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Forsmark site investigation

Analyses of biogenic silicon in sediment from Lake Eckarfjärden

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Abstract

Sediment from the Lake Eckarfjärden has been analysed for contents of biogenic silicon. This parameter is expected to be used in the refinement of a model predicting the development of lakes. The determined content of biogenic silicon varies between 0 and 12% which is within the expected range for European lakes.

Sammanfattning

Sediment från sjön Eckarfjärden har analyserats för att bestämma halten biogent kisel. Detta är en parameter som förväntas kunna användas för att förfina en modell som predikterar sjöars utveckling. De halter av biogent kisel som uppmätts varierar mellan 0 och 12 % vilket är i det förväntade intervallet för europeiska sjöar.

Contents

1 Introduction

This document reports the data gained by the activity "Analyses of biogenic silicon in sediments from Lake Eckarfjärden", which is one of the activities performed within the site investigation at Forsmark. The work was carried out in accordance with activity plan AP PF 400-07-008. In Table 1-1 controlling documents for performing this activity are listed. Activity plans are SKB's internal controlling documents.

Original data from the reported activities are stored in the primary database SICADA. Data are traceable in SICADA by the Activity plan number AP PF 400-07-008. Only data in databases are accepted for further interpretation and modelling. The data presented in this report are regarded as copies of the original data. Data in the databases may be revised, if needed. Such revisions will not necessarily result in a revision of the P-report, although the normal procedure is that major data revisions entail a revision of the P-report. Minor revisions are normally presented as supplements, available at www.skb.se.

Table 1-1. Controlling documents for performance of the activity.

Activity plan	Number	Version
Analyses of biogenic silicon in sediments in Lake Eckarfjärden	AP PF 400-07-008	1.0
Method description		
Ohlendorf C, Sturm M. PM-BSi: A modified method for biogenic silica determination. In press: Journal of Paleolimnology.		

2 Objective and scope

Lars Brydsten at Umeå University has, at request from SKB, developed a model which predicts the creation of lakes /Brydsten 2004, Brydsten 2006/. The data used are from lakes in the vicinity of Forsmark. In order to refine the model, biogenic silicon in sediment from Lake Eckarfjärden in the Forsmark area has been analysed. Previously determined quota between concentrations of silicon and aluminium in the glacial clay in the area (analyses reported by /Hannu and Karlsson 2006/) has been used in order to distinguish between biogenic and non-biogenic silicon in the sediment samples. The sampling locations are shown in Figure 2-1 and the samples are described in Table 2-1.

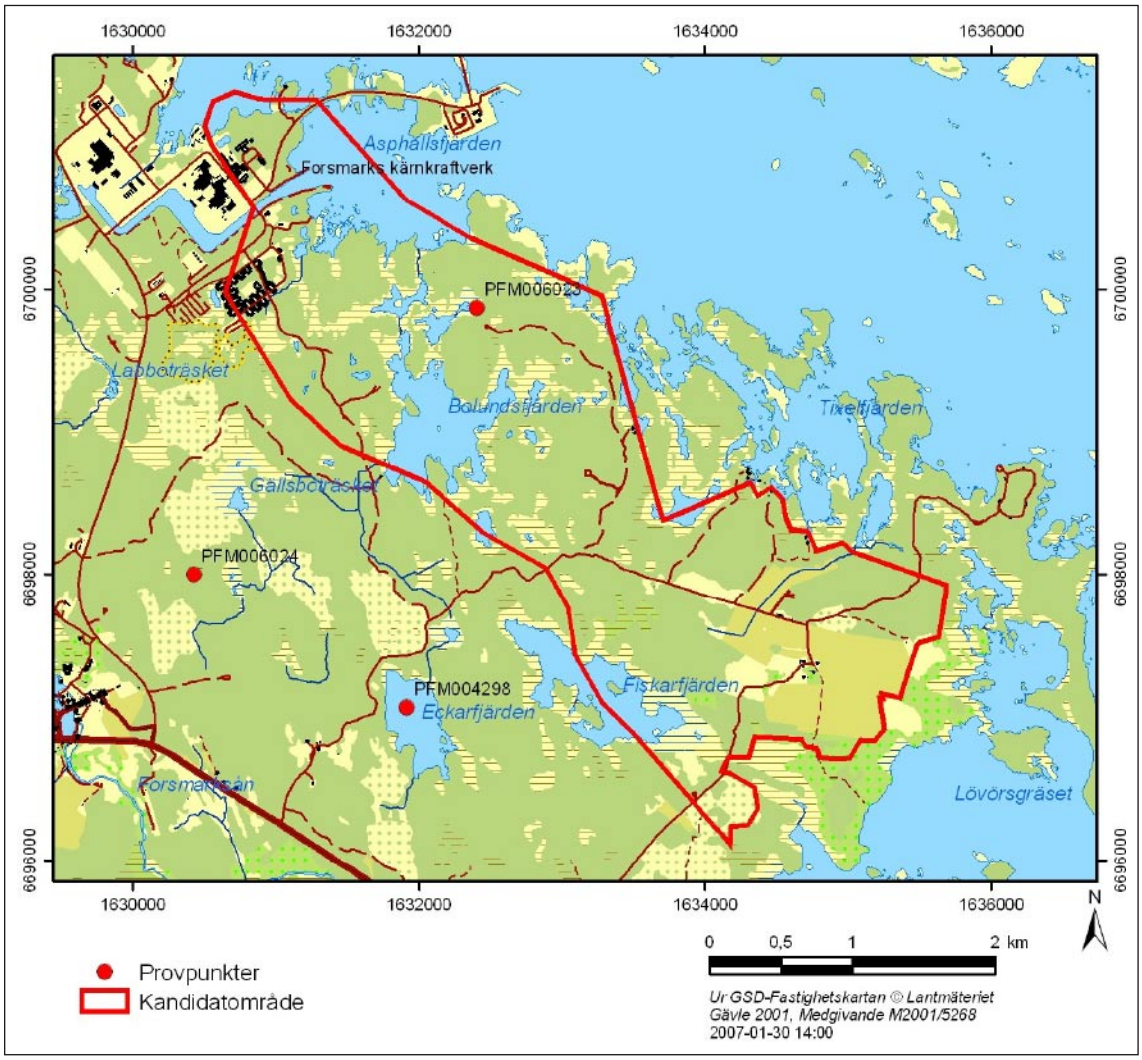

Figure 2-1. *Location of the sampling sites for analyses of silicon.*

Table 2-1. Sample description.

SKB idcode	Subsample number	Depth (m)	Sediment type
Samples for analyses of biogenic silicon			
PFM004298	8	2.75–2.82	Algal gyttja
PFM004298	9	2.83–2.85	Calcareous gyttja
PFM004298	10	2.85–2.92	Algal gyttja
PFM004298	11	2.93–3.03	Algal gyttja
PFM004298	12	3.03–3.10	Algal gyttja
PFM004298	13	3.20–3.27	Algal gyttja
PFM004298	14	3.40–3.50	Algal gyttja
PFM004298	15	3.62–3.65	Clay gyttja
PFM004298	16	4.15–4.20	Clay
Glacial clay samples			
PFM006023	4	1.93–1.96	Clay
PFM006024	6	2.63–2.66	Clay

3 Equipment

3.1 Description of equipment

The analyses have been performed by ICP-SFMS (sector field mass spectrometry). In ICP-SFMS, a plasma is used to convert elements to ions, which are then separated by mass in a mass spectrometer. This allows the different elements in a sample (and their natural isotopes) to be separated and their concentrations determined.

4 Execution

4.1 General

The samples were collected by SKB and the sample preparations and chemical analyses were performed by ALS Analytica AB using a method based on that described by /Ohlendorf and Sturm in press/.

4.2 Preparations

Approximately 100 mg wet sample was accurately weighed into a 50 ml HDPE tube, and 10 ml of 1 M NaOH was added. After sonication for 1 min in an ultra sound bath, the closed sample tubes were placed in an autoclave and heated at 100°C for 3 h. Following this treatment, 100 µl of the supernatant was transferred to an acid-washed PS tube containing 9.9 ml of 67 mM tartaric acid in 0.75 M HNO^3 (the latter solution is used routinely in the laboratory to stabilize silicon in samples prepared by alkaline fusion). Preliminary measurements using ICP-AES showed that the silicon and aluminium concentrations in the diluted NaOH leachates were close to the LOQs of the technique. Therefore, ICP-SFMS was used to quantify silicon and aluminium after a further 10-fold dilution in 0.28 M HNO^3, with indium being added as internal standard.

Separate aliquots were used to determine the dry weight of each sample. Results were reported on a dry weight basis.

4.3 Execution of analysis

The instruments were optimised and calibrated at the start of the working day. Calibration consisted of running a sequence of synthetic blanks, sample preparation blanks, quality control samples prepared in parallel with the unknowns, and standard solutions. The calibration sequence was repeated after every 10–15 sample measurements. For measurements by ICP-AES and ICP-SFMS, the internal standard technique was employed to allow correction for instrumental drift and non-spectral interference effects during the analyses. Duplicate aliquots were analysed on the sediment samples.

4.4 Nonconformities

A few modifications were made to the method. Sodium (Na) was not used as an internal standard, and has therefore not been reported. The content of aluminium (Al) and silicon (Si) was, after dilution, too low to provide reliable results by ICP-AES (atomic emission spectrometry). Reported values were obtained using ICP-SFMS and indium (In) as internal standard.

Duplicate aliquots were analysed. One of the sample vessels was found to have opened during treatment in the autoclave, and no results are reported for that subsample.

5 Results

The results from the chemical analyses are presented in Table 5-1, whereas the results from previous analyses of glacial clay /Hannu and Karlsson 2006/ are presented in Table 5-2. In Table 5-3 the calculated concentrations of biogenic silicon are shown.

Correction of biogenic silicon for contributions from mineralogenic silicon is based on the average Si/Al elemental ratio determined in two glacial clay samples. The concentration of biogenic silicon (Si_{bio}) was calculated using of the total concentrations of silicon (Si_{tot}) and aluminium (Al_{tot}) in the sediment samples and the aluminium/silicon ratio ($R_{Si,Al}$) in the glacial clay (average value from the two samples):

$$Si_{bio} = Si_{tot} - Al_{tot} \cdot R_{Si,Al}$$

The determined content of biogenic silicon varies between 0 and 12% which is within the expected range for European lakes.

The relative standard deviation for duplicate estimations of biogenic silicon did not exceed 33% and averaged 15%.

Table 5-1. Results of the chemical analyses and calculated concentrations (%) of biogenic silicon.

Idcode	Secup (m)	Seclow (m)	Subsample no	Dno	Laboratory sample id	Sample weight (g)	dry_ substance (%)	Al (mg/kg)	Si (mg/kg)	Biogenic silicon (%)
PFM004298	2.75	2.82	8	1	U10302182	0.0605	5.67	3,207	46,934	3.80
PFM004298	2.75	2.82	8	2	U10302182	0.0788	5.67	2,462	56,178	4.94
PFM004298	2.83	2.85	9	1	U10302183	0.0628	14.5	1,098	22,183	1.91
PFM004298	2.83	2.85	9	2	U10302183	0.0725	14.5	1,046	23,401	2.05
PFM004298	2.85	2.92	10	1	U10302184	0.0886	5.31	2,126	23,806	1.79
PFM004298	2.85	2.92	10	2	U10302184	0.1065	5.31	1,591	21,573	1.72
PFM004298	2.93	3.03	11	1	U10302185	0.1117	5.31	1,855	34,563	2.94
PFM004298	2.93	3.03	11	2	U10302185	0.0790	5.31	1,907	34,566	2.93
PFM004298	3.03	3.10	12	1	U10302186	0.1244	4.21	1,337	33,033	2.93
PFM004298	3.03	3.10	12	2	U10302186	0.0935	4.21	3,049	31,247	2.28
PFM004298	3.2	3.27	13	1	U10302187	0.0866	10.3	6,502	126 684	10.9
PFM004298	3.2	3.27	13	2	U10302187	0.0538	10.3	4,872	142 202	12.9
PFM004298	3.4	3.50	14	1	U10302188	0.1121	7.63	3,157	57,522	4.88
PFM004298	3.4	3.50	14	2	U10302188	0.1007	7.63	6,898	49,978	3.09
PFM004298	3.62	3.65	15	1	U10302189	0.0973	42.2	4,067	54,310	4.30
PFM004298	3.62	3.65	15	2	U10302189	0.0543	42.2	*	*	*
PFM004298	4.15	4.20	16	1	U10302190	0.0389	76.9	13,840	26,275	–1.21
PFM004298	4.15	4.20	16	2	U10302190	0.0413	76.9	12,846	28,086	–0.75

* No analyses performed, sample vessel broken (see section 4.4).

Table 5-2. Concentrations of aluminium and silicon in samples of glacial till /Hannu and Karlsson 2006/.

Idcode	Secup (m)	Seclow (m)	Al_2O_3 (%)	Al (%)	SiO_2 (%)	Si (%)	Si/Al	Lab sample id
PFM006023	1.93	1.96	16.8	8.9	51.8	24.2	2.72	U10243291-00 U10243298-00 U10243305-00
PFM006024	2.63	2.66	12.4	6.6	39.6	18.5	2.82	U10243294-00 U10243301-00 U10243308-00

Table 5-3. Average concentrations.

Idcode	Secup (m)	Seclow (m)	Sediment type	Average conc. (mg/kg) Al	Si	Average conc. biogenic silicon (%) Si
PFM004298	2.75	2.82	Algal gyttja	2,834	51,556	4.37
PFM004298	2.83	2.85	Calcareous gyttja	1,072	22,792	1.98
PFM004298	2.85	2.92	Algal gyttja	1,859	22,690	1.75
PFM004298	2.93	3.03	Algal gyttja	1,881	34,564	2.94
PFM004298	3.03	3.10	Algal gyttja	2,193	32,140	2.61
PFM004298	3.2	3.27	Algal gyttja	5,687	134,443	11.9
PFM004298	3.4	3.50	Algal gyttja	5,027	53,750	3.98
PFM004298	3.62	3.65	Clay gyttja	4,067	54,310	4.30
PFM004298	4.15	4.20	Clay	13,343	27,181	-0.98

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