

P-07-08

Forsmark site investigation

Sampling and analyses of gas in sediment

Sample from Lake Puttan

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January 2007

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ISSN 1651-4416

SKB P-07-08

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Keywords: Gas, Sediment, Lake Puttan, AP PF 400-06-111.

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Abstract

During collection of sediment samples at an early stage of the site investigation in Forsmark large amounts of gas were observed in the sediments of lakes and shallow sea bays. The gas was assumed to consist of methane which is formed from decomposition of organic matter within the sediments but it was also suggested that the gas may originate from the bedrock, i.e. deep gas. As a first step in order to answer this question, a gas sample from lake sediment was analysed and its composition was compared with the gas composition in groundwater from different sections of deep boreholes in the Forsmark area. As expected, the gas in the sediment sample contained mostly methane (56 percent by volume) which clearly distinguishes it from the deep gas samples. The latter contain mostly nitrogen which however is also present in a relatively large amount in the sediment gas sample. From the analytical result it is not possible to exclude deep gas from being present as a small fraction in the actual sample.

Sammanfattning

Vid insamling av sedimentprov i ett tidigt skede under platsundersökningen i Forsmark observerades stora mängder gas i sedimenten i sjöar och grunda havsvikar. Gasen antogs bestå av metan som bildas vid nedbrytning av organiskt material i sedimenten, men det har också föreslagits att gasen kan komma från berggrunden, s k djupgas. Som ett första steg för att besvara frågeställningen analyserades ett prov bestående av sedimentgas. Därefter jämfördes gassammansättningen med motsvarande sammansättning i grundvatten från olika sektioner i djupa borrhål i Forsmarksområdet. Som väntat innehöll gasen från sedimentet en stor andel metan (56 volymprocent) vilket skiljer den från djupgasproven. De senare innehåller till övervägande del kvävgas som dock också finns i relativt stor mängd i gasen från sedimentprovet. Från analysresultatet går det inte att utesluta att det finns en liten andel djupgas i det aktuella provet.

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1 Background and objective

This document reports the results gained by the activity “Sampling of gas in sediment”, which is one of the activities performed within the site investigation at Forsmark, /1/ and /2/. The work was carried out according to the Activity Plan given in Table 1-1. Activity plans are SKB’s internal controlling documents.

Large quantities of gas were observed in the sediments both in shallow bays and in lakes at the Forsmark investigation site. The gas may be a result of decomposition processes within the sediment (methane) but there is also a possibility that it originates from depth. Gas formed within the bedrock may reach the surface systems through migration in connected fractures. If this could be verified, it would provide supporting information about the fracture connectivity between deep and shallow parts of the bedrock and between the shallow bedrock and the regolith. A first attempt to identify the gas was performed in autumn 2006 and is documented in this report. The site where gas were sampled are shown in Figure 1-1.

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

Activity plan	Number	Version
Sampling of gas in sediment	AP PF 400-06-111	1.0



Figure 1-1. Site for gas sampling.

2 Equipment

2.1 Description of equipment

The gas sampling equipment was constructed especially for this activity. It consisted of a circular frame of aluminium with a shaft which was bent so that the handle was positioned about 1 metre above the centre of the frame. The frame had a diameter of c 50 cm. A strong film of polyethene was fastened on the frame with tape. It had a hole in the centre from which a wire was stretched so that the film formed a funnel. From the centre hole a 6 mm polyethene tube led to the sampling vessel; a 10 litre bag of Teflon. An outline of the equipment is given in Figure 2-1 and photos from the sampling are presented in Figure 2-2.

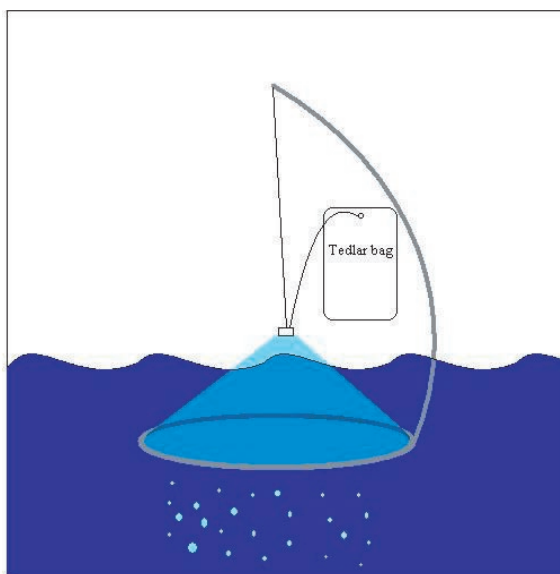


Figure 2-1. Outline of equipment for gas sampling from sediments.



Figure 2-2. Sampling of gas in sediments, starting (left) and finishing (right).

3 Execution

3.1 Execution of field work

Sampling was performed at selected locations where large fracture zones meet the rock surface according to the order of priority recommended by the activity leader in geology.

The equipment was placed under water, see Figures 2-1 and 2-2, and the sediment was disturbed in order to release eventual gas. The field work resulted in one gas sample which was sent to the Finnish laboratory Paavo Ristula OY for chemical analyses. The analysed gases are listed in Table 3-1.

3.2 Data handling and interpretations

The analytical results were stored as data on released gas in the database SICADA without further processing. Data are traceable by the Activity Plan number. The gas composition was compared to corresponding results from deep borehole samples from the Forsmark area.

3.3 Nonconformities

No nonconformities occurred.

Table 3-1. Gas analyses.

Argon
He
Nitrogen
Carbon dioxide
Methane
Oxygen
Hydrogen
Ethane
Ethene
Acetylene
Propane
Propene
Carbon monoxide

4 Results

The only sample obtained was collected from the southern part of Lake Puttan (SKB id-code PFM002293, coordinates 6699786, 1632029). Its gas composition is presented in Table 4-1.

Table 4-1. Gas composition in the gas sample.

Gas	Percentage (v%)
Argon	0.59
He	< 0.001
Nitrogen	37.4
Carbon dioxide	2.2
Methane	56
Oxygen	0.85
Hydrogen	< 0.001
Ethane	< 0.001
Ethene	< 0.001
Acetylene	< 0.001
Propane	< 0.001
Propene	< 0.001
Carbon monoxide	< 0.001

5 Comparison between sediment gas sample and gas data from deep groundwaters

Data on gas content and composition in groundwaters are available from ten borehole sections in a number of deep core drilled boreholes at the Forsmark site. The gas data are presented in Table 5-1.

The gas composition in deep groundwaters differs from the sediment gas sampled in Lake Puttan. While the sediment gas consisted of mainly methane, the major gas constituent in deep groundwaters is nitrogen. Further, the contents of argon and helium are significant in the deep groundwater. Argon is present also in the sediment gas sample but at a much smaller concentration. From the analytical result it is not possible to exclude presence of a deep gas component in the sediment gas sample. However, the amount must be relatively small.

From this simple study it is concluded that additional analyses of different isotopes are needed in order to exclude or verify migration of deep gas from the bedrock to the surface at this single sampling location. Furthermore, the investigation needs to be extended to several sampling locations (the necessary number is however unknown) or the question of possibly migrating deep gases will remain.

Table 5-1. Gas composition (percentage by volume) of deep groundwaters in the Forsmark area . “_” indicates value below detection limit.

Bore hole	Secup	Seclow	Argon	He	Nitrogen	Carbon dioxide	Methane	Oxygen	Hydrogen	Ethane	Ethene	Acethylene	Propane	Propene	Carbon monoxide
KFM01A	176.8	183.9	1.8	1.8	94.0	2.06	0.21	0.16	< 0.01	< 0.001	< 0.001	-	< 0.001	-	-
KFM01D	428.5	435.64	26.2	11.1	62.4	0.15	0.14	0.03	-	< 0.001	< 0.001	-	< 0.001	< 0.001	-
KFM01D	428.5	435.64	28.4	1.2	69.9	0.22	0.15	0.07	-	< 0.001	< 0.001	-	< 0.001	-	-
KFM01D	568	575.14	38.2	0.8	56.9	0.04	4.09	0.01	-	< 0.001	-	-	< 0.001	-	-
KFM02A	509	516.08	1.1	6.7	86.3	5.44	0.05	0.16	0.27	< 0.001	< 0.001	< 0.001	< 0.001	-	-
KFM02A	509	516.08	1.0	1.3	92.9	4.69	0.04	0.05	0.03	< 0.001	< 0.001	-	-	-	-
KFM03A	639	646.12	10.7	1.1	87.4	0.64	0.08	0.03	-	< 0.001	< 0.001	-	-	-	-
KFM03A	939.5	946.62	13.6	1.1	85.0	0.13	0.05	0.10	0.04	< 0.001	< 0.001	-	< 0.001	-	-
KFM03A	980	1,001.19	16.2	1.3	82.4	0.02	0.04	0.03	-	< 0.001	-	-	< 0.001	-	-
KFM03A	448.5	455.62	1.8	1.1	94.9	1.88	0.04	0.09	0.27	< 0.001	< 0.001	< 0.001	-	-	-
KFM06A	768	775.12	26.3	0.9	72.5	0.0	0.08	0.16	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
KFM07A	848	1,001.55	16.7	1.1	85.2	-	0.03	0.12	-	< 0.001	-	-	-	-	-
KFM08A	683.5	690.64	10.5	1.1	87.2	0.06	0.02	1.05	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-
KFM10A	478	487.49	0.5	11.5	85.8	2.18	0.04	0.05	-	< 0.001	< 0.001	-	< 0.001	< 0.001	-
KFM10A	478	487.49	0.5	1.1	95.5	2.79	0.04	0.08	-	< 0.001	< 0.001	-	< 0.001	< 0.001	-
Average			13.7	3.0	81.7	1.40	0.35	0.15	0.15	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-

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- /1/ **SKB, 2001.** Site investigations. Investigation methods and general execution programme. SKB TR-01-29, Svensk Kärnbränslehantering AB.
- /2/ **SKB, 2005.** Forsmark site investigation. Programme for further investigations of geosphere and biosphere. SKB R-05-14, Svensk Kärnbränslehantering AB.