Recognition of fine-grained sediments from excavation activities using chemical analysis. The Øresund Link project

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ABSTRACT

A method of determining the influx of sediment (spill) derived from the construction activities in Øresund has been developed and tested. The method is based on chemical analysis of sediment cores, using the fact, that the construction activities are mainly conducted in limestone and till, both characterised by high contents of calcium carbonate in the fine-grained fraction. Consequently chemical analyses of the spill show high contents of elements as Ca, Sr and (total) carbon and low content of e.g. Al, Y and organic carbon.

However, apart from the calcium carbonate derived from the spill, there is a calcium carbonate contribution to the natural sediments from shell debris. Accordingly, it was necessary to compensate for the natural content of calcium carbonate. This was possible because there is a relation between:

- The calcium carbonate and the clay content in the natural sediment.
- The Total Carbon and the Total Organic Carbon in the natural sediment.
- The Sr/Ca ratio in the natural sediment (shell debris) and the spill (limestone).

A total of four spillcharts has been constructed to separate seabed materials with spill material from natural seabed sediment.

The differences in chemical composition between the natural sediments and the spill is used to determine the percentage of spill in the sediment cores, calibrated against artificial mixtures of natural sediment and spill.

The results of the spill monitoring method certify that it is possible to distinguish between natural sediments and sediments with an influx derived from the construction activities, and further it was possible to determine the weight percentage of spill at one position (FBC) in samples from the interval 0-1 cm and 1-3 cm below the seabed.

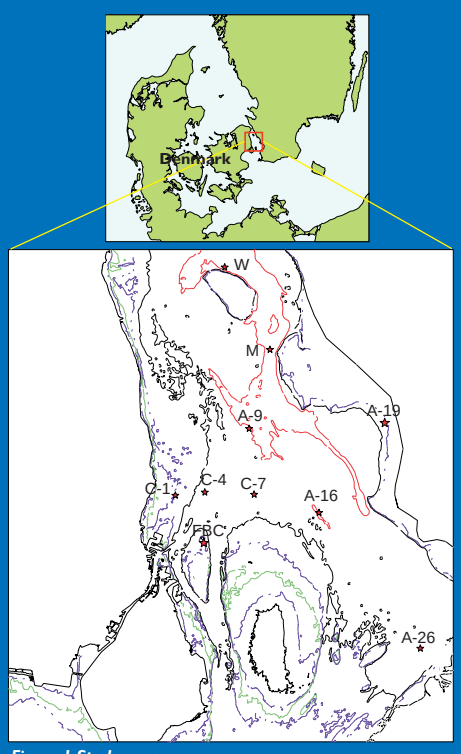

Figure 1 Study area

The objective of the study

The objective is to develop a method to monitor the amount of sediment derived from construction activities associated with the fixed link across Øresund, with emphasis on deposition in areas dominated by fine grained sediments.

Material

10 sediment cores were taken during the construction activities (in 1997) at positions located in potential accumulation areas for fine grained sediments in Øresund (the sound between Denmark and Sweden). Sediment composition at these 10 positions was investigated together with 18 mixtures of natural sediment with a known content of spill material. In 9 samples natural sediment were mixed with spill from till and 9 with spill from limestone. Finally shells of 5 marine mollusc species from Øresund were analysed.

Methods

The sediment cores were taken using a "Hapscore sampler" (Figure 2). The samples were analysed at GEUS for Total Organic Carbon (TOC) and Total Carbon (TC) using a LECO IR 212, and at Activation Laboratories using ICP.

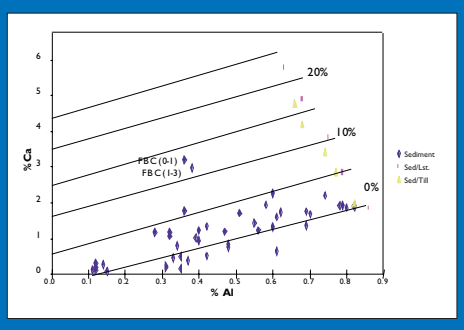

Figure 3 *Calcium versus Aluminium in sediment cores. Notice the two samples FBC (0-1 and 1-3). These represent the top 0-1 and 1-3 cm of the seabed, where spill influx was expected.*

Calcium carbonate versus clay:

Two "spill charts" are based on the relation between calcium carbonate content and clay content namely Ca versus Al and Sr versus Y, where Ca and Sr represents the calcium carbonate and the Al and Y represents the clay component. .

Total Organic Carbon (TOC) versus Total Carbon (TC)

There is a linear relationship between the total carbon (TC) and the Total Organic Carbon (TOC) in the natural sediments. Influx of carbonate from spill can be identified on a TC-TOC crossplot as excess TC, and accordingly the ratio between TC and TOC can be used to generate a third spill-chart.

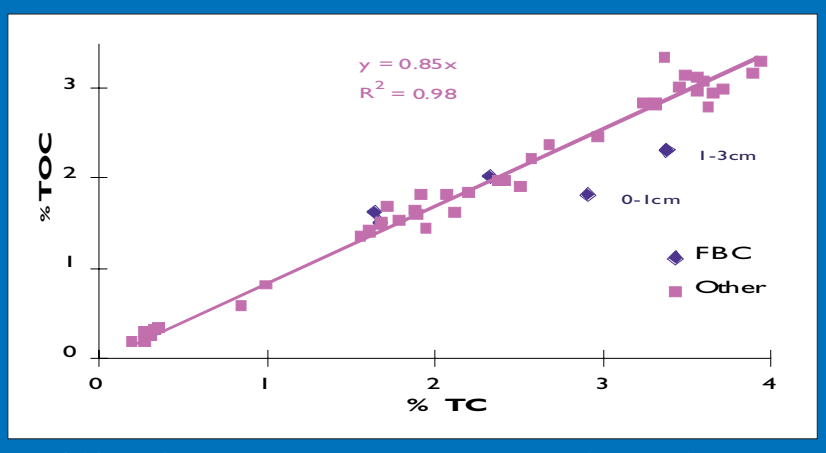

Figure 4 *TOC versus TC. Notice, that the two samples which were anomalous on Figure 3 can be identified here as well.*

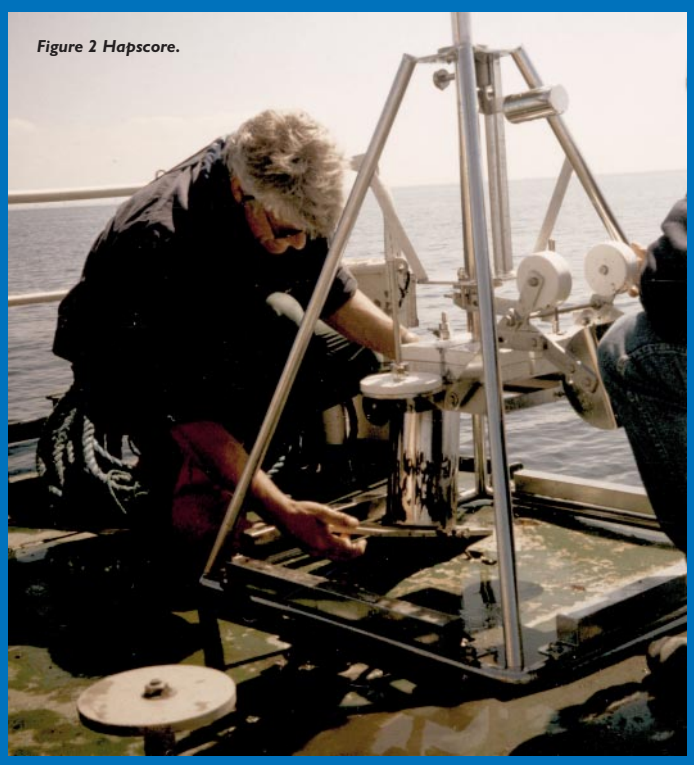

Figure 2 Hapscore.

The Sr/Ca ratio

There is a different Sr/Ca ratio in the calcium carbonate in the natural sediment derived by decomposition of shell material and the Sr/Ca ratio in Danian and Cretaceous calcium carbonate.

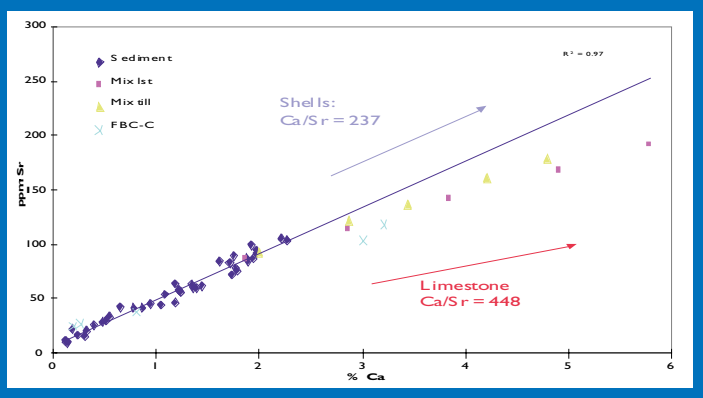

Figure 5 Sr versus Ca in sediments and sediment/spill mixtures.

Spill index

Using the above mentioned relations, four more or less independent spill charts can be established, and accordingly the amount of spill in individual samples ("spill index") can be calculated.

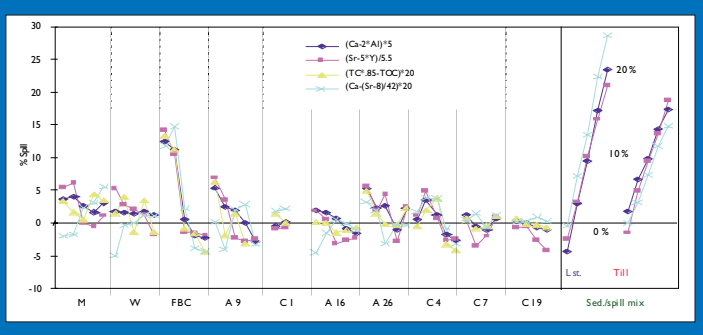

Figure 6
Spill index for the ten different positions calculated using the four individual spill charts. The results in each position represents (left to right) 0-1 cm, 1-3 cm, 3-7 cm, 7-15 cm and 15-25 cm. The results are compared to results of artificial mixtures of natural sediment and spill (to the right, Danian limestone and till respectively).

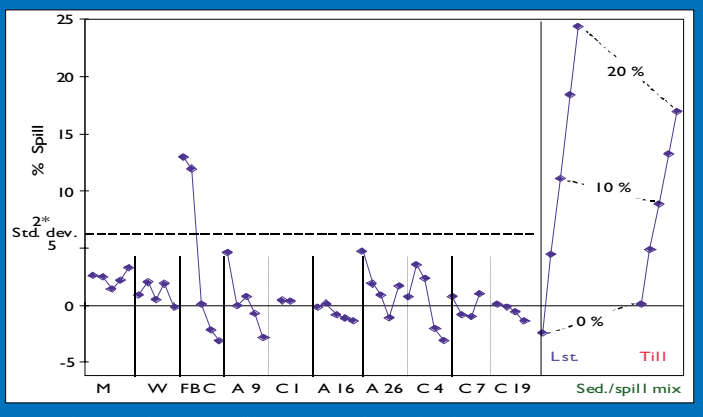

Figure 7 Spill index for the ten different positions *(mean of the four individual spill indices on Figure 6).*