DESCRIPTION OF A BOTTOM-SEDIMENT SAMPLE DREDGED FROM HALLEY BAY

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ON 22 January 1962 D. A. Ardus, C. Dean and M. H. Thurston obtained a 3 kg. bottom sample from Halley Bay (Fig. 1). The sampling was carried out by working a grab of the Petersen type through the tide crack at the foot of the ice slope in Halley Bay. The water depth

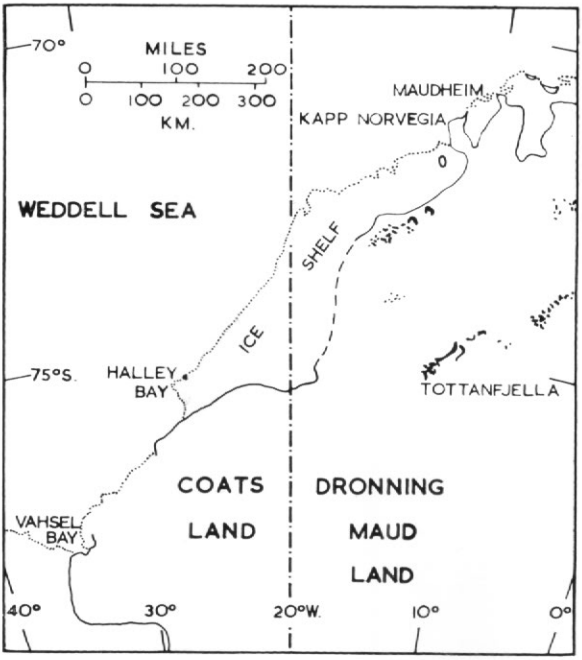

Fig. 1. Sketch map showing the position of Halley Bay, where the bottom-sediment sample was collected.

recorded at the sampling point was 675 ft. (206 m.), a value uncorrected for current or tidal effects. According to M. H. Thurston (personal communication), observations during sampling indicated that the bottom was quite firm and composed of a relatively homogeneous mixture of stones, sand and silt, together with a large percentage of organic debris.

GRAIN-SIZE ANALYSIS

Approximately 300 g. of the bulk sample were oven dried and, after successive quartering, 112 g. of this were used for size analysis. The analysis was carried out using the standard sieving procedure (B.S. test sieves shaken mechanically). In Table I the results are presented as weight per cent per size class (Wentworth), and Fig. 2 shows the cumulative size-distribution curve drawn from the analysis data.

The entire sample has a median diameter of 240μ ($+2\cdot08\phi$) and can be further described in terms of its sorting and skewness as follows. Using the definitions adopted by Folk (1959), the sample is poorly sorted ($\sigma_I = 1\cdot52\phi$) and is strongly coarse-skewed ($Sk_I = -0\cdot33$). The

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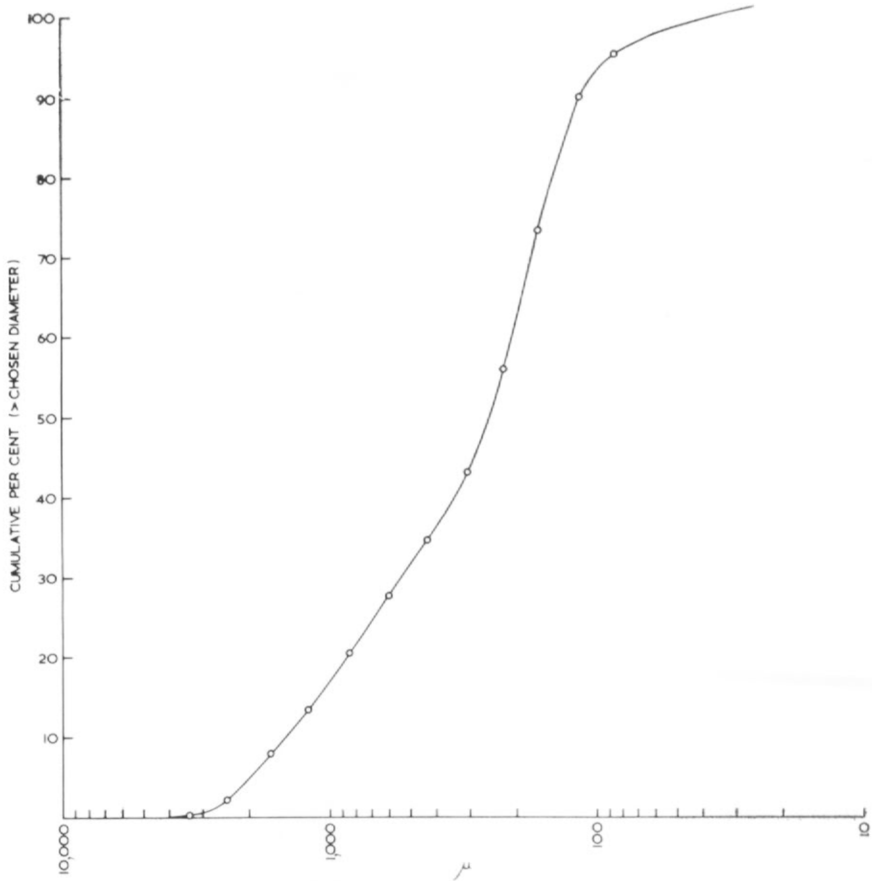

Fig. 2. Cumulative size-distribution curve.

TABLE I. GRAIN-SIZE ANALYSIS AS WEIGHT PER CENT PER SIZE CLASS

Wentworth Size Class	*Weight* (per cent)
Granule	5·0
Very coarse sand	12·0
Coarse sand	14·2
Medium sand	17·0
Fine sand	33·8
Very fine sand	14·0
Silt	4·0

marked skewness towards the coarser sizes is illustrated by the frequency curve in Fig. 3. From this curve it can be seen that there are possibly composite modes in the range —0·5 to 1·5ϕ, besides the pronounced mode in the fine sand class.

Poor sorting and the occurrence of composite modes has been suggested by Kagami (1964), from a more detailed study of several bottom-sediment samples, as indicative of sediments transported by ice rafting. Therefore, it is probable that the sediment described here was derived in this manner, particularly since the sampling site was in close proximity to the front of the Brunt Ice Shelf.

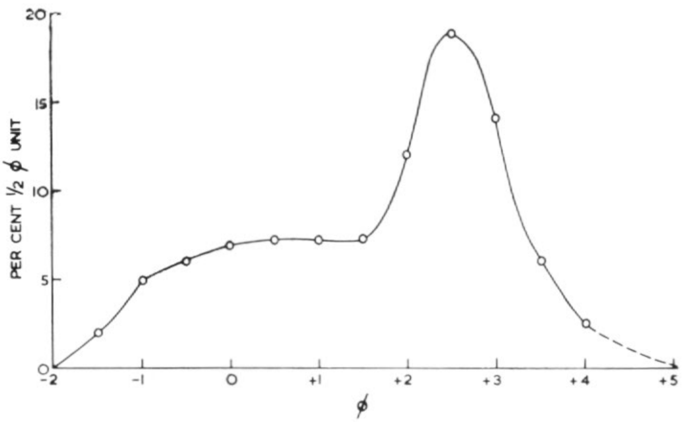

Fig. 3. Frequency curve of size distribution.

Description of the Sediment

The granule fraction of the sediment is composed of angular to sub-rounded, separate and composite grains. Visual estimation shows this fraction is composed of:

Colourless, whitish grey and composite grains	63%
Greenish grey grains	25%
Reddish to pale pink grains	12%

Thus, dark-coloured grains account for approximately one-third of the fraction. No identification of these grains has been attempted, since more useful information is obtainable from an examination of the heavy minerals occurring in the fine sand fraction.

The sediment as a whole contains an appreciable percentage of organic material, approximately 1·2 per cent by weight in the size classes greater than fine sand. From an estimation of relative percentages in three fractions (Table II) it is apparent that the organic components are concentrated in the finer size classes. The organic material includes abundant Foraminifera, Bryozoa, echinoid spines, sponge spicules and ostracods, as well as shell fragments. Specific identification of these groups is now being undertaken by Dr. J. Neale and will be the subject of a later paper.

Table II. Distribution of Organic Material

Fraction (*Size Limits*) (μ)	*Weight* (per cent)
>1676	0·94
1676–500	1·80
500–250	2·75

Mineralogy of the Sediment

Identification of the detrital grains composing the fine sand fraction of the sediment was completed by microscopical examination of the light and heavy fractions obtained after separation in tetrabromethane (S.G. = 2·95).

Light fraction

The light fraction is dominantly composed of sub-angular quartz grains. Most of the quartz is characterized by inclusions but some clear individuals are also present. The inclusions are commonly opaque iron ore (magnetite) but some grains show intersecting sets of rutile needles and zircon is not uncommon. Feldspar is present in addition to quartz but in a subordinate amount. The majority of the feldspar is seen as cloudy altered grains; in some, original multiple lamellar twinning is still observable. There is a noticeable absence of micas.

Heavy minerals

The heavy minerals, a selection of which is shown in Fig. 4, comprise approximately 2·5 per cent of the fine sand fraction and include:

andalusite	hornblende	sillimanite
apatite	ilmenite	spinel
augite	kyanite	tourmaline
biotite	leucoxene	zircon
epidote	magnetite	zoisite
garnet	rutile	

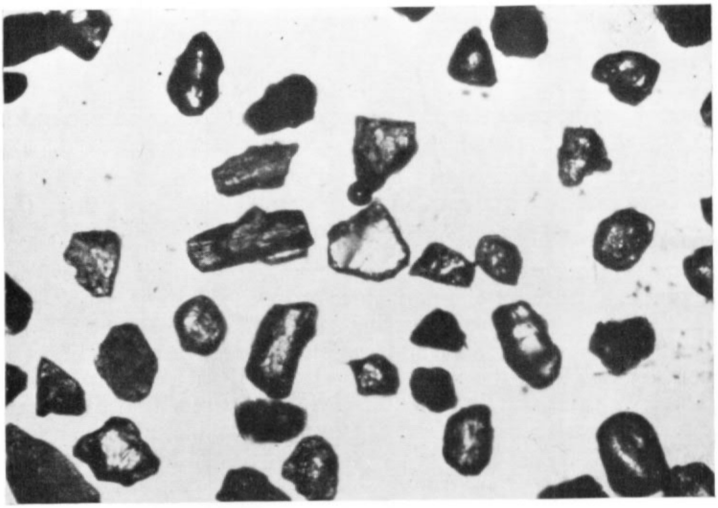

Fig. 4. A selection of the heavy mineral grains (ordinary light; ×60).

Garnet and hornblende occur in equal proportions, forming about 30 per cent of this heavy mineral assemblage. At least three types of garnet are present:

i. Pale pink, sharply angular fragments.
ii. Colourless fragments.
iii. Reddish pink, very well rounded grains.

Of these, types i and ii are the most prevalent, representing 75 per cent of the garnets occurring in the sediment. The third type is in complete contrast to any other mineral grains seen in the sediment, in that the degree of rounding is so well defined, whereas the majority of the grains are angular to sub-angular. This is illustrated in Fig. 5, in which the more common angular garnet is compared with the well-rounded variety.

Angularity of the grains supports the hypothesis that the sediment is freshly derived and has undergone a minimum of transportation, or has been protected from abrasion during transport, as would be the case if the sediment were carried by ice. The presence of the well-rounded garnet would not support this contention. It is possible, however, that these garnets are derived from an older sediment that is now being re-worked.

Several varieties of hornblende are present, ranging from common hornblende to the more deeply coloured soda-hornblendes. The other minerals that are present, with the possible

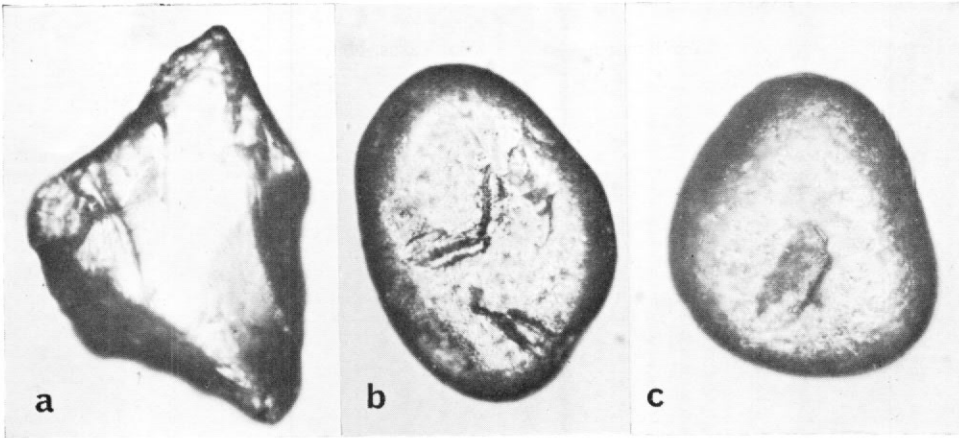

Fig. 5. Garnets from the heavy mineral separation (ordinary light; ×150).
a. Sharply angular fragment (type i).
b, c. Very well rounded grains (type iii).

exception of zircon and apatite which are relatively rare in this sediment, typically denote a metamorphic assemblage. It is probable, therefore, that the bulk of this sediment represents detritus derived from an area of garnetiferous, amphibole-, and possibly, pyroxene-schists or gneisses. The nearest extensive rock outcrops occur in the Shackleton Range about 300 miles (480 km.) south-east of Halley Bay. These mountains are composed predominantly of metamorphic rocks (Stephenson, in press), thus providing some support as a possible provenance area of the required composition.

A similar mineral assemblage has been described by Kagami (1964) from studies on bottom sediments from the Lützow-Holmbukta region on the eastern coast of Dronning Maud Land. He has identified the source area as the pyroxene-gneiss, garnet-gneiss, granite and basic metamorphic rocks which occur along the coast in this region (Tatsumi, Kikuchi and Kizaki, 1964).

Conclusions

A description has been given of the size distribution of this bottom-sediment sample, together with an appraisal of the mineralogy with particular reference to the heavy mineral assemblage. It is concluded that the sediment has been derived predominantly from an area of metamorphic rocks and transported by floating ice. Some re-working of an older sediment may be taking place, thus providing material to be incorporated together with the large percentage of detritus derived from floating ice. The importance of the organic component has yet to be evaluated, but it could provide a useful indication of the age of the Halley Bay sediments.

Since there are no rock outcrops in the immediate vicinity of the Halley Bay area, more detailed sampling and investigation of the bottom sediments would seem to be well worth while in this area, if not in other parts of the Weddell Sea.

Acknowledgements

I am grateful to the British Antarctic Survey for making the sample available for study. I should like to thank P. J. Loveland for his valuable assistance with the analyses, and Dr. R. J. Adie for helpful criticism of the manuscript.

MS. received 13 August 1965

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