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A Simple Method for the Determination of Ice-Rafted Debris in Sediment Cores*

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Summary: The distribution of ice rafted debris (IRD) is an important parameter in glaciomarine sediments. A simple method is presented allowing the determination of the IRD-contents by counting the gravel fraction of the x-radiographs which are generally taken during sampling. In comparison with sieve analyses corresponding values are obtained by both methods. However, more information can be made available in a shorter time by this method.

Zusammenfassung: Der Anteil eistransportierten Materials (IRD) ist ein wichtiger Parameter glazialmariner Sedimente. Es wird eine einfache Methode vorgestellt, die es ermöglicht, durch Auszählen der Kiesfraktion in den bei der Probennahme meist standardmäßig erstellten Radiographien den IRD-Gehalt zu ermitteln. Der Vergleich mit Siebanalysen zeigt, daß beide Methoden übereinstimmende Werte liefern, durch Zählen jedoch schneller eine höhere Informationsdichte erreicht werden kann.

1. INTRODUCTION

Ice rafted debris (IRD) content in glacial-marine sediments represents an interesting sedimentological parameter, providing information about factors such as distribution and number of icebergs, continental erosion by ice, sediment transport mechanisms and melt rate corresponding to water temperature (PIPER & BRISCO 1975). This parameter is therefore additionally important for the reconstruction of paleoclimatic conditions in polar regions. A number of different methods have been used to determine the IRD content in sediment cores.

CONNOLY & EWING (1965) and SMITH et al. (1983) estimated the sand and gravel content in intervals of 20—30 cm, whilst VORREN et al. (1983) found that the most suitable parameter reflecting ice-drop activity seems to be the number of rock fragments in the 1—2 mm size range per 100 gram of dry sediment. LISITZIN (1960), on the other hand, expressed the gravel distribution in surface sediments in kg/m². Other methods include counting IRD particles in the 63—250 μm fraction under the microscope, having the typical sharp angular surface (WATKINS et al. 1974, 1982; LEDBETTER & WATKINS 1978), counting ice rafted quartz grains in the >63 μm fraction of a known sediment volume (LABEYRIE et al. 1986) as well as using the weight percentages of different fractions as an IRD-parameter (1000-63 μm, COOKE & HAYS 1982; >63 μm, PIPER & BRISCO 1975; >250 μm, KENT et al. 1971; BORNHOLD 1983). Sample interval for these analyses varies between 5 and 150 cm.

The above-mentioned methods have, according to the fraction tested, different disadvantages. A large amount of work is involved when qualifying gravel and sand content by sieving, weighing, and counting of individual grains. When using the gravel content as an IRD-parameter, a sample interval of 5 or more centimeters is only suitable for the recognition of long-term-trends in the ice raft signal. When evaluation DSDP-cores a sampling interval of 100—150 cm is used to determine the input of IRD during the last 8.6 m. y. (BORNHOLD 1983). If a higher resolution in the variations of sedimentological parameters is desired (1 sample per 5,000—10,000 years), the gravel fraction of samples with a mean sampling interval of 5—10 cm is not sufficiently representative. So, for example, a single large dropstone in a sample from a horizon which is otherwise poor in IRD would bias the result when using the weight-percentages. Simple counting of grains is certainly more useful in obtaining a more reliable result.

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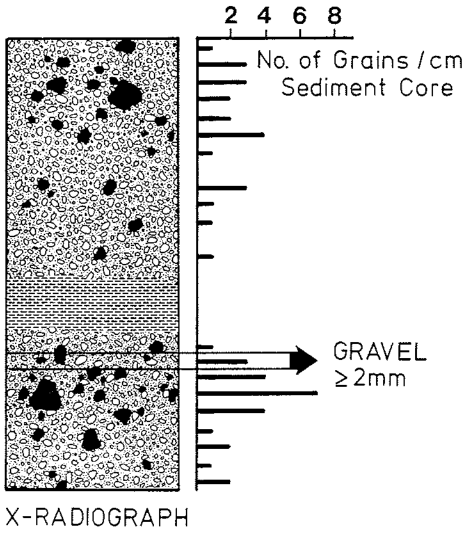

Fig. 1: X-radiographs, prepared from 1 cm slabs during sampling of sediment cores as a standard method, were used to determine the distribution of ice-rafted debris (IRD). The gravel content (>2 mm) was counted in horizons of 1 cm width and plotted as grains per cm in a diagram, with lines corresponding in length with the number of grains counted.

Abb. 1: Die Verteilung der Eisfracht (IRD) wurde an Radiographien ausgezählt, die während der Beprobung von jedem Kern erstellt werden. Der Kiesgehalt (> 2 mm) wurde in Horizonten von 1 cm Breite ausgezählt und gegen die Tiefe mit Linien entsprechend der Anzahl an Körner aufgetragen.

2. PRINCIPLES OF THE METHOD

Because of the disadvantages mentioned, a new type of IRD analysis has been tested and used (GROBE 1986), producing much information concerning the spreading of the ice transported material within a sediment core. The results can be obtained within a short time.

Preceding on the assumption that an iceberg transports sediment with a grain size distribution similar to a till, ice-rafted sediment contains particles of all grain sizes which will settle to the sea floor after melting of the ice (transitional glacial marine sediment). This sediment may be modified by the addition of particles derived from bottom currents (compound glacial marine sediment) or the "non"-sedimentation of the finer fraction of ice rafted sediment due to current erosion (residual glacial marine sediment). Independent of the modifying processes, the coarse material not can be transported or eroded by currents and is representative of the degree of iceberg activity.

This method presupposes that the content of particles >2 mm is representative of the IRD contribution, corresponding to the iceberg activity. For this purpose, X-radiographs, which are standard preparations from each core for structural analysis, were used. The X-radiographs were placed on a light table, and using graph paper the particles >2 mm diameter were counted in 1 cm intervals. Enrichments of coarse sediment due to bioturbation were not considered in this process. Using an X-radiograph width of 10 cm and an interval of 1 cm, the amount of sediment counted represents about 10 cm^3.

Graphical illustration is made by lines, the length of which corresponds to the number of gravel particles (Fig. 1). The method enables data for every centimeter of the core to be obtained which, in combination with the histogram plot, gives a good survey of the distribution of IRD in the sediment. To smooth the histogram, running averages can be calculated (Fig. 2, C).

Pebble counting was used first by v. HUENE et al. (1973) to test the assumption that coarse sand is ice rafted. He compared the number of pebbles counted out in X-radiographs from one half of a DSDP-core with the dry weight percentage of the sand fraction 2000-250 μm. A good correlation was shown.

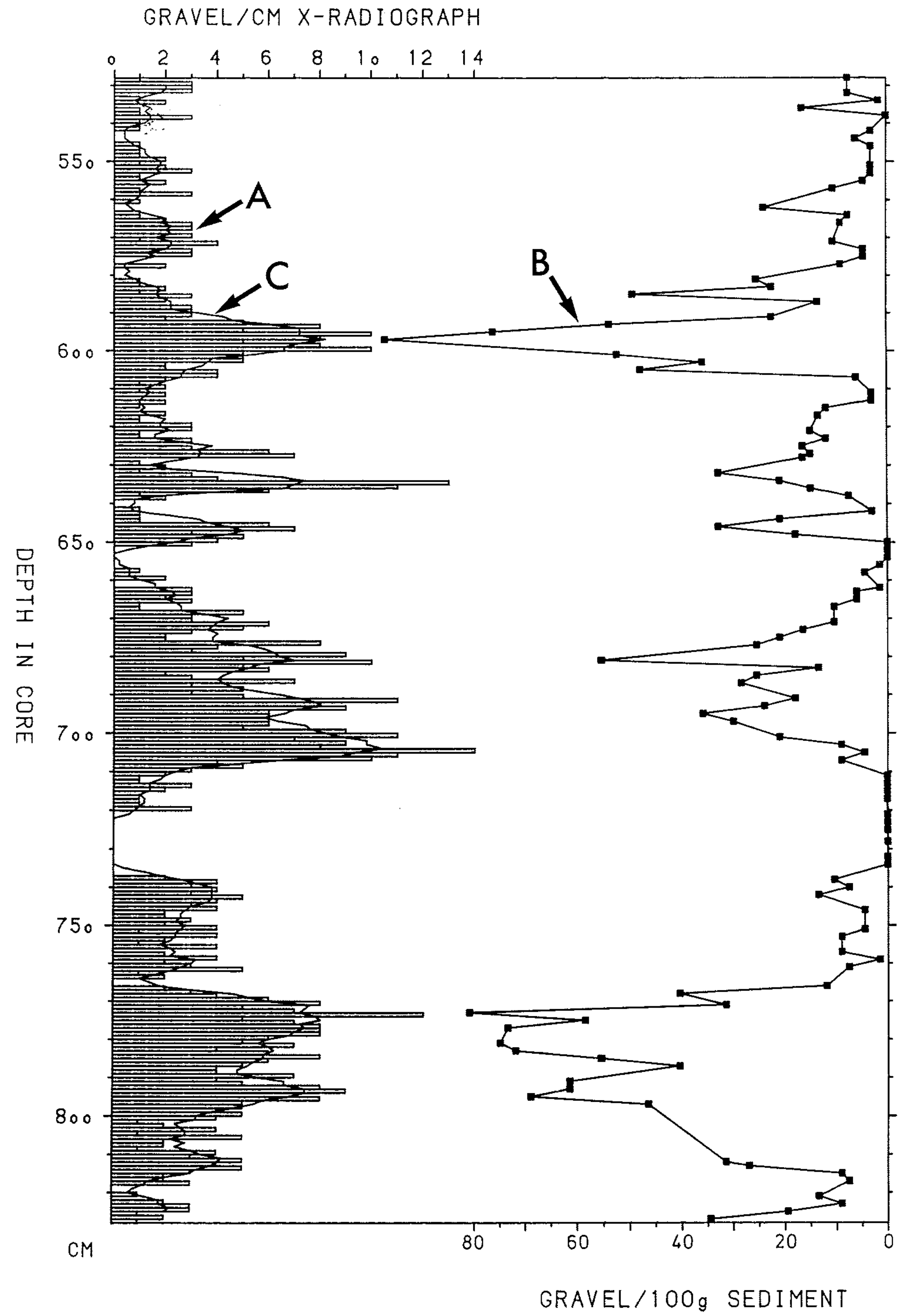

Fig. 2: Comparison of the number of grains counted out in the X-radiographs (A) with the results of a sieve analysis (B) shows a good correlation of the different methods. (C) shows 7-step running averages of the results of method (A).

Abb. 2: Der Vergleich zwischen den Ergebnissen aus der Zählung (A) mit denen einer Siebanalyse (B) zeigt eine gute Übereinstimmung der beiden Methoden. (C) zeigt gleitende Mittelwerte über jeweils 7 Horizonte der Methode (A).

3. COMPARISON WITH SIEVE ANALYSIS

To examine the reproducibility of the IRD-counting method, a 3 m long gravity core section from the Antarctic continental margin off Kapp Norvegia (AWI 1021-1 SL, 528—828 cm), containing cyclical variations in IRD content, was completely divided up into slices of 1.5 cm width, weighed wet and then sieved at 2 mm and 63 μm and dried. The gravel part was counted in all samples and reevaluated to 100 g wet weight of the total sediment. The data evaluated (Fig. 2, B) show good conformity with the data from the new method (Fig. 2, A).

A disadvantage of this method may be that a relatively high amount of larger IRD-particles is necessary to get a significant result. It should therefore only be used in sediments deposited under conditions of intense iceberg activity.

4. CONCLUSIONS

A method for the quantification of IRD in sediment cores has been evaluated and tested. It shows that counting of the gravel fraction within horizons of X-radiographs, mostly prepared during sedimentological analysis of sediment cores as a standard method, offers a rapid and accurate method for the analysis of IRD-distribution in sediment cores. A large amount of information from the sediment cores is thus readily determined.

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