 3 4 5 6 7 8
ASH
?
⊙ – // to core axis
• – ⊥ to core axis
ASH
CORRECTED TO 20°C
?
BROWN CLAY
CARBONATES
HOLE 576 B


Figure 2

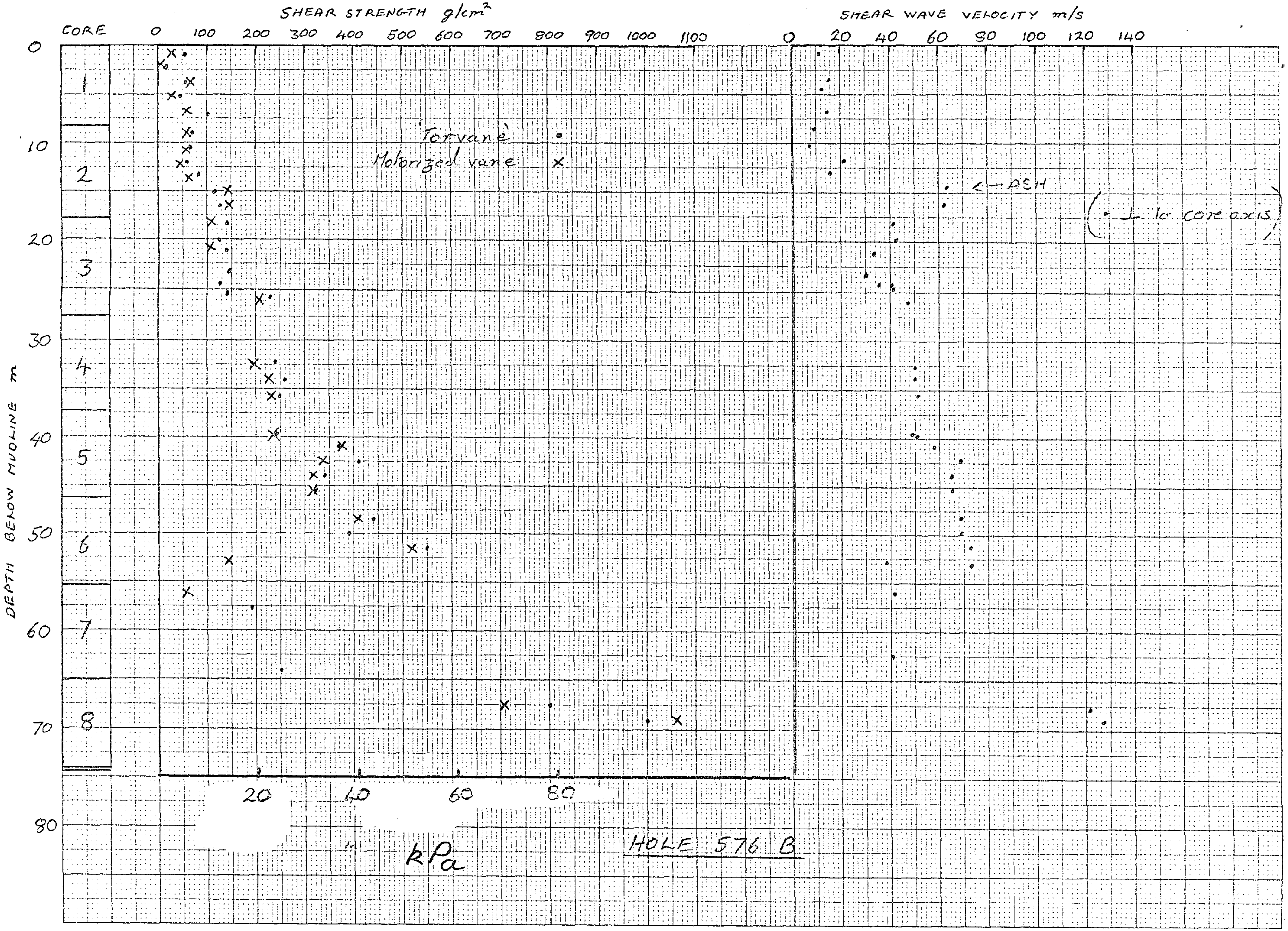

SHEAR STRENGTH g/cm²
0 100 200 300 400 500 600 700 800 900 1000 1100
SHEAR WAVE VELOCITY m/s
0 20 40 60 80 100 120 140
CORE
1 2 3 4 5 6 7 8
DEPTH BELOW MUDLINE m
0 10 20 30 40 50 60 70 80
'Torvane' •
Motorized vane ×
← ASH
(• ⊥ to core axis)
20 40 60 80
kPa
HOLE 576 B

Figure 3

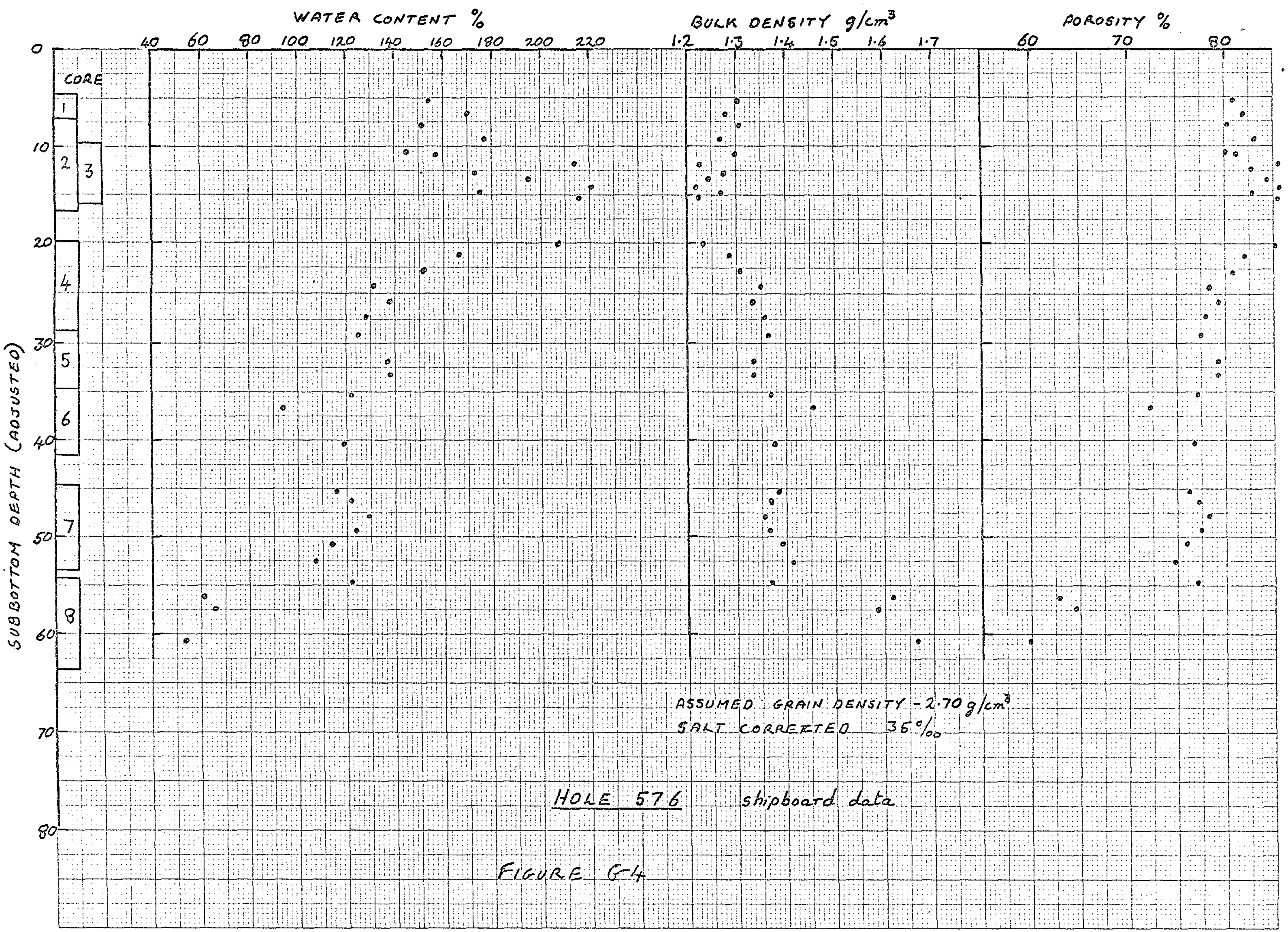
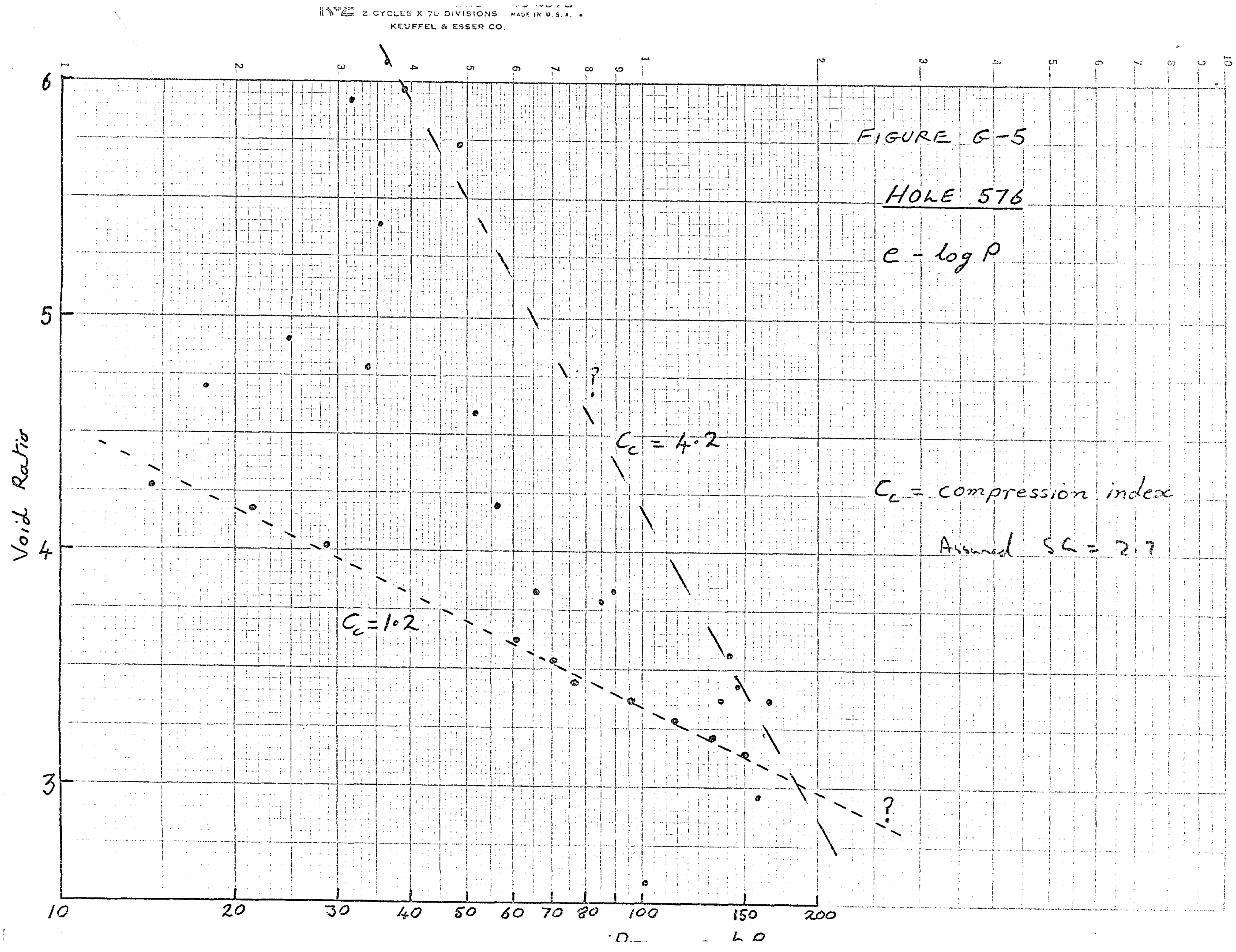

WATER CONTENT %
40 60 80 100 120 140 160 180 200 220
BULK DENSITY g/cm³
1.2 1.3 1.4 1.5 1.6 1.7
POROSITY %
60 70 80
SUBBOTTOM DEPTH (ADJUSTED)
0 10 20 30 40 50 60 70 80
CORE
1 2 3 4 5 6 7 8
ASSUMED GRAIN DENSITY - 2.70 g/cm³
SALT CORRECTED 35‰
HOLE 576 shipboard data

FIGURE G-4


2 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
FIGURE G-5
HOLE 576
e - log P
$C_c = 4 \cdot 2$
$C_c$ = compression index
Assumed SG = 2.7
$C_c = 1 \cdot 2$
?
?
Void Ratio
6
5
4
3
10
20
30
40
50
60
70
80
100
150
200

# SITE 577

## G. PHYSICAL PROPERTIES

### Introduction

The following table summarizes the physical properties measurements made and samples taken from the two HPC holes, 577 and 577A.

| | | 577 | 577A |
|---|---|---|---|
| Shear strength: | hand operated vane | x | x |
| | motorized vane | x | x |
| Wave velocity: | shear wave | x | x |
| | compressional wave | x | x |
| Water content/bulk density: | shipboard analysis | x | – |
| | laboratory analysis | x | x |
| Bulk density by 2-minute GRAPE | | x | – |
| Consolidation and permeability | | – | x |

### Techniques

In Hole 577 the above measurements or samples were taken at approximately 3-meter intervals throughout the core (alternate sections). For Hole 577A measurements or samples were taken at approximately 4.5-meter intervals.

The techniques used have previously been described for Site 576; no significant changes were made for this site.

### Data

Figures G-1, -2 and -3 show profiles (Holes 577 and 577A) of shear strength, compressional wave velocity and shear wave velocity, respectively. Shipboard determinations of water content and bulk density are shown in Figure G-4.

The following points are worth noting:

1. There are wide variations in the shear strength measurements down to 50 meters, below which there is a rapid decrease in strength which remains consistently low. The reduction in shear strength correlates with the boundary of lithologic units I and II (Chapter D), and is thought to occur as a result of the changing carbonate content (Fig. D-2). It is postulated that at carbonate contents in excess of 90 to 95 percent, the sediment strength is drastically reduced by the coring process (the interparticulate bonding may be more brittle). If this is the case, then the shear strength profile shown in Figure G-1 bears little relation to the *in situ* profile.

2. The shear wave velocity data shown in Figure G-3 show no distinct trends throughout the two holes, the velocity varies between 20 m/s and 70 m/s. Poor signal quality in most of these cores limits the accuracy of these measurements to ±10 m/s.

3. Figure G-4 shows profiles of water content and bulk density for Hole 577. A sudden increase in bulk density (decrease in water content) at about 60 meters is the major feature which occurs just below the lithologic boundary between Units I and II. This corresponds to a possible 30-40 m.y. missing section in the mid-Tertiary (see biostratigraphic summary, Chapter E), which at 3.9 m/m.y. would represent up to 156 meters of missing sediment. Laboratory consolidation data from Hole 577A may be able to indicate whether this was a non-depositional or an erosional hiatus.

4. The compressional wave velocity profile (Fig. G-2) also shows a major discontinuity at 60 meters. The velocity increases rapidly from

around 1480 m/s to 1530 m/s. The corresponding impedance change using bulk density values of 1590 and 1720 $kg/m^3$, respectively, are $2.35 \times 10^6$ and $2.63 \times 10^6$ $kg\ m^{-2}S^{-1}$ (a change of more than 10%). However, this depth does not correspond to a distinct reflector on the 3.5 kHz seismic record.

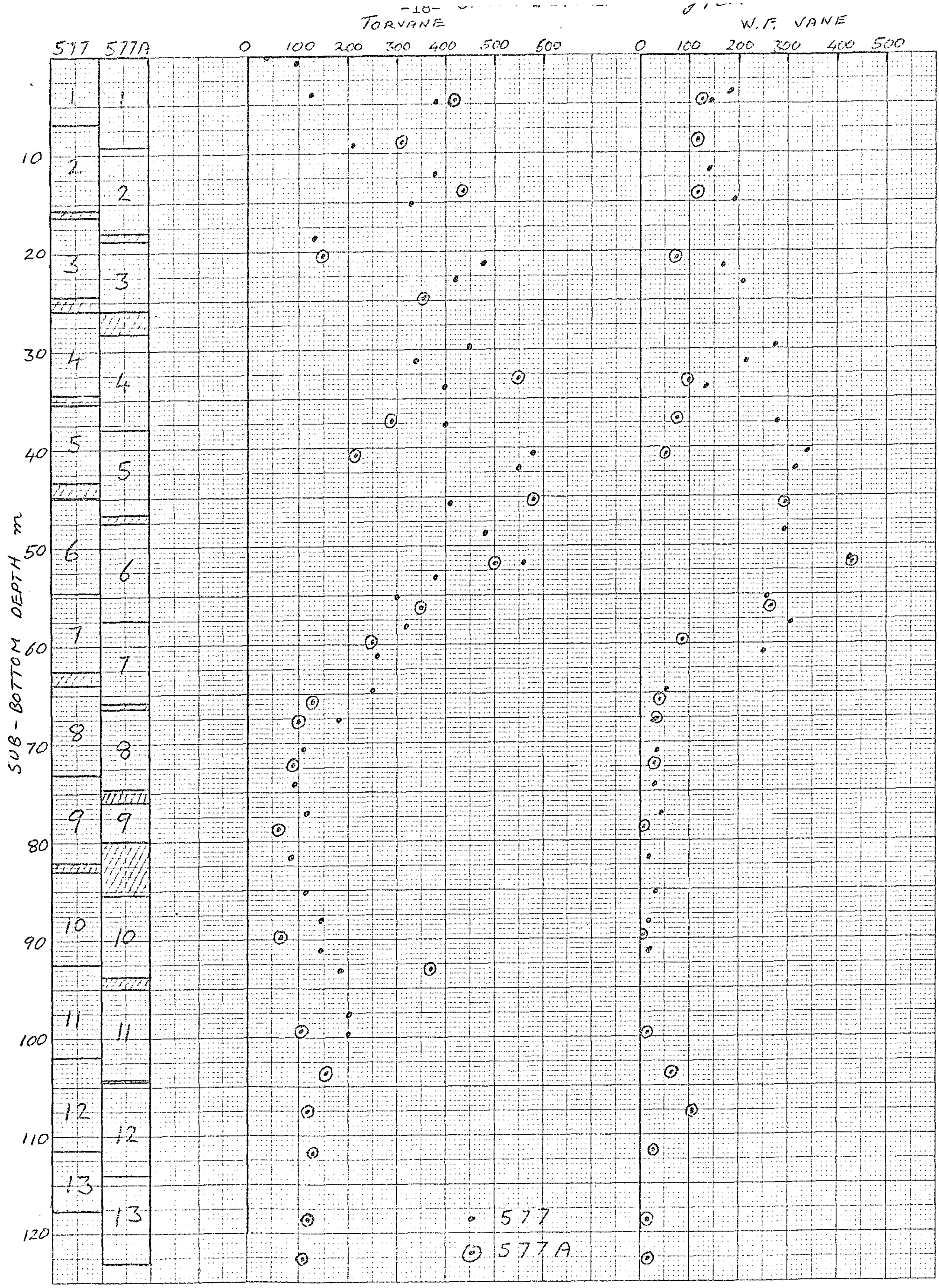

TORVANE
W.F. VANE
577
577A
0
100
200
300
400
500
600
SUB-BOTTOM DEPTH m
10
20
30
40
50
60
70
80
90
100
110
120
1
2
3
4
5
6
7
8
9
10
11
12
13
577
577A

FIGURE G-1

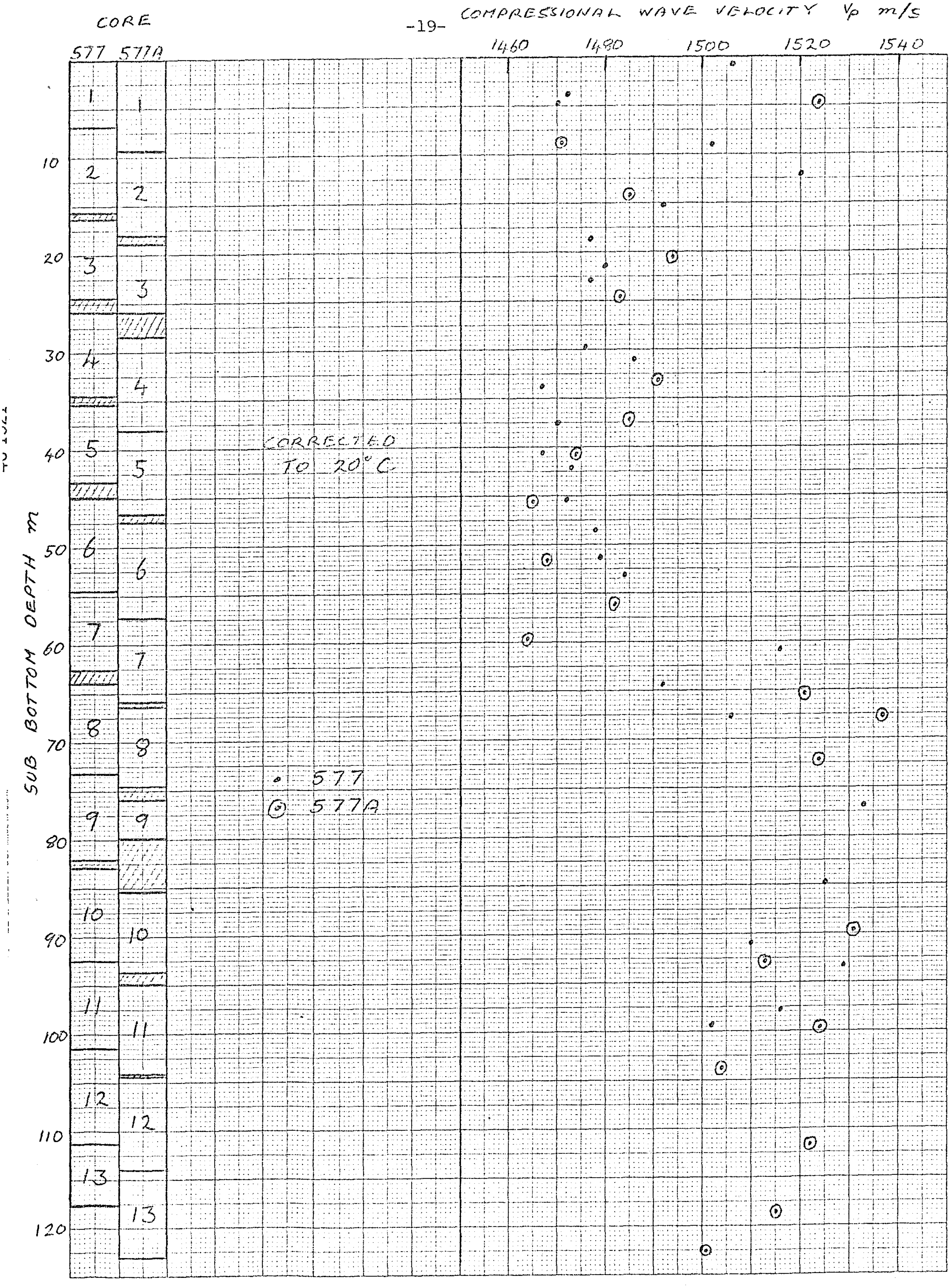

CORE
577 577A
COMPRESSIONAL WAVE VELOCITY Vp m/s
1460
1480
1500
1520
1540
SUB BOTTOM DEPTH m
10
20
30
40
50
60
70
80
90
100
110
120
CORRECTED TO 20°C
577
577A

FIGURE G-2

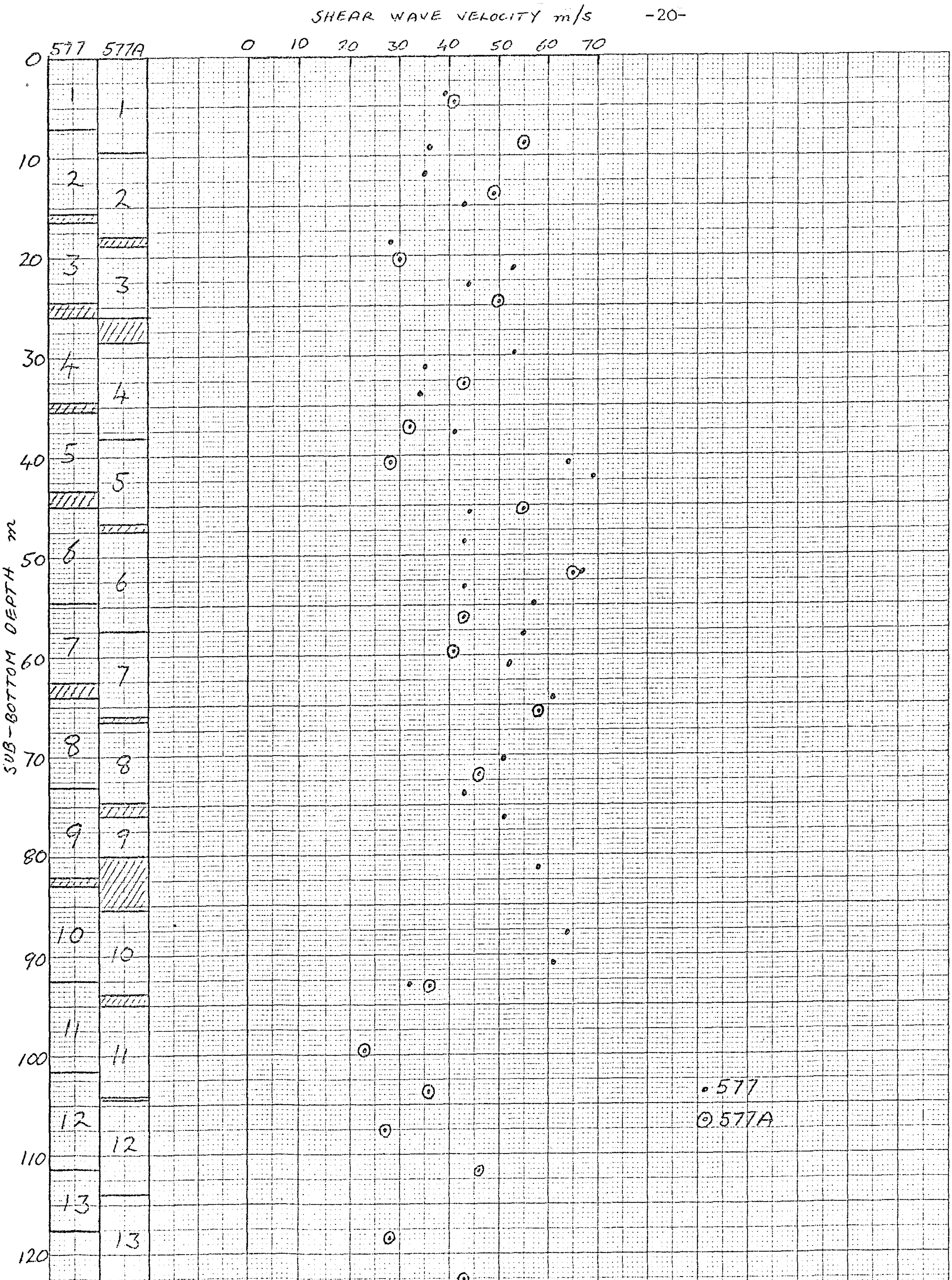

SHEAR WAVE VELOCITY m/s
0 10 20 30 40 50 60 70
577 577A
0 10 20 30 40 50 60 70 80 90 100 110 120
SUB-BOTTOM DEPTH m
1 2 3 4 5 6 7 8 9 10 11 12 13
• 577
⊙ 577A

FIGURE G-3

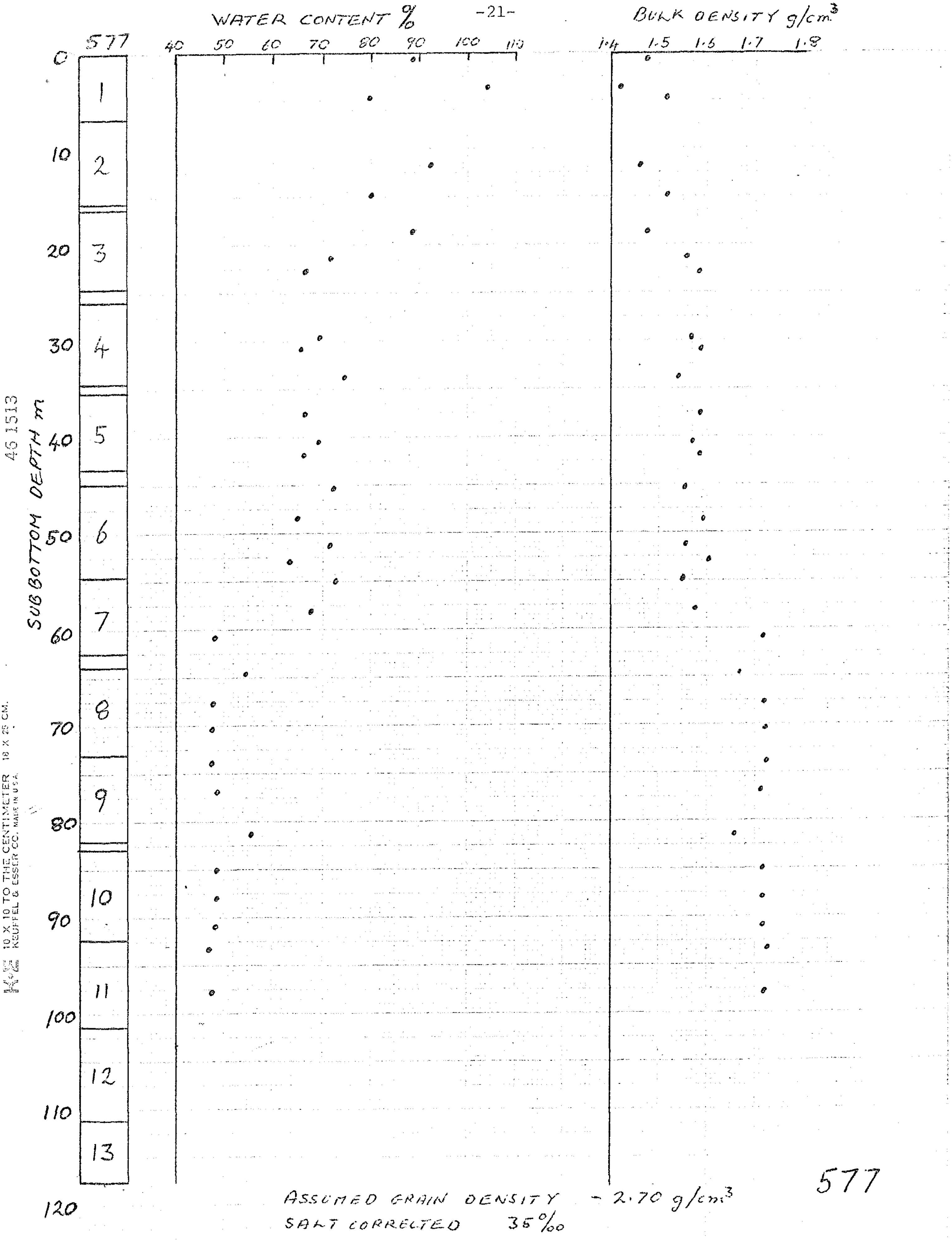

577
WATER CONTENT %
40 50 60 70 80 90 100 110
BULK DENSITY g/cm³
1.4 1.5 1.6 1.7 1.8
SUBBOTTOM DEPTH m
0 10 20 30 40 50 60 70 80 90 100 110 120
1 2 3 4 5 6 7 8 9 10 11 12 13
ASSUMED GRAIN DENSITY - 2.70 g/cm³
SALT CORRECTED 35‰
577
10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 1513

FIGURE G-4

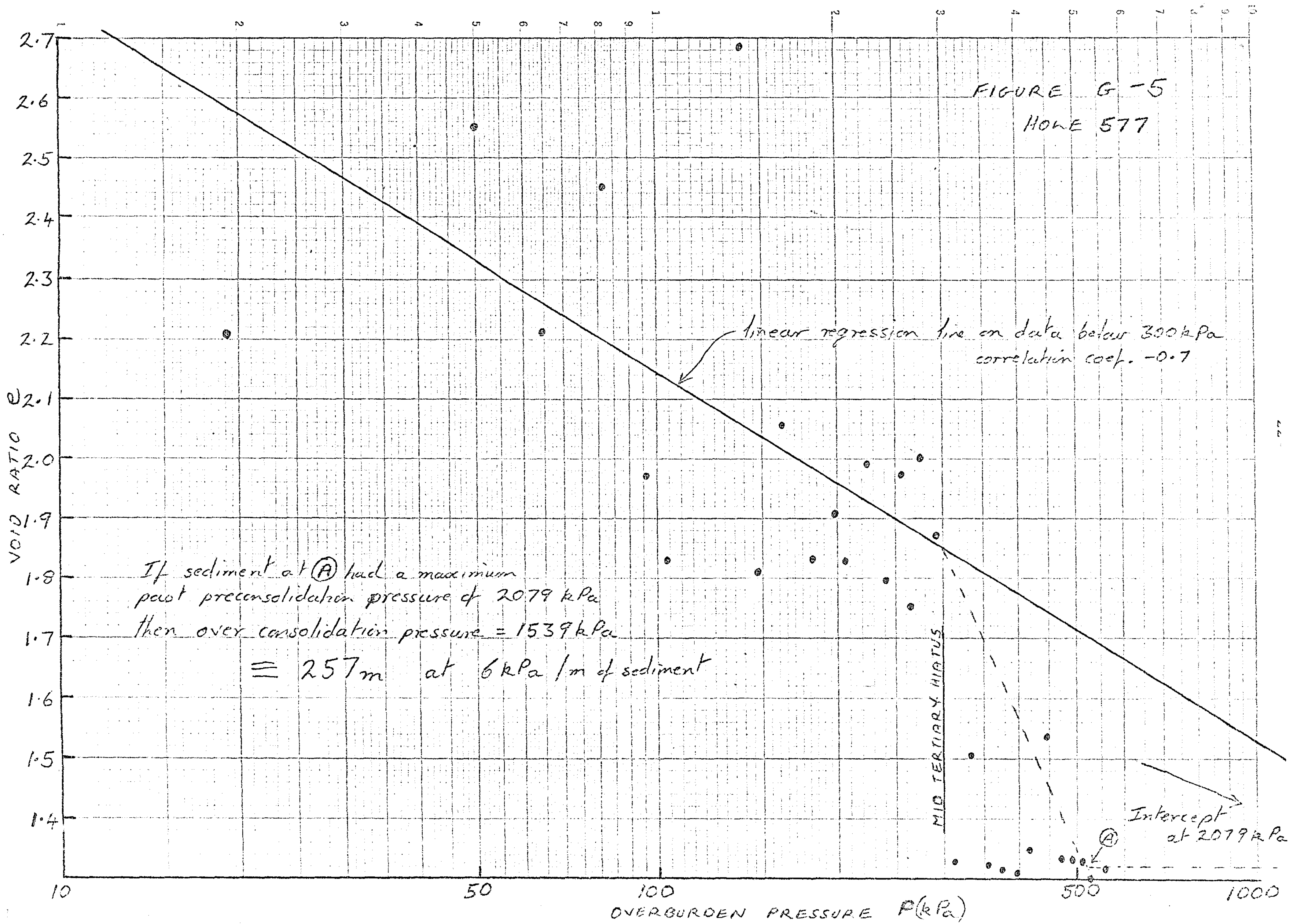


FIGURE G-5
HOLE 577
linear regression line on data below 300 kPa
correlation coef. -0.7
If sediment at (A) had a maximum
past preconsolidation pressure of 2079 kPa
then over consolidation pressure = 1539 kPa
≡ 257m at 6kPa /m of sediment
MID TERTIARY HIATUS
Intercept
at 2079 kPa
(A)
VOID RATIO e
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
10
50
100
500
1000
OVERBURDEN PRESSURE P(kPa)

# SITE 578

## G. PHYSICAL PROPERTIES

### Introduction

The following table summarizes the physical properties measurements made and samples taken from the HPC hole, 578.

| | | 578 |
|---|---|---|
| Shear strength: | hand operated vane | x |
| | motorized vane | x |
| Wave velocity: | shear wave | x |
| | compressional wave | x |
| Water content/bulk density: | shipboard analysis | x |
| | laboratory analysis | x |
| Bulk density by 2-minute GRAPE | | x |
| Consolidation and permeability | | x |

### Techniques

In Hole 578 the above measurements or samples were taken at approximately 3-meter intervals throughout the core (alternate sections). Four samples were taken from 10 cm whole core sections (Cores 17 and 19) for consolidation and permeability tests.

The techniques used have previously been described for Site 576; no significant changes were made for this site.

### Data

Figures G-1, and G-2 show profiles of shear strength, compressional and shear wave velocity, respectively. Shipboard determinations of water content and bulk density are shown in Figure G-3.

The following points are worth noting:

1) The compressional wave profile (Fig. G-2) is dominated by high velocity layers of pyrite-indurated clay and ash beds superimposed on a

constant velocity profile down to 160 meters. Not all of the numerous layers were measured but it can be assumed that they all have higher velocities. Below 160 meters there is an indication that a positive velocity gradient is developing in the very dark pelagic clay.

2) Shear wave velocities increase slowly up to 65 m/s at a depth of 120 meters (Fig. G-2). A rapid increase up to 128 m/s occurs between 120 and 130 meters, below which the velocity remains essentially constant. This transition coincides with the lithologic boundary between Unit II and III (Chapter D) in the pelagic clay.

3) The lithologic boundary between Units II and III is also characterized by a reduction in water content from 120% to 90% with a corresponding increase in the bulk density from 1.37 to 1.47 g/cm$^3$ (Fig. G-3). Another significant change in water content occurs between Cores 17 and 18 (155-160 m) where it falls rapidly from 90% to 60%. This transition does not coincide with any obvious lithological boundary.

4) The shear strength profiles (Fig. G-1) show an increasing strength with depth from 0 at the sea floor to around 1500 g/cm$^2$ at 176 meters in Core 20. Recovery from Cores 17, 18, 19 and 20 were progressively shorter, with Core 20 being only 0.81 meters long. These shear strengths in pelagic brown clays obviously represent the operational limits of the HPC in its present configuration. It is also interesting to note that the high lateral stresses within the core prevented any flow-in occurring (presumably water must have flowed around the piston during pull out).

The two discontinuities of water content at 120-130 meters and 155-160 meters discussed above are also revealed by rapid increases in the shear strength profiles. At 123 meters (boundary of Units II and III) there is a rapid increase from 500 $g/cm^2$ to 1100 $g/cm^2$ according to the motorized vane measurements (a less pronounced step is revealed by the hand held vane). At 157 meters the hand held vane shows an increase from 1050 $g/cm^2$ to 1500 $gm/cm^2$ (a less pronounced step is revealed in this case by the motorized vane).

5) The four dark brown pelagic clay samples taken from Cores 17 and 19 for consolidation testing will supplement those samples taken at Site 576 by extending the depth of burial from 70 meters to 170 meters. It is interesting that the brown clay from 70 meters at Site 576 had a water content of 60% with a shear strength of approximately 1000 $g/cm^2$ while at Site 578 the brown clay from 170 meters still has a water content of 60%, but a significantly higher shear strength (1500 $g/cm^2$).

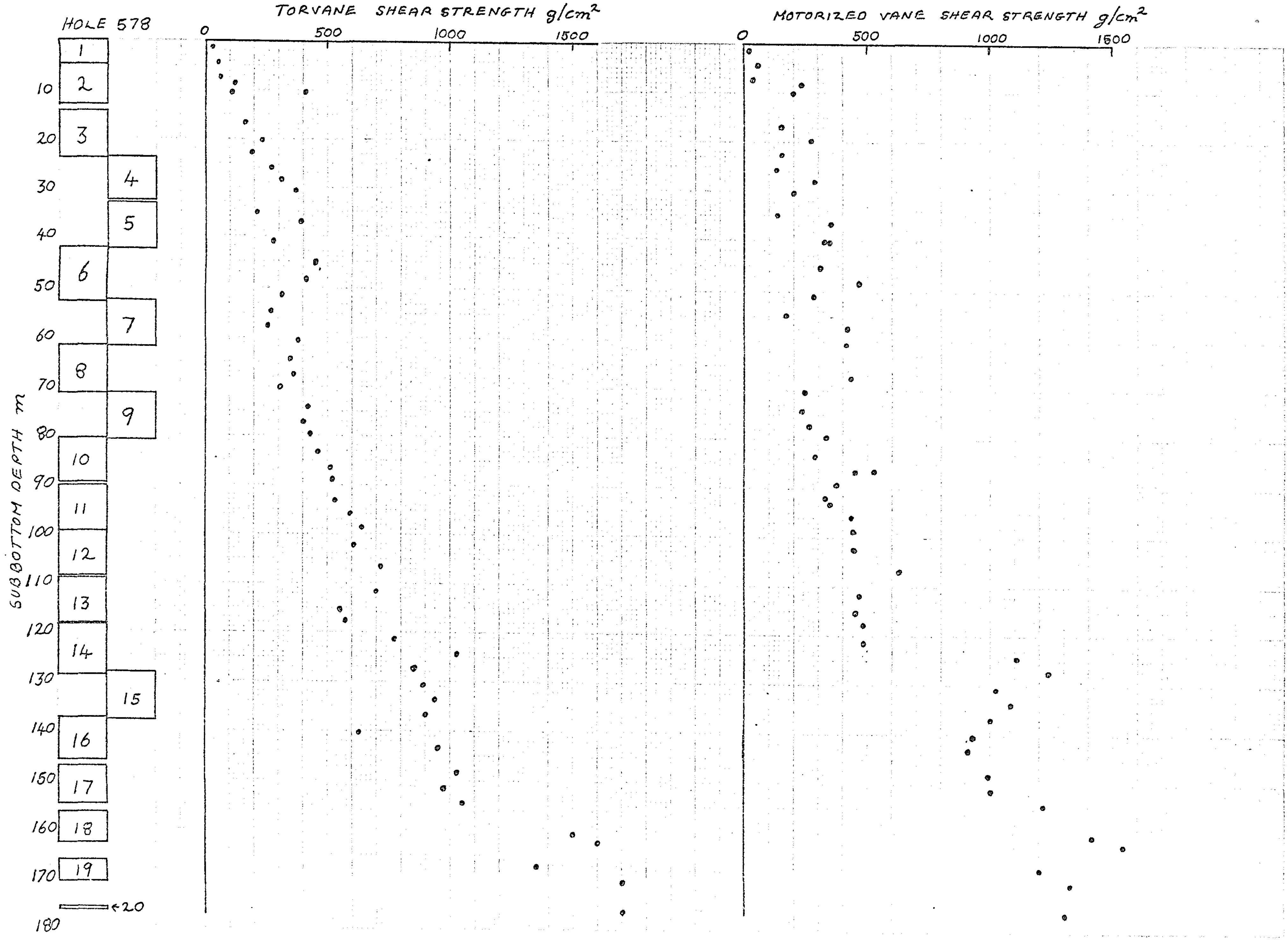

HOLE 578
TORVANE SHEAR STRENGTH g/cm²
MOTORIZED VANE SHEAR STRENGTH g/cm²
0
500
1000
1500
SUBBOTTOM DEPTH m
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
←20

FIGURE G-1

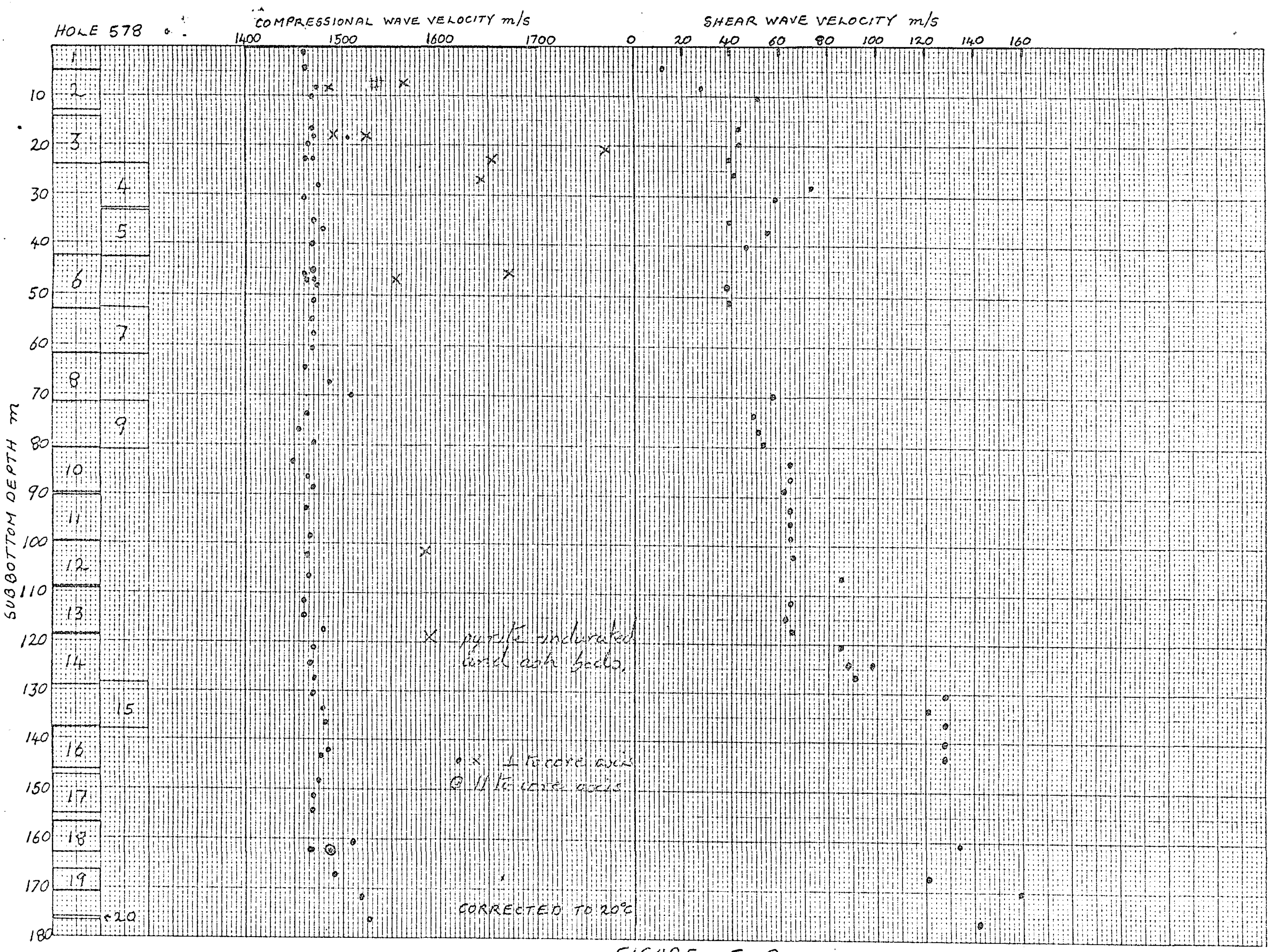

HOLE 578
COMPRESSIONAL WAVE VELOCITY m/s
1400 1500 1600 1700
SHEAR WAVE VELOCITY m/s
0 20 40 60 80 100 120 140 160
SUBBOTTOM DEPTH m
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
X pyrite indurated and ash beds.
X ⊥ to core axis
⊙ ‖ to core axis
CORRECTED TO 20°C

FIGURE G-2

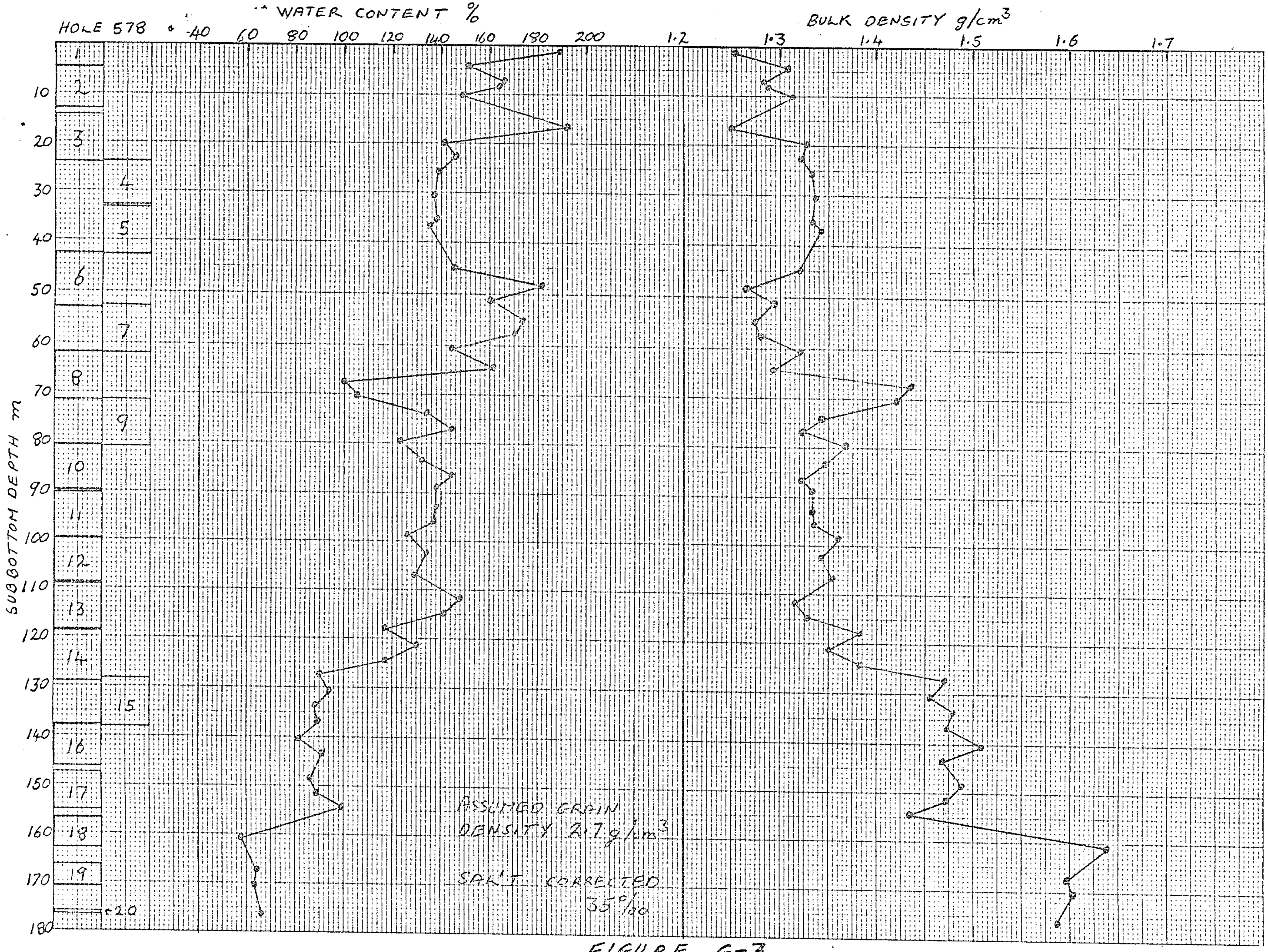

HOLE 578
WATER CONTENT %
40
60
80
100
120
140
160
180
200
BULK DENSITY g/cm3
1.2
1.3
1.4
1.5
1.6
1.7
SUBBOTTOM DEPTH m
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
ASSUMED GRAIN
DENSITY 2.7 g/cm3
SALT CORRECTED
35‰

FIGURE G-3

# SITE 579

## G. PHYSICAL PROPERTIES

### Introduction

The following table summarizes the physical properties measurements made and samples taken from the HPC holes 579 and 579A.

| | | 579 and 579A |
|---|---|---|
| Shear strength: | hand operated vane | x |
| | motorized vane | x |
| Wave velocity: | shear wave | x |
| | compressional wave | x |
| Water content/bulk density: | shipboard analysis | x |
| | laboratory analysis | x |
| Bulk density by 2-minute GRAPE | | x |

### Techniques

The above measurements or samples were taken at approximately 4.5-meter intervals throughout the core.

The techniques used have previously been described for Site 576; no significant changes were made for this site.

### Data

Figures G-1, and G-2 show profiles of shear strength, compressional and shear wave velocity, respectively. Shipboard determinations of water content and bulk density are shown in Figure G-3.

The following points should be noted:

1) The compressional wave velocity profile is dominated by many (61) high velocity ash layers and numerous (∿325) thin (<0.5 cm) stiff indurated dark greenish gray layers. Velocities measured in a few ash layers are typically about 1600 m/s. The thin indurated green layers also have higher velocities but they tend to be variable, one was as high as 1770 m/s.

Velocities in the siliceous clay and ooze are remarkably uniform throughout the hole at 1480 m/s (Fig. G-2).

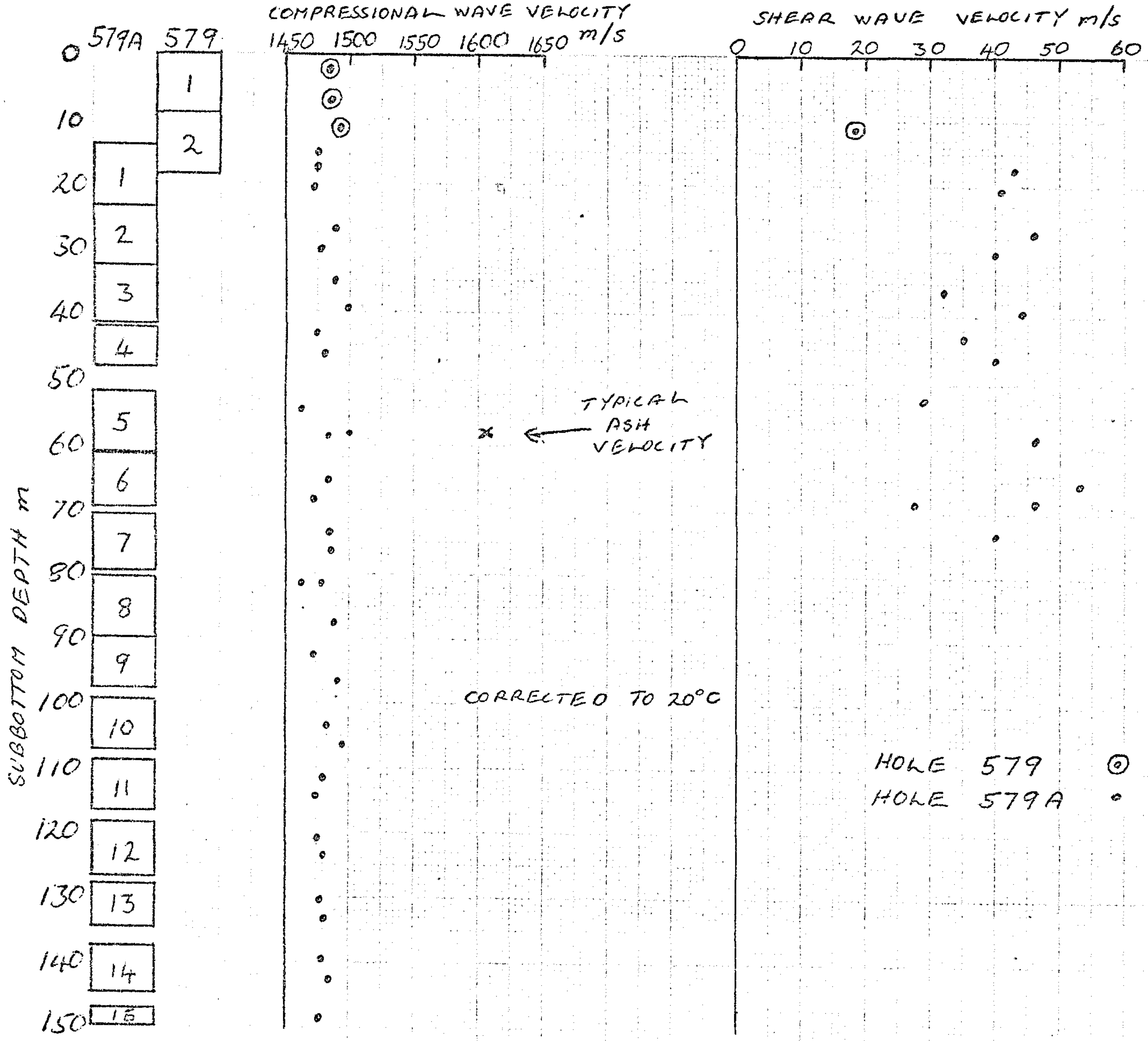
2) Shear wave velocity measurements show no distinct trends down to 73 meters. The transducer broke at this point, preventing further measurements.

3) Shear strength measurements (Fig. G-1), although exhibiting a large amount of scatter, show increasing strength down the hole. A major discontinuity exists in Core 9 with very high shear strengths in Section 5 relative to shallower sections. Values decrease again in Core 10, however. This maximum cannot be explained by any visible lithological changes.

4) In the bottom of Core 6, Section 5, a good example of flow in occurred. Measurements with both the hand held and motorized vane showed that the remolded flow-in section had decreased in strength by a factor of ∿4 from 380 g/cm$^2$ in the 'undisturbed' region to 100 g/cm$^2$ in the flow-in section.

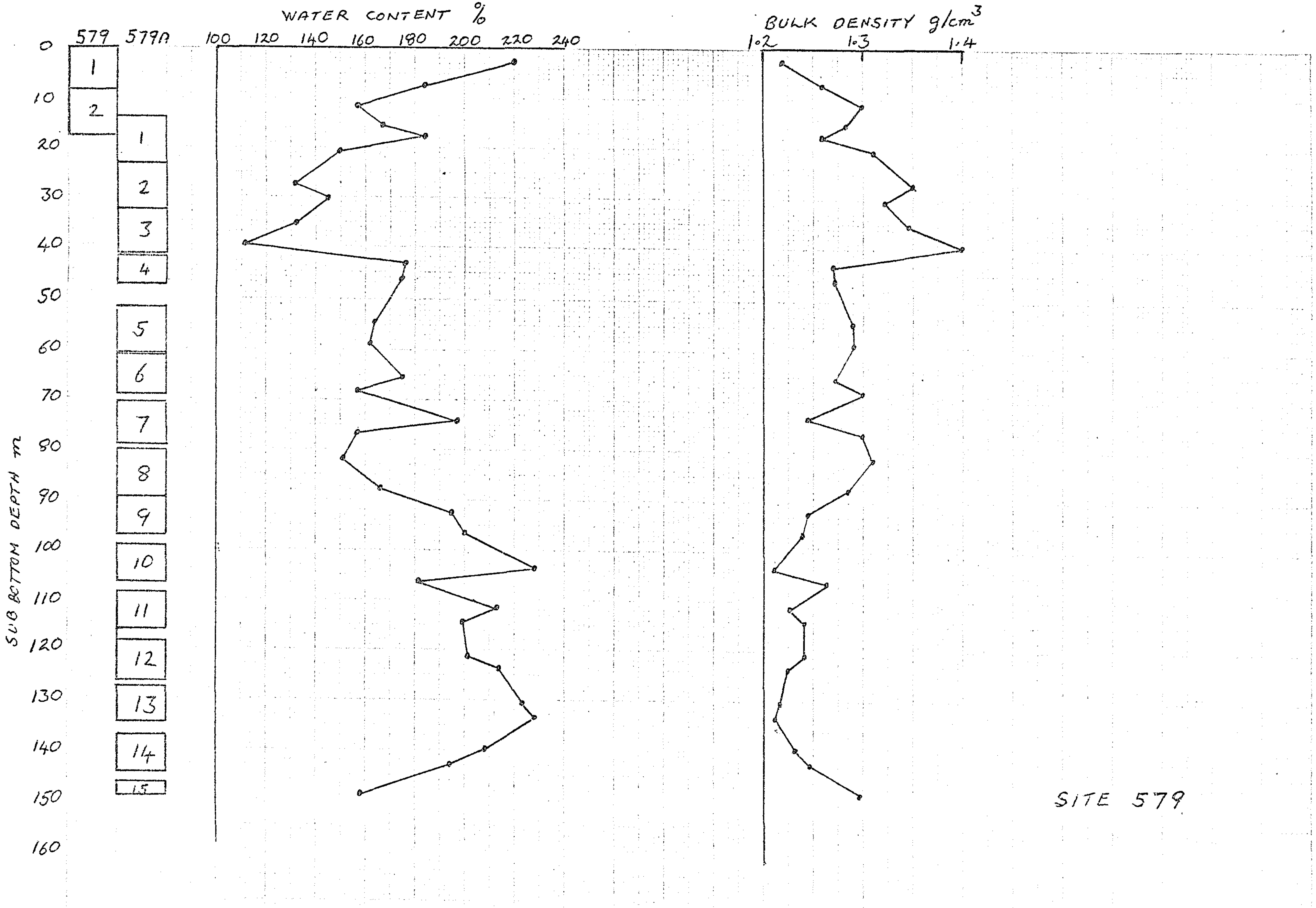
5) The water content profile (Fig. G-3) can be split into three units. Unit I from 0-41 meters has a decreasing water content from 220% to 111% which is probably caused by normal consolidation processes. Unit II from 41-134 meters has slowly increasing water content from around 170% to 228%, with a rapid change occurring between Units I and II. Unit III, below 134 meters, shows a decreasing water content down to 158% at 149 meters.

These units do not correlate to the lithological units based on visual descriptions. It is probable that changes in clay mineralogy are responsible for the strength variations observed.



SUBBOTTOM DEPTH m
579A
579
COMPRESSIONAL WAVE VELOCITY
1450 1500 1550 1600 1650 m/s
SHEAR WAVE VELOCITY m/s
0 10 20 30 40 50 60
TYPICAL ASH VELOCITY
CORRECTED TO 20°C
HOLE 579
HOLE 579A


FIGURE G-2



WATER CONTENT %
BULK DENSITY g/cm3
SUB BOTTOM DEPTH m
579
579A
SITE 579


FIGURE G-3

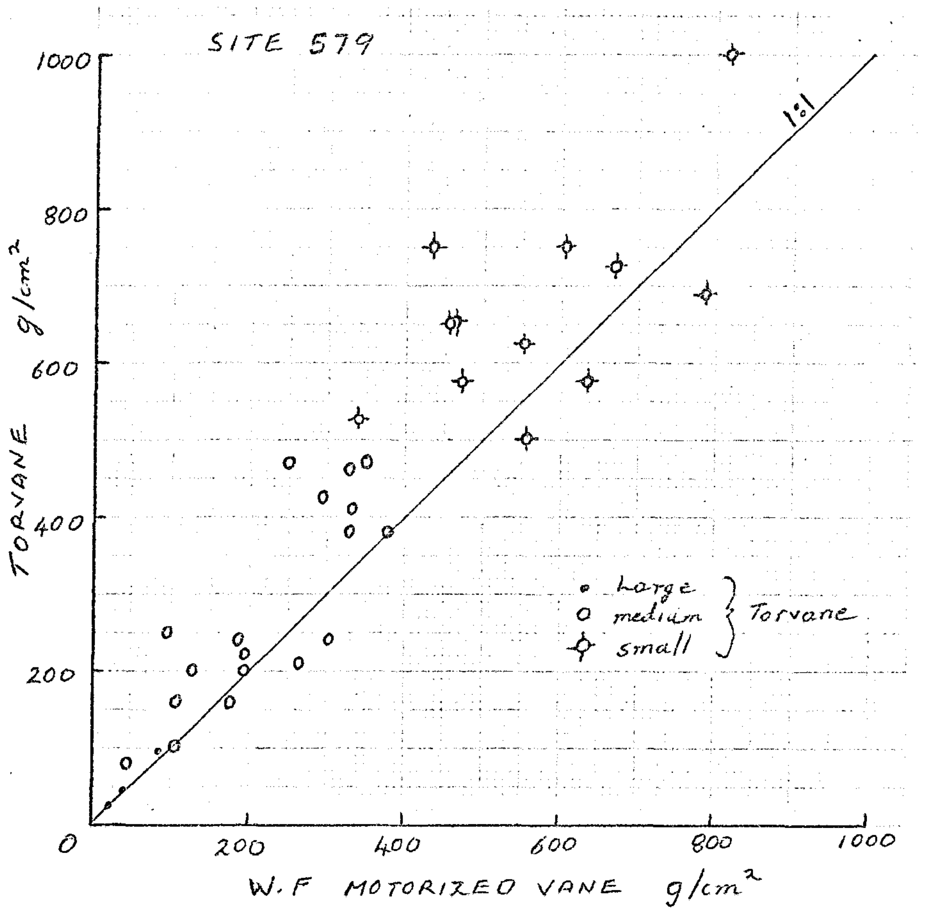



FIGURE G-4 Comparison of shear strength data from hole 579 using the hand-held 'Torvane' and the motorized Wykeham Farrance vane device (vane :- dia. = 1.29 cm, height = 1.27 cm)

# SITE 580

## G. PHYSICAL PROPERTIES

### Introduction

The following table summarizes the physical properties measurements made and samples taken from the HPC hole, 580.

| | | 580 |
|---|---|---|
| Shear strength: | hand operated vane | x |
| | motorized vane | x |
| Compressional wave velocity: | | x |
| Water content/bulk density: | shipboard analysis | x |
| | laboratory analysis | x |
| Bulk density by 2-minute GRAPE | | x |

### Techniques

In Hole 580 the above measurements or samples were generally taken at 4.5-meter intervals throughout the core. Detailed compressional wave velocity profiles were made on selected ash layers to determine the fine-scale velocity structure.

The techniques used have previously been described for Site 576; no significant changes were made for this site.

### Data

Figures G-1, and G-2 show profiles of shear strength and compressional wave velocity, respectively. Shipboard determinations of water content and bulk density are shown in Figure G-3.

The following points are worth noting:

1) As at Sites 578 and 579, the velocity profile for Site 580 (Fig. G-2) is dominated by high velocity pyrite-indurated clay and ash beds. Velocities in the siliceous clays and oozes rise gradually downhole from ~1470 m/s in Core 1 to 1490 m/s in Core 17 at 150 meters.

2) A detailed velocity structure was obtained on 5 ash layers by taking measurements at 1 or 2 cm intervals through the beds. These are also shown in Figure G-2. Some of these examples clearly show the effect of a sharp basal contact producing a maximum velocity near or at the bottom of the ash layer. The velocities tend to decrease more slowly up through the layers.

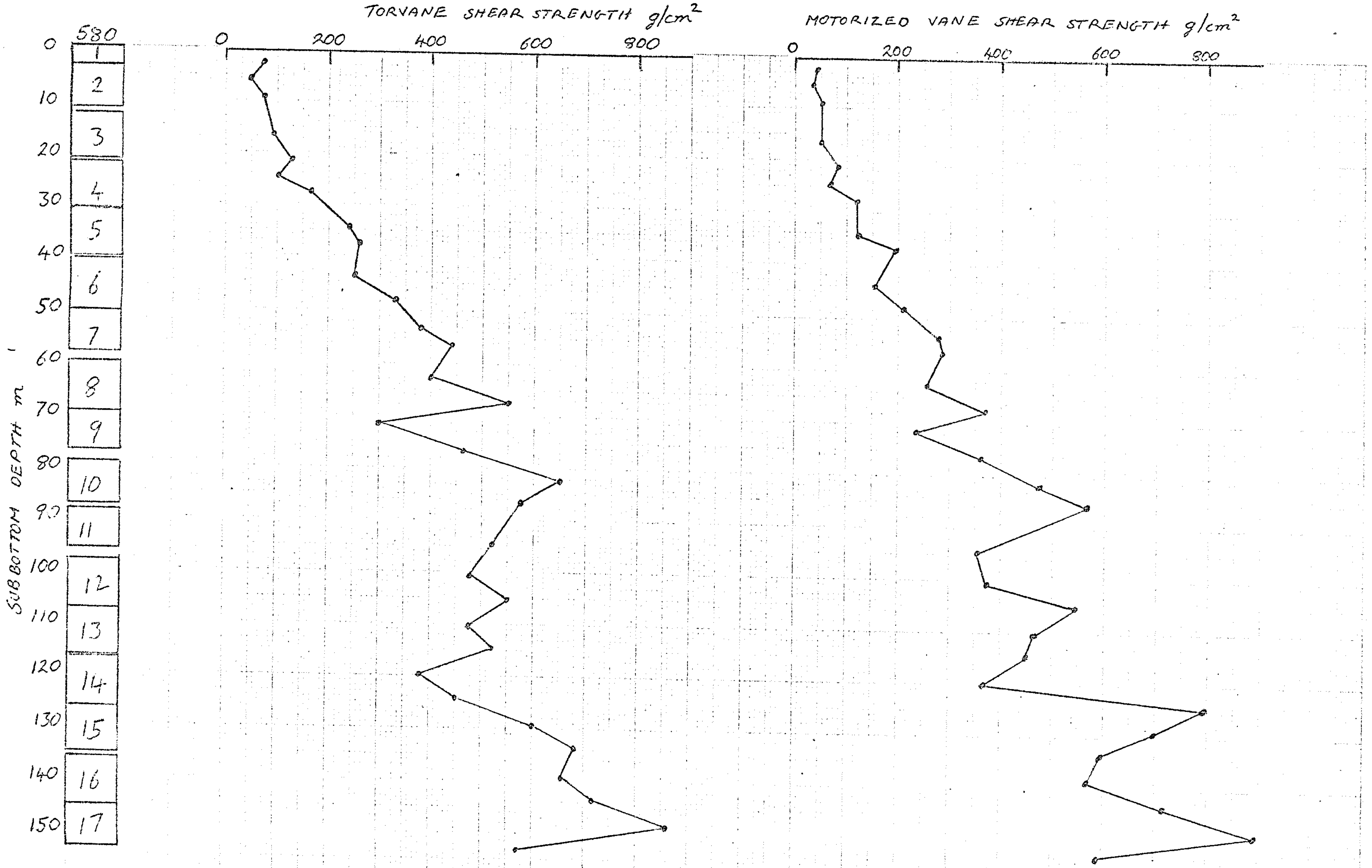
3) The velocity structure in these ash beds are primarily governed by their bulk density structure. A GRAPE record for Core 2, Section 2, is shown in Figure G-4, illustrating the close relationship between the two profiles. This type of detailed profile may prove useful for modeling acoustic reflectors for correlation with seismic sections.

4) The water content profile (Fig. G-3) shows an erratic decrease from around 230% at the sea floor to 120% at 63 meters. This corresponds roughly to lithologic subunit IA (biosiliceous clay). An increase of up to 212% in water content occurs in subunit IB (calcareous biosiliceous clay, 60-79 m). In subunit IC (79-117.3 m), which is lithologically similar to subunit IA, the water content is essentially constant at $\sim$180%. Subunit ID (diatom ooze) initially exhibits a decrease in water content to 140% but then increases slowly through subunit ID before decreasing again in subunit IE (which is lithologically similar to IA and IC).

Although the correlation of water content with lithologic units is not a good one, there does seem to be a pattern which more accurate laboratory determinations may reveal more clearly.

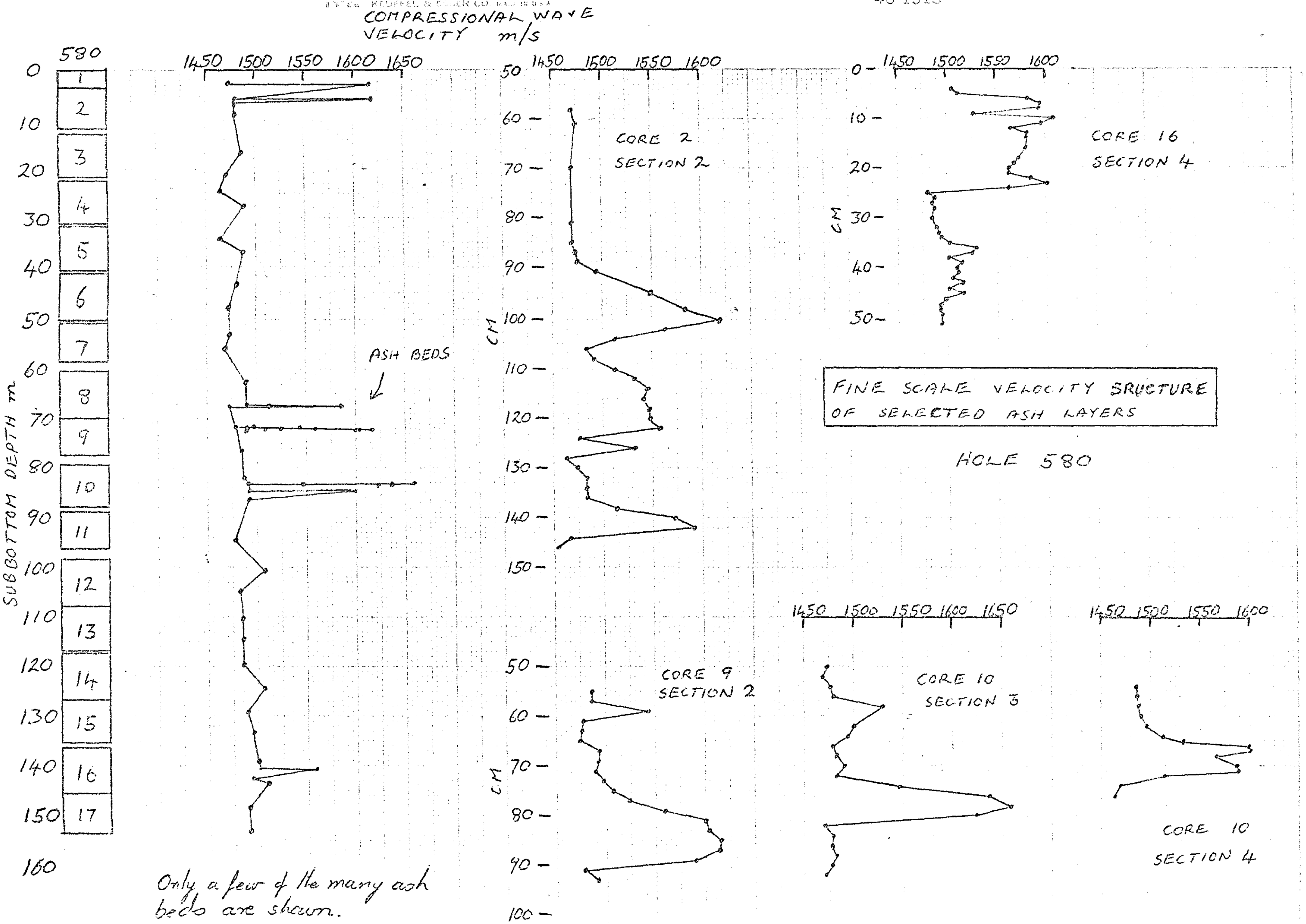
5) The shear strength measurements (Fig. G-1) shows a nearly linear increase with depth up to 800 g/cm$^2$ at 150 meters. Figure G-5 is a comparison of the shear strength data obtained using the two techniques.

It can be seen that the Torvane gives strengths which are 30% higher than the motorized vane tests.



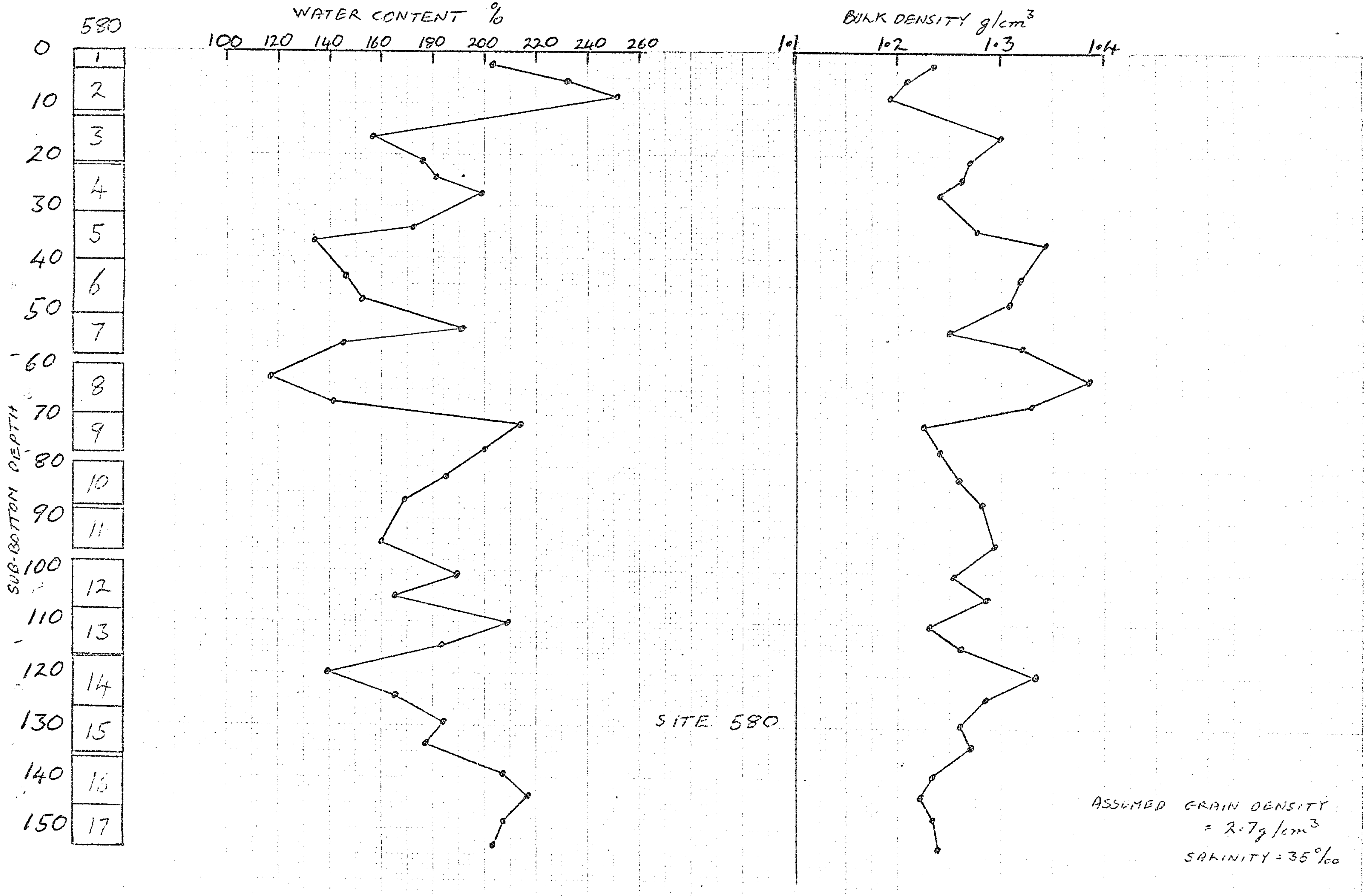

HOLE 580

FIGURE C-1



COMPRESSIONAL WAVE VELOCITY m/s
580
1450 1500 1550 1600 1650
SUBBOTTOM DEPTH m
ASH BEDS
Only a few of the many ash beds are shown.
CORE 2 SECTION 2
CORE 16 SECTION 4
CORE 9 SECTION 2
CORE 10 SECTION 3
CORE 10 SECTION 4
CM
FINE SCALE VELOCITY STRUCTURE OF SELECTED ASH LAYERS
HOLE 580


FIGURE G-2



580
WATER CONTENT %
100 120 140 160 180 200 220 240 260
BULK DENSITY g/cm³
1·1 1·2 1·3 1·4
SUB-BOTTOM DEPTH
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
SITE 580
ASSUMED GRAIN DENSITY
= 2·7g/cm³
SALINITY = 35°/oo


FIGURE G-3

CORE
(in liner)

LEG: 86
SITE: 580
HOLE:
CORE: 2
SECTION: 2
LENGTH: 150

(the scales
are nominal)

* COMPLETE *

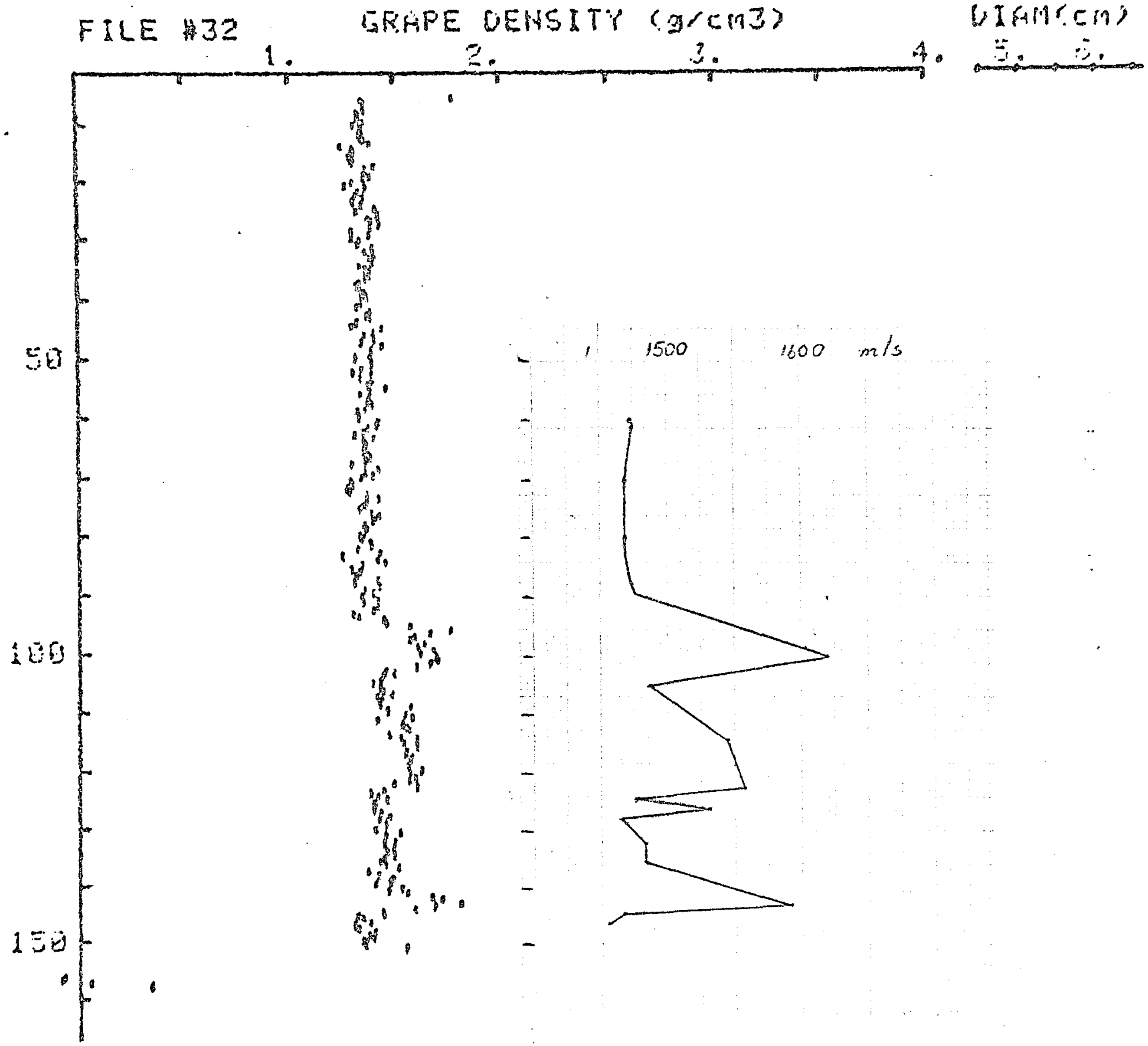



FIGURE G-4

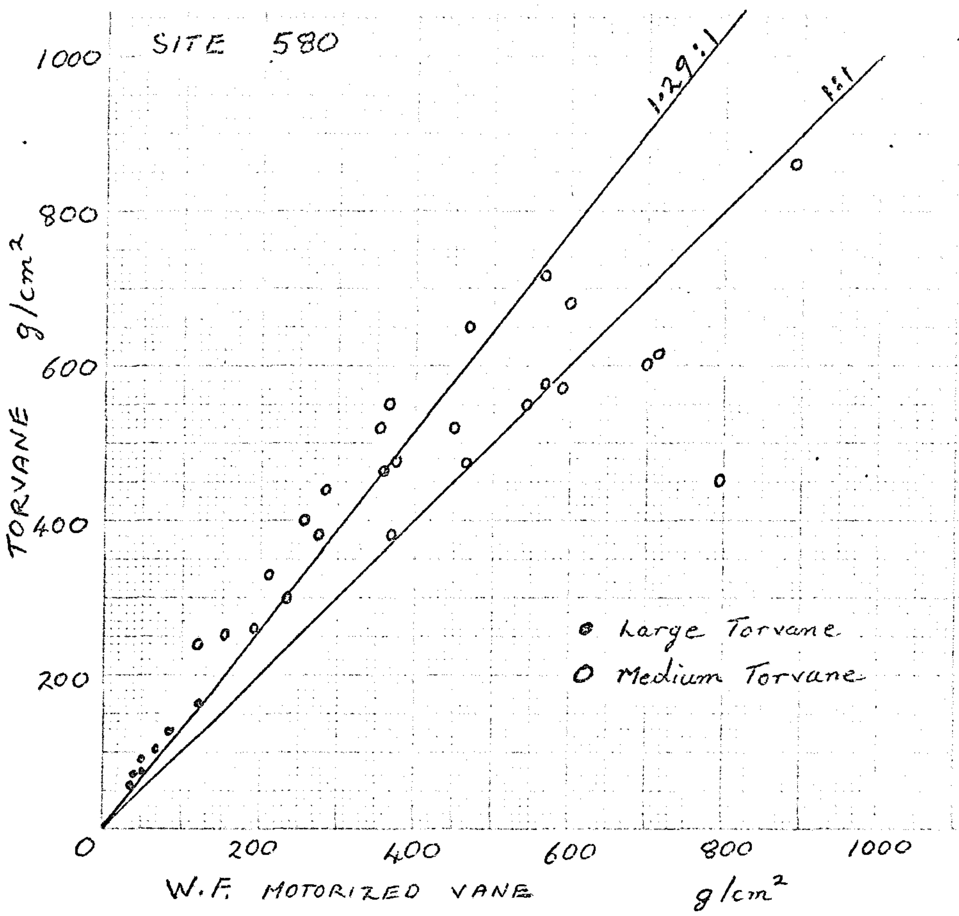



FIGURE G-5 Comparison of shear strength data from hole 580 using the hand-held 'Torvane' and the motorized Wykeham Farrance vane device (vane :- dia = 1.29cm, height = 1.27cm)

SITE 581

## G. PHYSICAL PROPERTIES

### Introduction

The following table summarizes the physical properties measurements made and samples taken from the rotary-cored hole, 581.

| | | 581 |
|---|---|---|
| Shear strength: | hand operated vane | x |
| | motorized vane | x |
| Compressional wave velocity: | | x |
| Water content/bulk density: | shipboard analysis | x |
| | laboratory analysis | x |
| Bulk density by 2-minute GRAPE | | x |

### Techniques

The above measurements on samples were taken approximately once per core in the unconsolidated sediments. A number of compressional wave velocity measurements were taken on the chert and basalt samples. Shear strength measurements were hampered by the brittle nature of the semi-indurated sediments. This resulted in major cracks developing either upon initial insertion of the vane or during the test. If this happens the test is invalid because the failure plane is no longer a cylinder described by the vane blades. In an attempt to overcome this problem, a minimum amount of confining pressure was applied by using two strips of angle aluminum either side of the split core which were held together by G clamps (see Fig. G-1). This eliminated the gap between the liner and the sediment and prevented the cracking described above.

Other measurement techniques have previously been described for Site 576 and no other significant changes were made for this site.

Data

Figures G-1 and G-2 show profiles of shear strength and compressional wave velocity, respectively. Shipboard determinations of water content and bulk density are shown in Figure G-3.

The following points should be noted:

1) The shear strength measurements (Fig. G-1) should be viewed with even more caution than usual. Rotary coring causes significantly more structural disturbance than the HPC. This is true even when the stratigraphic sequence looks undisturbed. Much of the material in Cores 1-7 consisted of alternating layers of soft and stiff sediments which is probably caused by intermittent 'rotation' and 'punch' coring (rotation causing the most disturbance and hence the softer layers). Measurements were made in the largest sections of stiff material that could be found in each core. The first few readings were taken without the G-clamp modification and show comparatively low strengths. In the remaining sections of unconsolidated sediments, the shear strengths lie between 600 and 1300 $g/cm^2$.

2) Compressional wave measurements (Fig. G-2) show a small decrease in velocity below 240 meters which correlates with the boundary of lithologic units I and II (biosiliceous clay-clay). Some measurements were made on selected chert and basalt samples and these varied between 4000 m/s and 5500 m/s as shown in Figure G-2).

3) The water content and bulk density profiles (Fig. G-3) show a rapid change below 200 meters. Water content reduces rapidly from 200% to 75% at 262 meters. This corresponds to a rapid increase in clay content through units IA, IB and II. Water content in the pelagic clay (unit II)

is 75% at a sub-bottom depth of 262 meters, whereas at Sites 576 and 578 water contents as low as 60% were found at sub-bottom depths of 60 and 170 meters, respectively.

4) The lack of good recovery in the pelagic clay section prevented a whole core sample being obtained for consolidation analysis. Hopefully, this can be achieved on Leg 88 using the HPC.

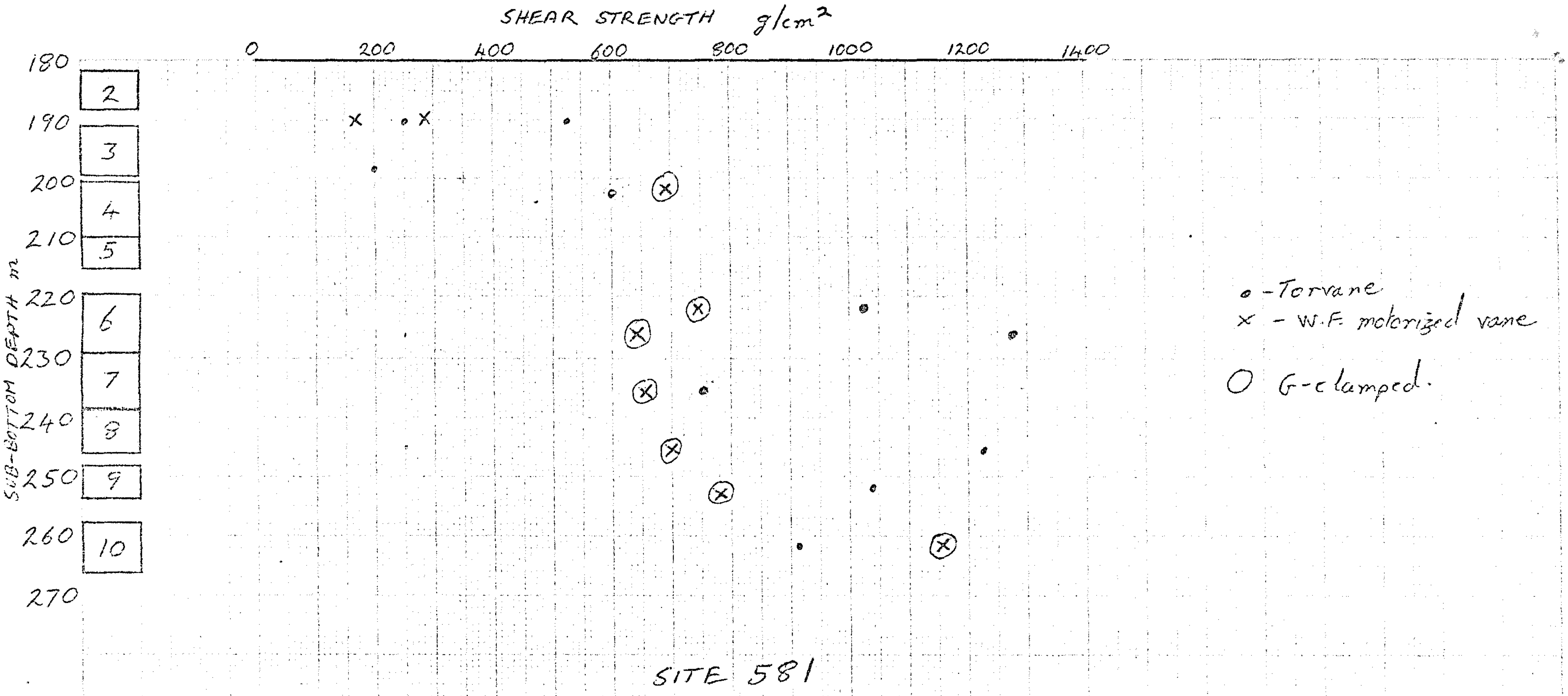
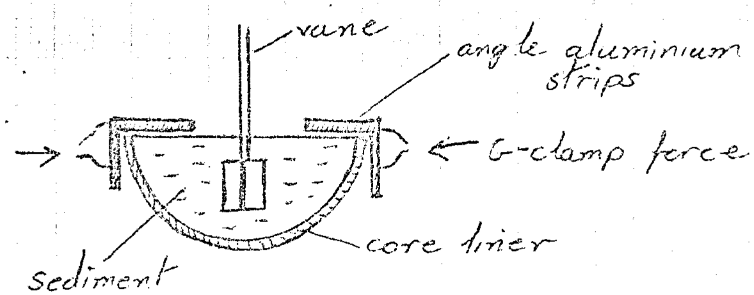



FIGURE G-1




G-clamp arrangement used to prevent semi-indurated sediments from cracking

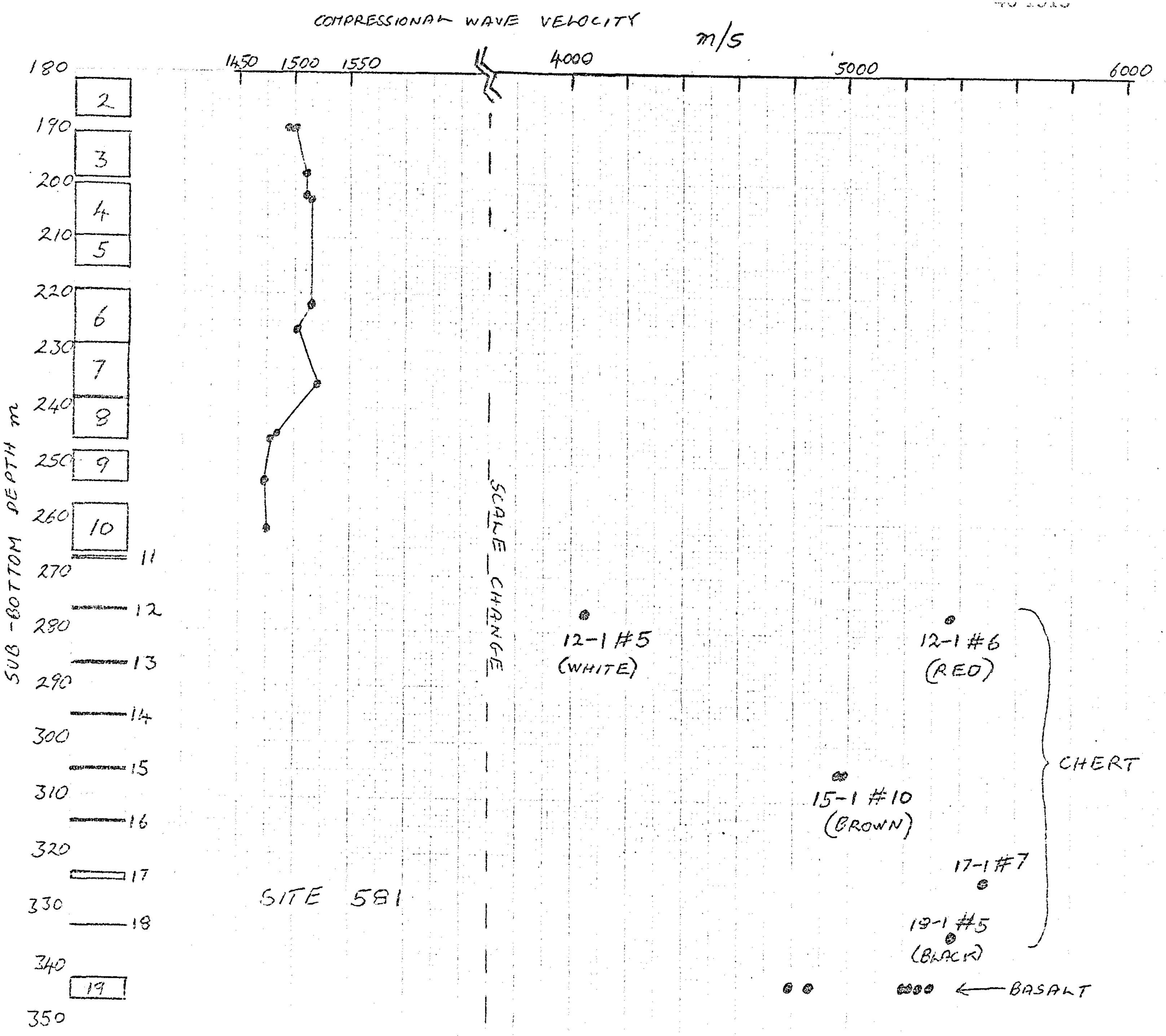
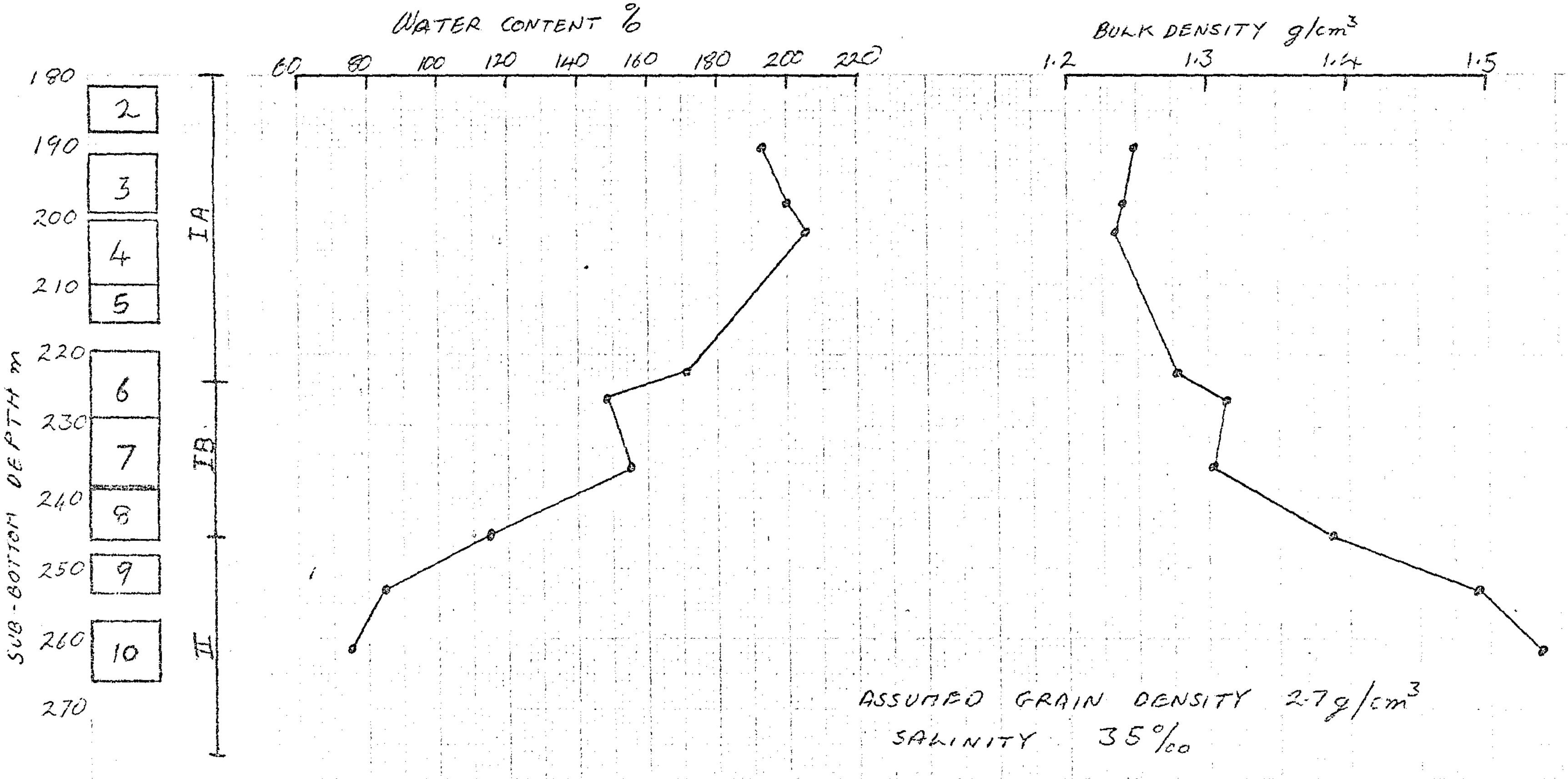

COMPRESSIONAL WAVE VELOCITY
m/s
1450
1500
1550
4000
5000
6000
SUB-BOTTOM DEPTH m
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
SCALE CHANGE
12-1 #5
(WHITE)
12-1 #6
(RED)
15-1 #10
(BROWN)
17-1 #7
19-1 #5
(BLACK)
CHERT
BASALT
SITE 581

FIGURE G-2




SITE 581

FIGURE G-3