

The strontium isotopic composition of Maastrichtian and Danian chalk

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The isotopic composition of strontium has been measured in 22 samples of Maastrichtian and Danian chalk from various localities in the Danish region. The chalk is an extremely pure biogenic carbonate sediment. The material examined includes bulk samples as well as individual bryozoan skeletons. The $^{87}\text{Sr}/^{86}\text{Sr}$ ratios obtained were all within the analytical error of the value 0.7075 supporting this value as the isotopic composition of sea water at Late Cretaceous and Early Tertiary time.

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Studies of the strontium isotopic composition of ancient marine carbonate sediments have demonstrated that the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of sea water has varied systematically during Phanerozoic time (Peterman et al. 1970, Veizer and Compston 1974). Due to the long residence time of strontium in the oceans (at present 19×10^6 yr) compared to the mixing rate for ocean water (ab-

out 10^3 yr) sea water must have been isotopically homogeneous during a major part of the earth history. Detailed investigations of pure marine carbonates from selected areas thus contribute to the exact fixation of the curve of $^{87}\text{Sr}/^{86}\text{Sr}$ variation through geologic time (e.g. Tremba et al. 1975, Faure et al. 1978).

The present study supplements existing data by

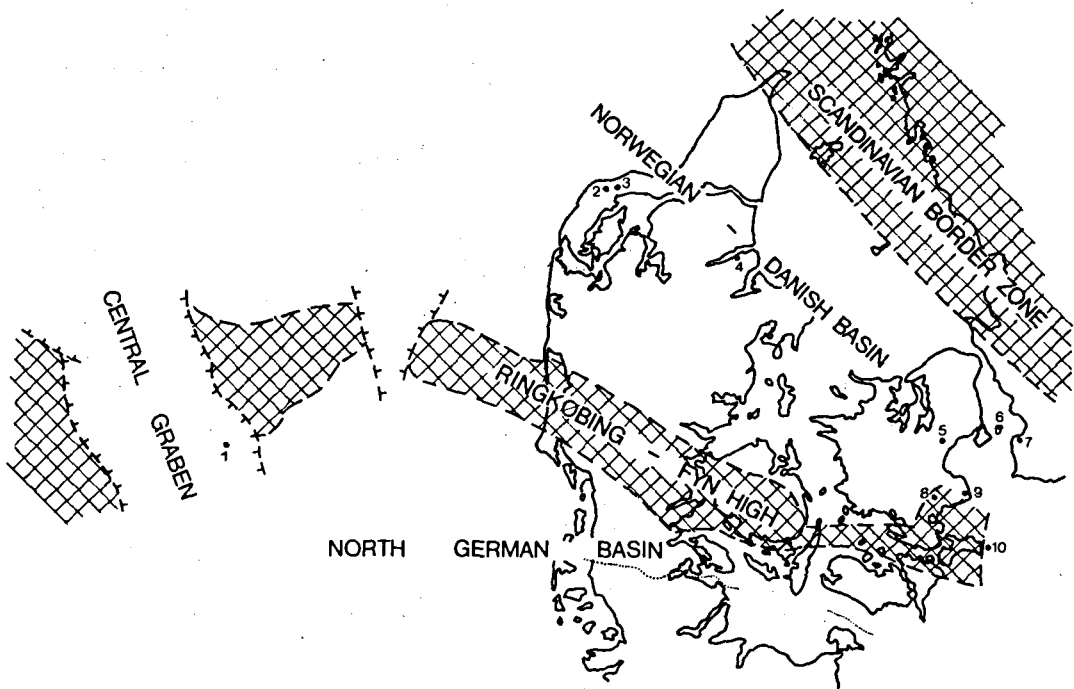


Fig. 1. Map of Denmark and the North Sea showing the localities studied. 1: M-1x; 2: Bjerre; 3: Hillerslev; 4: Dania; 5: Karlstrup; 6: Saltholm; 7: Limhamn; 8: Kongsted; 9: Stevns; 10: Hvidskud.

reporting isotopic results obtained from 22 samples of chalk representing Maastrichtian and lowermost Danian strata. The material was collected from 10 outcrops and boreholes in the Danish basin and the North Sea Central Graben (fig. 1). The chalk is an extremely pure biogenic carbonate sediment only slightly affected by diagenesis. The content of insoluble residue, primarily quartz and clay minerals, ranges from 1 to 10 wt%. The strontium concentration in the carbonate is relatively constant with Sr/Ca ratios varying between 1.60×10^{-3} and 2.88×10^{-3} (Jørgensen 1975, 1979). In addition to bulk samples individual bryozoan skeletons were analysed.

Isotopic measurements and results

The mass spectrometer used was a manually run Varian MAT TH5 solid source machine equipped with a TTY punched tape digital output for off-line evaluation of isotopic ratios. The low content of non-carbonate residue offered the opportunity of measuring the isotopic composition of strontium without previous chemical separation of this element. The sample was dissolved and transferred directly onto the filament using 2 drops of 6 N HCl. Despite the large amounts of calcium present on the filament, it proved possible to obtain a sufficiently stable emission of strontium to measure the isotopic composition with an error of only 1–4 parts in 10^4 . This simple procedure is extremely fast and holds promise for future work on low-residue carbonates. Four measurements on the Eimer and Amend isotopic standard were included in this study. The $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of the Eimer and Amend standard (normalised to 0.1194) averaged 0.70818 with a standard deviation of ± 0.00007 .

The isotopic ratios measured are given in table 1. For comparison with published data the ratios have been adjusted to a value of 0.7080 for the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of the Eimer and Amend standard. Deviations from an overall average of 0.7075 are within the range of the analytical error and are not significant. Thus no trend in the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio is indicated for the stratigraphic sequence covered by this study. Furthermore, ratios obtained from bryozoan skeletons are in accordance with those measured on bulk samples.

Table 1. Isotope ratios. The abbreviation *br.* represents samples of bryozoan skeletal fragments.

Sample	$^{87}\text{Sr}/^{86}\text{Sr}$	Average	Stratigraphy
M-1x, 9	0.7073 +/- 0.0001	0.7074	Danian
M-1x, 16	0.7074 +/- 0.0002		
Saltholm 13	0.7074 +/- 0.0002		
Bjerre 9	0.7075 +/- 0.0001		
Bjerre 4	0.7076 +/- 0.0001	0.7075	Upper Maastrichtian
Bjerre 1	0.7076 +/- 0.0001		
Dania 55, br.	0.7072 +/- 0.0002		
Karlstrup	0.7075 +/- 0.0001		
Karlstrup, br.	0.7074 +/- 0.0003		
Stevns 7	0.7074 +/- 0.0001		
Stevns 7, br.	0.7075 +/- 0.0002		
Limhamn 835	0.7075 +/- 0.0001		
Limhamn 834	0.7076 +/- 0.0001		
Hillerslev 2	0.7074 +/- 0.0001		
Hillerslev 2, br.	0.7077 +/- 0.0004		
Hvidskud A6	0.7075 +/- 0.0001	0.7075	Lower Maastrichtian
Hvidskud A6, br.	0.7075 +/- 0.0001		
Hvidskud B6	0.7075 +/- 0.0002		
Kongsted 4	0.7076 +/- 0.0001		
Kongsted 5	0.7074 +/- 0.0002		
M-1x, 105	0.7078 +/- 0.0003		
M-1x, 138	0.7076 +/- 0.0002		

$^{87}\text{Sr}/^{86}\text{Sr}$ ratios obtained in the present study agree well with results reported by Peterman et al. (1970) based on a considerable collection of skeletal material from the North American continent, which yielded an average ratio of 0.70755 ± 0.00011 for the Upper Cretaceous (when adjusted to 0.7080 for the Eimer and Amend standard). Tremba et al. (1975) reported similar ratios (0.7073 and 0.7075, both ± 0.00012) from un-metamorphosed limestones collected on Euboea, Greece.

Conclusion

The present measurements on marine carbonate sediments from the Danish Basin and the North Sea Central Graben support the value of 0.7075 for the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of ocean water during the Upper Cretaceous. No change in this value is apparent in the investigated samples which represent the time span from the Lower Maastrichtian into the Danian.

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Dansk sammendrag

Strontium isotop sammensætningen i 22 prøver af marine karbonatsedimenter fra det danske Maastrichtian og Danian fremviser særdeles konstante $^{87}\text{Sr}/^{86}\text{Sr}$ forhold. Den beregnede midelværdi på 0.7075 bekræfter tidligere publicerede målinger af strontium isotop forholdet i oceanisk havvand fra Øvre Kridt. Der er desuden ikke påvist nogen signifikant forskel mellem strontium isotop forholdet i karbonatsedimentet og skeletfragmenter af bryozoaer fra samme prøve.

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