1985/39. Geophysical logging of borehole DOB1, Wesley Vale Basin

J.W. Hudspeth

Abstract

DOB1 is a groundwater observation bore near Port Sorell which was open to a depth of 77 m when logged. As revealed by CCL logging, the NQ casing is in lengths of about three metres, some lengths of which are in less than perfect condition. Gamma ray logging detected a sedimentary zone between two layers of (variably weathered) basalt. Variable weathering in the basalt may have been detected by the density log.

INTRODUCTION

DOB1 is sited on A. Duff's property 'Boisdale' in the north-eastern part of the Wesley Vale Basin, a Tertiary basin utilised as a source of groundwater by farms in the area. DOB1 was drilled as one of a number of observation bores in the area, which were designed to allow measurements to determine whether or not the groundwater system is under stress. Geophysical logging of the hole was carried out for two reasons; firstly as part of the geophysical contribution to groundwater investigation and secondly because DOB1 was a suitable and safe hole for testing of certain geophysical tools, namely caliper and CCL (casing collar locating) tools.

The DOB1 bore is located on the Moriarty basalt, was sited by R.C. Donaldson and drilled by R. Stevens during August/September of 1984. The bore was drilled to 168 m and cased with NQ steel to 100 m. On 20 March 1985 geophysical logging of DOB1 commenced with the dummy tool, which could not be lowered past 78 m. The geophysical logging depth of the hole was then set at 75-77 m, dependent on the tool. The casing precluded electric logs. The water depth at this date was 44.08 m and has been within a couple of metres of this during the logging period. CCL and natural gamma runs were carried out on 20 March 1985; repeated density runs and one caliper run were carried out on 27 March 1985.

LOGGING PROCEDURE AND RESULTS

The caliper and repeated density runs were recorded on both magnetic tape and paper chart. Natural gamma and CCL runs were recorded on paper chart only.

The CCL tool was operated on very low gain and was raised from 77 m at four metres/minute with a chart scale of 1:200. The chart record is reproduced in annotated form in Figure 1.

The natural gamma tool was raised from 77 m at six metres/minute with a chart scale of 1:200. The time constant was two seconds and full scale deflection 25 CPS (98.4 API). The gamma plot is shown in Figure 4.

The caliper tool was calibrated with an 80 mm ring and raised from 75 m at about six metres/minute (fig. 2).

The density tool would not fit down the casing with the smaller bow-spring attached and so was put down the hole without any bowspring. Several runs were made in order to check the repeatability of results with the tool 'free swinging'. Both spacers were fitted for all runs. Runs up commenced at 75 m depth, the tool was raised at six metres/minute, the chart scale was 1:500, the time constant was two seconds and all upward runs were recorded on cassette tape. Each downward run was used to check repeatability and was run with the same settings and cable speed as the upward run immediately following but was not recorded on tape. The first upward/downward run pair was run with full scale deflection of 5000 CPS but this was changed to 2500 CPS for the two subsequent run pairs. The density plots are shown in Figure 3.

HOLE CONDITION LOGS INTERPRETATION

The caliper run was completely inside casing. It simply shows that the casing internal diameter is the same (about 60 mm) all the way up the hole from 75 m, apart from a very brief interval (too small to measure) at about 7.5 m depth where the hole diameter decreases to about 58 mm. This is probably due to corrosion or other internal casing coating. There are suggestions on the caliper trace of further minor internal casing irregularities between 7.5 m and 12 m. This is supported by the CCL trace which is very noisy for parts of the top 34 m, including this interval. The noisy sections of the CCL trace probably indicate corrosion and/or internal and/or external irregularities of the casing. In the lower part of the (currently accessible) hole the casing is in better condition and the joins may be clearly seen at 2.5-3.0 m intervals on the CCL trace.

RADIOACTIVE LOGS INTERPRETATION

The natural gamma results are suitable for qualitative lithological interpretation. However, the gamma-gamma density logging must be viewed as highly suspect because the hole was steel cased and the tool was not held against the borehole side. Also, caving behind the casing is expected to be a significant source of error. Nevertheless, in order to carry out some form of qualitative density interpretation (quantitative interpretation being out of the question) some assumptions are necessary. Whether these assumptions are usually valid will be shown by further logging of similar holes. It is assumed from examination of the repeated runs that the steel casing and free-swinging effects do not preclude dividing the densities into higher and lower zones as can be seen from the minimum and maximum envelopes of Figure 4. This leaves the problem of whether the low densities are due to low density rocks or to caving. It will be assumed that any caving has occurred in lower density rocks, so that low densities on the plot are assumed genuine, although possibly exaggerated. It is possible that the minimum envelope of the density traces is the most reliable density indicator, on the assumption that the known sources of error (apart from the steel casing which is being treated as a constant) will only serve to decrease the density reading.

The main features immediately apparent on the gamma ray log are the low radiation which occurs over the intervals 0-50 m and 69-77 m and the higher, more erratic radiation over the 50-69 m interval. The low radiation is associated with basalt and decomposed basalt. The chips from the hole were examined but the variation in the basalt gamma radiation did not appear to correspond with the degree of weathering. The radiation peak at 0 to two metres depth is probably associated with material derived not wholly from eluvial weathered basalt. Cuttings from the interval between 50 m and 69 m contain sand, clay silt and carbonaceous material, with little evidence of basaltic material. The part of this zone between 50 m and 60 m is a fine dirty sand. The gamma log suggests that some parts are sandier than others (*e.g.* 53-55 m and 59-63 m). The major peak at 63-69 m is due to a black carbonaceous silt.

On the basis of these results it is tentatively suggested that basalt may be distinguished from non-volcanic sediments on the gamma ray log in this region by the following method. Draw two lines down the log parallel to the depth scale, one at 10 API and the other at 25 API. Zones of gamma radiation remaining between these lines for at least ten metres are likely to be due to basalt. Zones with peaks which significantly (*e.g.* 30 API) and repeatedly exceed 25 API are likely to be due to sediments, with the peaks being the more shaly material and the lower radiation levels between the peaks being due to the sandier material.

Interpretation of lithology from the gamma ray would be enhanced in the case of a proper density log being run and the basalt being reasonably unweathered. The basalt in the top 50 m of DOB1 shows variable weathering, generally moderate to severe. The density of the basalt in this interval would be expected to fluctuate accordingly. However, if reasonably unweathered basalt were encountered, we would expect it to display high density and low natural gamma radiation. Sand and shale should show moderate densities with sand having low gamma radiation and shale having moderate gamma radiation.

The DOB1 drilling chip samples represent six metre intervals. These were examined and described in the presence of the author by S.M. Forsyth and B. Weldon, whose invaluable assistance with this part of the work is gratefully acknowledged. From the chip descriptions, a basalt weathering index was prepared and the results graphed (fig. 4) which shows that the greater the weathering, the lower the density as measured. This relationship does not appear to hold for the extremely weathered basalt of the top 20 m. The very low measured densities in this interval are probably due to dry, low-density weathered material which has suffered some caving. The non-basalt low density peak at 60 m probably corresponds to the sandiest interval which may have caved somewhat.

[22 July 1985]

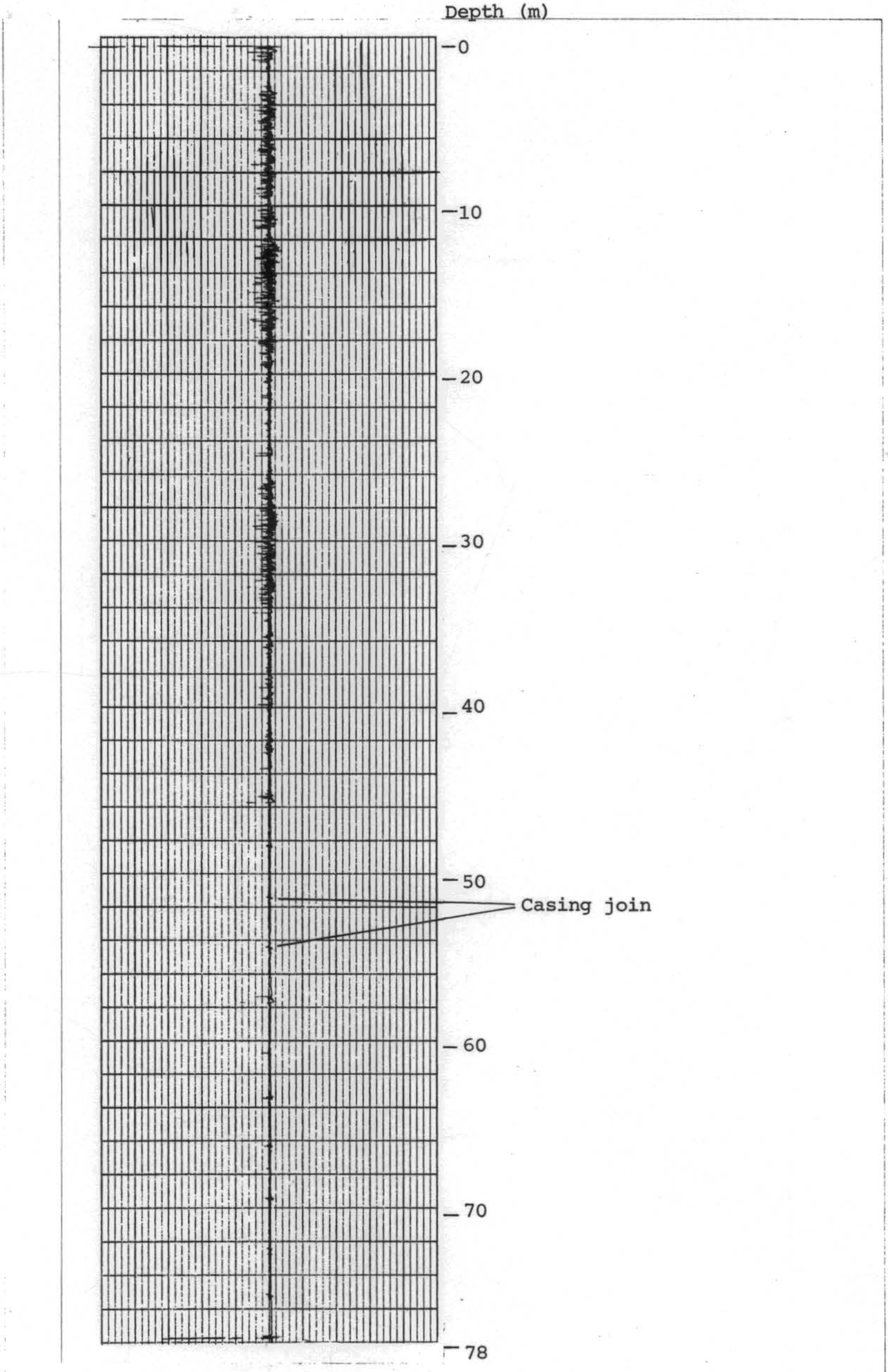
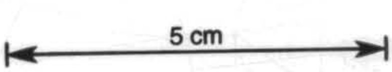


Figure 1. *DOB1 casing collar locating tool run. Gain constant.*



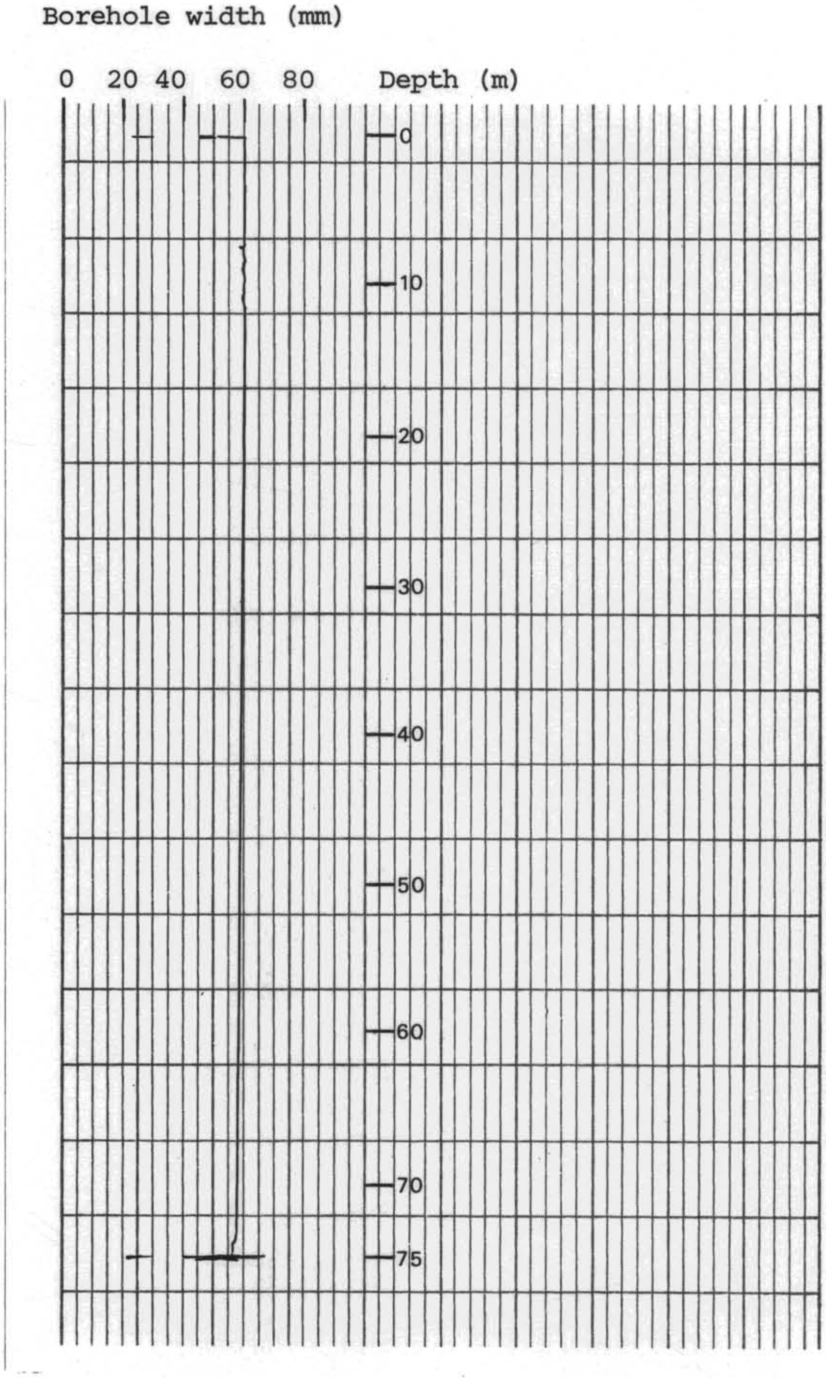
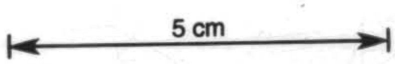


Figure 2. *DOB1 caliper run.*



M 1681

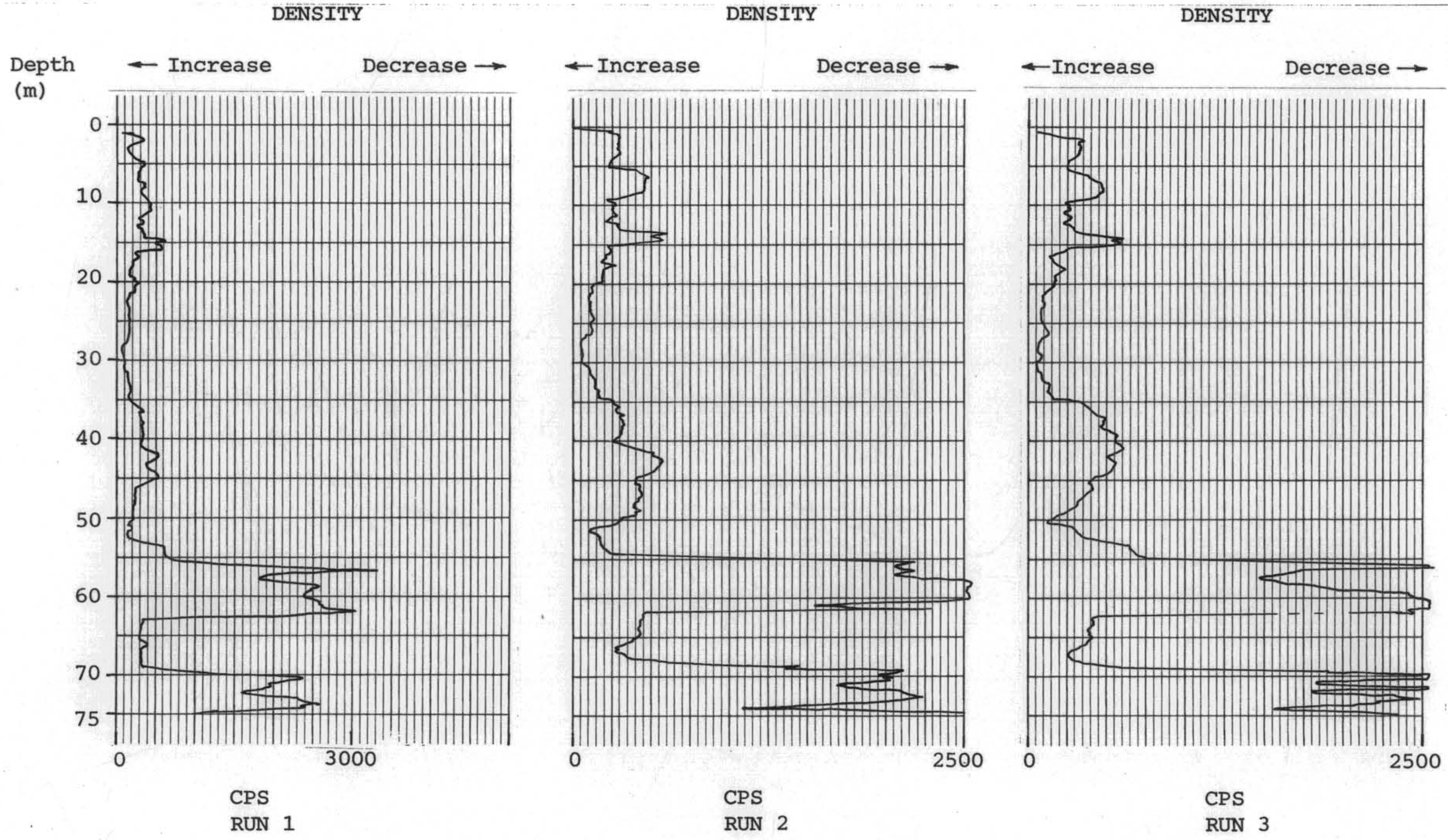


Figure 3a. *DOB1 density runs downward. Both spacers, TC2, CPS fsd as shown, no bowspring, six metres/minute.*

5 cm

39-6

M 1681

6/8

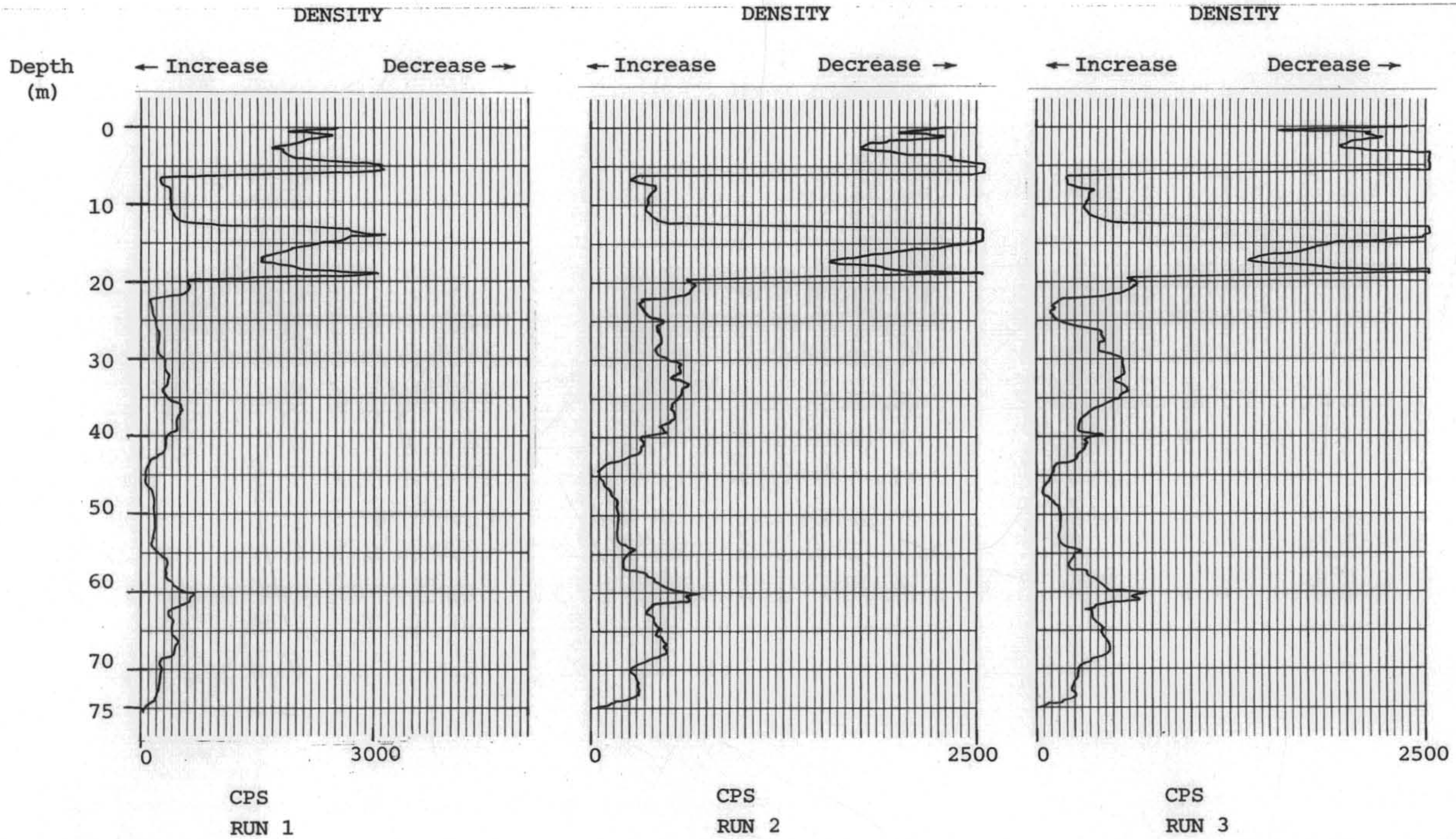
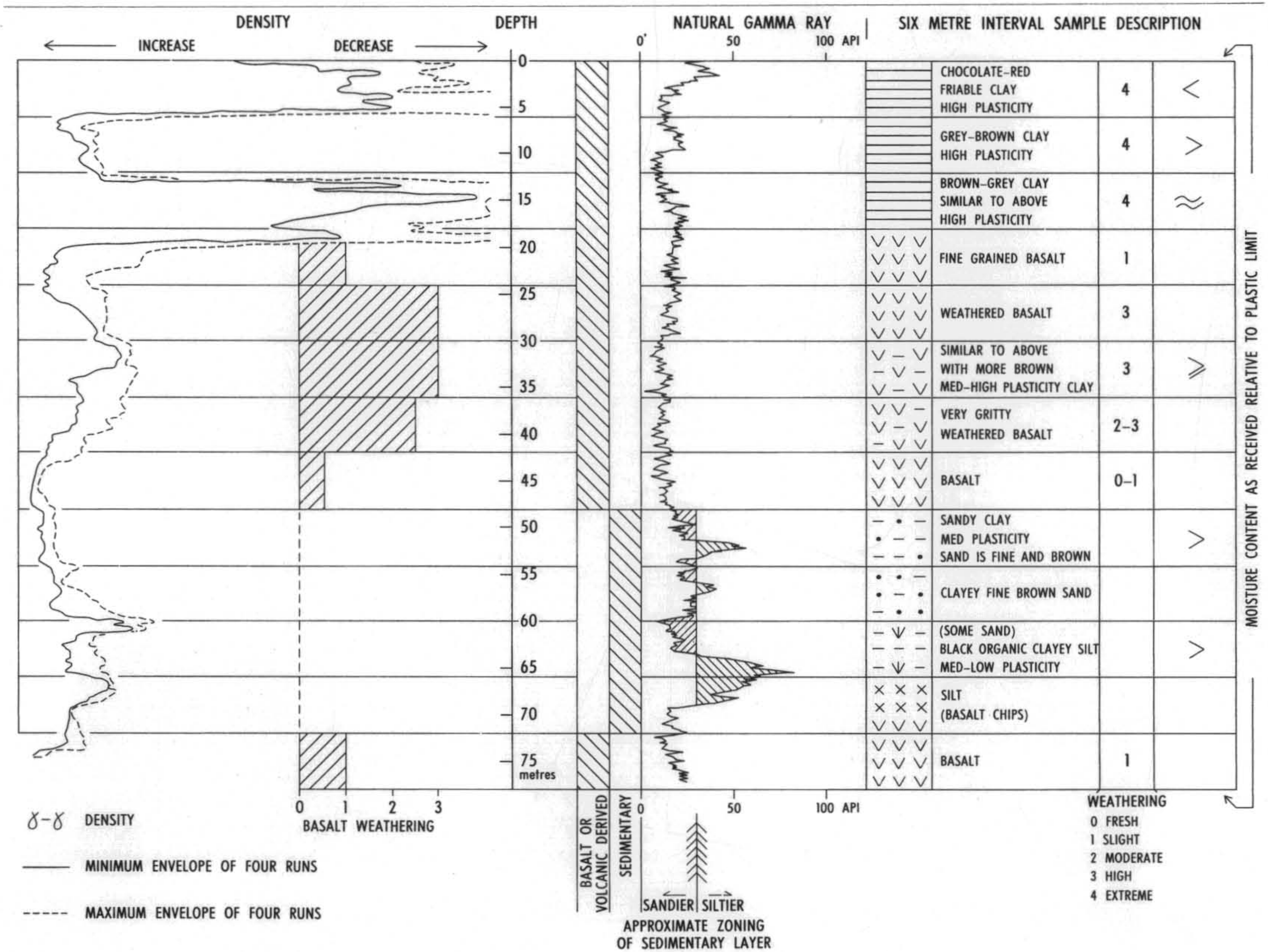


Figure 3b. *DOB1 density runs upward. Both spacers, TC2, CPS fsd as shown, no bowspring, six metres/minute.*

5 cm



DENSITY
INCREASE
DECREASE
DEPTH
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
metres
NATURAL GAMMA RAY
0
50
100 API
SIX METRE INTERVAL SAMPLE DESCRIPTION
CHOCOLATE-RED FRIABLE CLAY HIGH PLASTICITY
4
GREY-BROWN CLAY HIGH PLASTICITY
4
BROWN-GREY CLAY SIMILAR TO ABOVE HIGH PLASTICITY
4
FINE GRAINED BASALT
1
WEATHERED BASALT
3
SIMILAR TO ABOVE WITH MORE BROWN MED-HIGH PLASTICITY CLAY
3
VERY GRITTY WEATHERED BASALT
2-3
BASALT
0-1
SANDY CLAY MED PLASTICITY SAND IS FINE AND BROWN
CLAYEY FINE BROWN SAND
(SOME SAND) BLACK ORGANIC CLAYEY SILT MED-LOW PLASTICITY
SILT (BASALT CHIPS)
BASALT
1
MOISTURE CONTENT AS RECEIVED RELATIVE TO PLASTIC LIMIT
γ-γ DENSITY
MINIMUM ENVELOPE OF FOUR RUNS
MAXIMUM ENVELOPE OF FOUR RUNS
0 1 2 3
BASALT WEATHERING
BASALT OR VOLCANIC DERIVED
SEDIMENTARY
0 50 100 API
SANDIER
SILTIER
APPROXIMATE ZONING OF SEDIMENTARY LAYER
WEATHERING
0 FRESH
1 SLIGHT
2 MODERATE
3 HIGH
4 EXTREME

Figure 4.

5 cm