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17. marts 2020

Ferskvandsmonitering ved LNSGG's rubinmine ved Aappaluttoq i 2019

Dette notat præsenterer resultaterne af myndighedernes ferskvandsmonitering ved LNSGG's rubinmine ved Aappaluttoq i 2019. Programmet blev gennemført d. 4. september.

Minen, dvs. selve bruddet, er anlagt på en halvø i søen Ukkaata Qaava. Vandstanden i søen blev i løbet af årene 2015 og 2016 sænket 10 meter, og søen er nu opdelt i to adskilte bassiner, forbundet af en gravet kanal. I det sydøstre bassin deponeres tailings og waste-rock, mens det nordvestlige bassin fungerer som en slags klaringsbassin, hvorfra vandet løber til fjorden Tasiusaa via en ca. tre kilometer lang elv forbi sprængstoflager og mine-camp.

Lokaliteter

Der blev udtaget vandprøver ved 5 lokaliteter:

- W3 og W4 i to tilløb til søens sydøstre bassin
- W1 i elven ca. 200 meter nedstrøms fra udløbet fra søens nordvestlige bassin
- W21 i elven nedstrøms fra sprængstoflager og camp og ca. 300 meter opstrøms fra udløbet i fjorden
- W22 i en elv ca. 8 km sydvest for minen (= referencestation).

Metode

Vandprøverne blev udtaget efter retningslinjerne i DCE's indsamlingsinstruks, og der blev både indsamlet ufiltrerede prøver og prøver filtreret gennem et 0.45 µm nylonfilter. Grønlands vandkvalitetskriterier er baseret på filtrerede prøver, men da de oprindelige baselineprøver fra 2007-2009 er ufiltrerede, har man valgt stadig at analysere et sæt ufiltrerede prøver for sammenlignelighedens skyld.

Vandprøverne blev analyseret på DCE's akkrediterede laboratorium i Roskilde.

Resultater

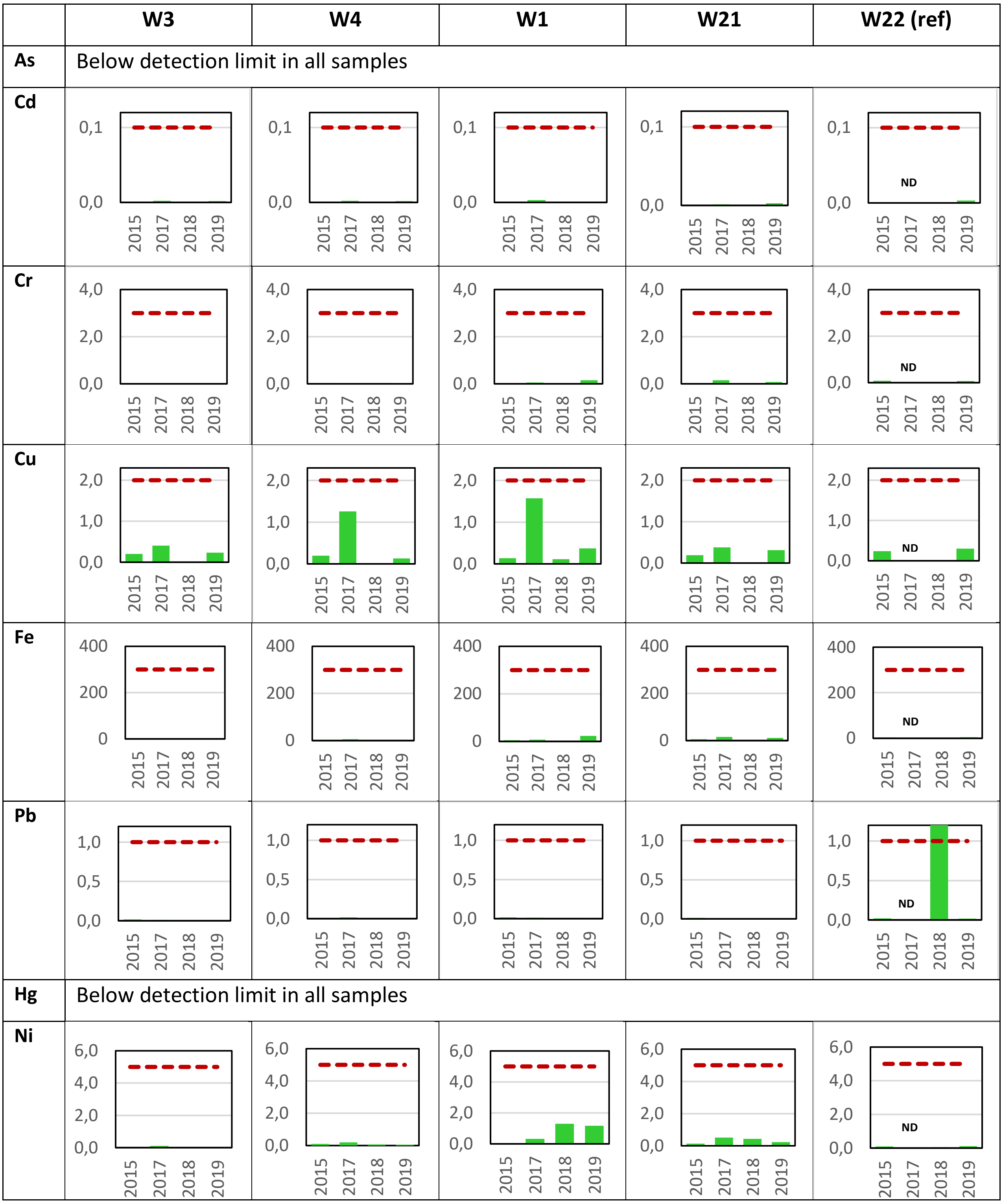
Resultaterne fra 2019 er vist i Figur 1, side 3, (filtrerede prøver) og Figur 2, side 4, (ufiltrerede prøver) sammen med resultaterne fra de samme lokaliteter i 2015, 2017 og 2018. Figurerne viser resultaterne for de metaller, for hvilke der er etableret grønlandske vandkvalitetskriterier. Kriterieværdierne er angivet på figurerne.

Vandkvalitetskriterierne bliver ikke overskredet noget sted i 2019. Der sker en svag berigning med nikkel i den opløste (filtrerede) fraktion ved passage gennem søen og en noget stærkere

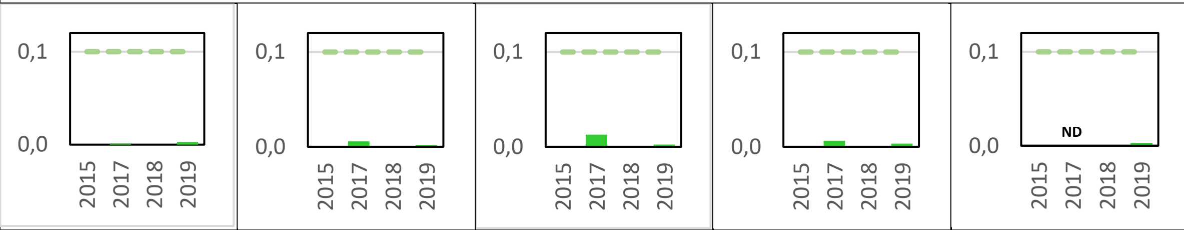
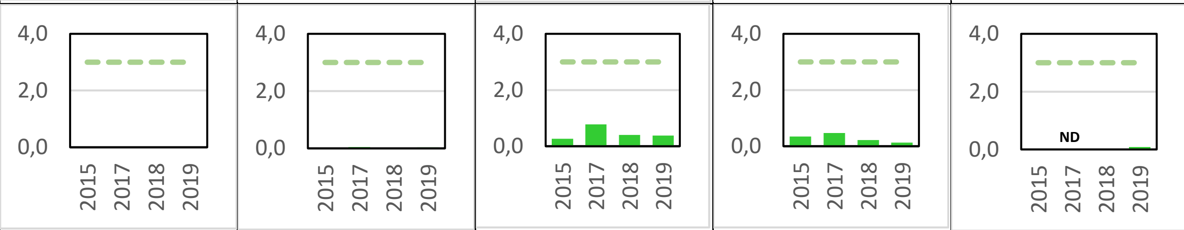
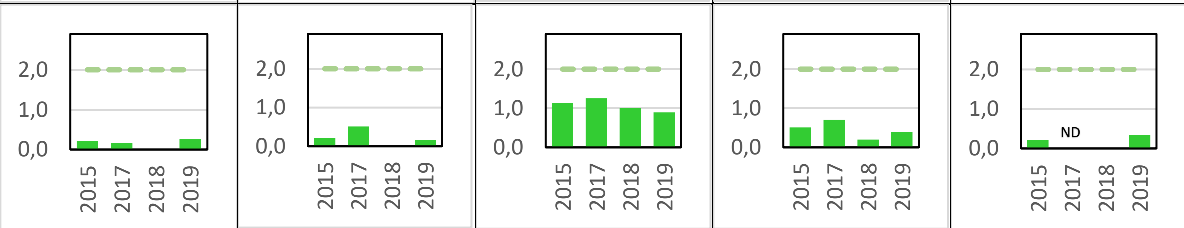
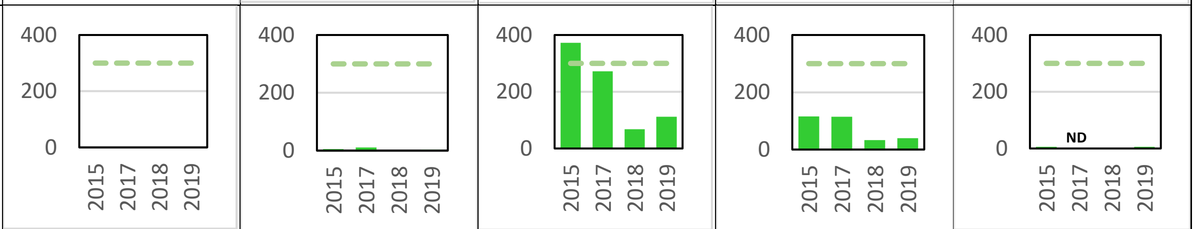
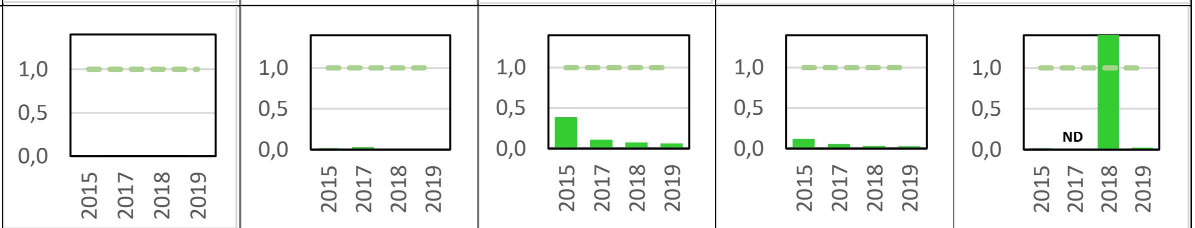
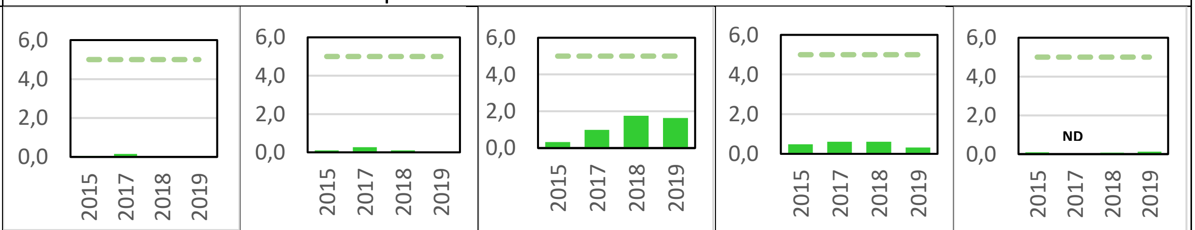
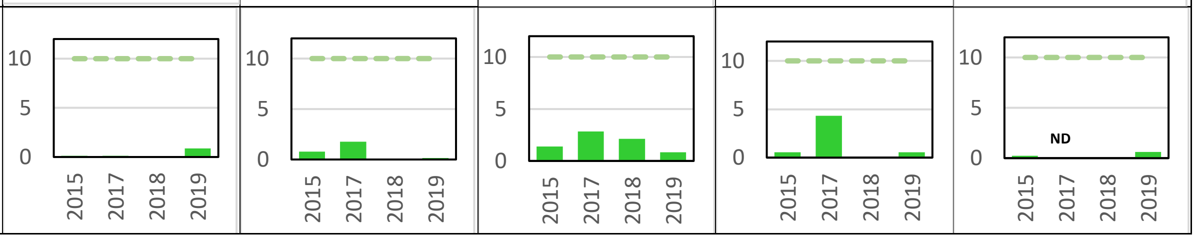
berigning i den partikulære fraktion af især krom, kobber, jern og bly. Berigningen kan skyldes udledning af tailings, men skyldes nok i højere grad den stærke erosion af kysten, der er opstået som følge af vandstandssænkningen.

Ud over ferskvandsmoniteringen, blev det noteret, at der lå en del affald spredt i området omkring campen. Det foreslås, at selskabet laver en oprydning af området 1-2 gange årligt.

Figur 1. Indholdet af udvalgte metaller i filtrerede vandprøver i 2015, 2017, 2018 og 2019. Det grønlandske vandkvalitetskriterie er markeret med rødt. Koncentrationerne er angivet i µg/l.



Figur 2. Indholdet af udvalgte metaller i ufiltrerede vandprøver. Der er ingen vandkvalitetskriterier for ufiltrerede prøver, men kriteriet for filtrerede prøver er markeret med grønt. Vandprøverne er taget i slutningen af august eller starten af september.no

	W3	W4	W1	W21	W22 (ref)
As	Below detection limit in all samples, except in W22 in 2019, where it was 0.047 µg/l. The Greenland WQ Criteria is 4 µg/l.				
Cd					
Cr					
Cu					
Fe					
Pb					
Hg	Below detection limit in all samples				
Ni					
Zn					

AARHUS
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DCE - NATIONALT CENTER FOR MILJØ OG ENERGI

Test report no. 1025

Water samples from the Aappaluttoq Ruby Mine, Southwest Greenland in 2019

Customer:	The Environmental Agency for Mineral Resource Activities, Nuuk (EAMRA)

Sample collection:

Sampling place:	Near the Aappaluttoq Ruby Mine, Southwest Greenland
Sampling time:	September 2019
Sample type:	Freshwater
Sampling performed by:	Maia Olsen (GINR) et al.
Sampling methods:	Standard DCE methods
Uncertainty in sampling:	Not evaluated here

Analyses:

Analyses performed by:	University of Aarhus, Institute for Bioscience National Centre for Environment and Energy (DCE) Frederiksborgvej 399 4000 Roskilde
Date of analyses:	November 2019
Analytical methods:	Freshwater samples were acidified with 1 ml/l Merck Suprapure nitric acid, left for a minimum of 24 h and analysed for elemental composition (c. 60 elements) by ICP-MS (Agilent 7900).
Uncertainty of measurement:	The laboratory is accredited by the Danish accreditation body DANAK to analyses of freshwater for the elements in listed in Appendix 1 with the specified detection limits and measurement uncertainties. The detection limits during the day of analyses (3 SD on

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	blank samples) were determined based on measurements of a series of blank samples treated in the same way as the samples. Blank values were subtracted from the sample values. The detection limits during the day of analyses are shown in the tables and it is indicated with a '<DL' if measured values were below the detection limit.
Notes:	For quality assessment/quality control (QA/QC), a certified freshwater reference material (SLRS-6) was analysed along with the freshwater samples. The reference material was analysed with satisfactory results and the results are provided in the report after the sample results.
	Data in this report has also been sent in an excel file.
Contact person:	Jens Søndergaard (DCE)
Appendixes:	Appendix 1. Uncertainty of measurements.

The results represent only samples that have been analyzed.

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Element concentrations in freshwater samples

Results are given in µg/l. The detection limit (DL) of the analyses is determined as 3 standard deviations on blank values measured during the analyses. Non-accredited elements are marked with a * in the table. <DL= below the detection limit.

ID no./name	Lab no.	Location	Station	Comment	Li	Be	Na	Mg	Al	P	K	Ca*	Sc*
Detection Limit (DL)					0.006	0.002	1	0	0.2	10	1	1	0.004
63114	2109	Rubinmine	W1	Filtreret	0.223	<DL	1464	405	32.5	<DL	746	1674	0.048
63113	2202	Rubinmine	W1	Ufiltreret	0.317	<DL	1519	463	166.1	<DL	806	1730	0.065
63115	2110	Rubinmine	W3	Filtreret	0.034	<DL	1010	118	14.7	<DL	92	331	0.032
63116	2203	Rubinmine	W3	Ufiltreret	0.040	<DL	998	119	15.4	<DL	94	332	0.029
63117	2111	Rubinmine	W4	Filtreret	0.200	<DL	1525	216	10.8	<DL	290	2062	0.078
63118	2204	Rubinmine	W4	Ufiltreret	0.187	<DL	1535	217	11.4	<DL	296	2090	0.083
63119	2112	Rubinmine	W21	Filtreret	0.139	<DL	1606	228	38.5	<DL	278	977	0.061
63120	2205	Rubinmine	W21	Ufiltreret	0.154	<DL	1608	248	69.1	<DL	304	997	0.071
63121	2201	Rubinmine	W22	Filtreret	0.157	<DL	1780	224	37.6	<DL	204	722	0.041
63122	2206	Rubinmine	W22	Ufiltreret	0.104	<DL	1783	225	38.8	<DL	203	725	0.047

Continued:

Ti*	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga*	As	Se	Rb*	Sr	Y*
0.009	0.010	0.025	0.009	0.1	0.001	0.013	0.0	0.080	0.001	0.045	0.006	0.001	0.01	0.001
1.550	0.195	0.154	1.047	23.2	0.024	1.165	0.4	0.292	0.019	<DL	0.037	2.301	6.30	0.014
7.888	0.395	0.384	2.966	111.6	0.091	1.632	0.9	0.845	0.073	<DL	0.044	2.694	6.64	0.049
0.046	0.055	<DL	0.296	1.4	0.024	0.018	0.2	0.853	0.002	<DL	0.017	0.187	2.37	0.011
0.195	0.052	<DL	0.314	2.7	0.024	0.031	0.3	0.882	0.003	<DL	0.023	0.189	2.38	0.012
0.141	0.164	0.035	0.108	3.2	0.011	0.053	0.1	0.334	0.008	<DL	0.024	0.363	7.05	0.010
0.065	0.153	0.036	0.171	3.3	0.011	0.046	0.2	0.147	0.007	<DL	0.031	0.362	7.12	0.011
0.300	0.099	0.073	1.115	11.0	0.026	0.230	0.3	0.244	0.017	<DL	0.030	0.970	3.33	0.040
2.452	0.143	0.125	1.607	39.8	0.039	0.317	0.4	0.557	0.026	<DL	0.035	1.153	3.38	0.044
0.201	0.079	0.070	0.473	4.6	0.018	0.106	0.3	0.736	0.012	<DL	0.033	0.522	3.20	0.046
0.191	0.074	0.073	0.875	5.4	0.022	0.118	0.3	0.605	0.015	0.047	0.032	0.527	3.24	0.046

Continued:

Zr*	Nb*	Mo	Ru*	Pd*	Ag*	Cd	Sb	Te*	Cs	Ba	La*	Ce*	Pr*	Nd*
0.003	0.002	0.005	0.001	0.000	0.000	0.001	0.016	0.010	0.000	0.017	0.000	0.000	0.000	0.000
0.013	0.003	0.450	<DL	0.009	<DL	<DL	0.018	<DL	0.018	1.420	0.123	0.143	0.027	0.089
0.022	0.010	0.370	<DL	0.010	<DL	0.002	<DL	0.012	0.048	3.265	0.620	0.775	0.125	0.384
0.003	<DL	0.021	<DL	0.004	<DL	0.003	<DL	<DL	0.001	1.323	0.047	0.074	0.010	0.032
<DL	<DL	0.020	<DL	0.003	<DL	0.003	<DL	<DL	0.002	1.360	0.051	0.080	0.010	0.039
0.004	<DL	0.443	<DL	0.010	<DL	0.002	<DL	<DL	0.002	0.876	0.046	0.036	0.010	0.033
<DL	<DL	0.457	<DL	0.012	<DL	0.002	<DL	<DL	0.002	0.869	0.048	0.039	0.010	0.032
0.007	<DL	0.421	<DL	0.004	<DL	0.003	<DL	<DL	0.011	0.788	0.351	0.393	0.072	0.233
0.009	<DL	0.377	<DL	0.005	<DL	0.003	<DL	<DL	0.025	1.110	0.376	0.427	0.073	0.234
0.006	<DL	0.117	<DL	0.005	<DL	0.003	<DL	<DL	0.004	1.028	0.367	0.213	0.066	0.230
0.007	<DL	0.101	<DL	0.005	<DL	0.003	<DL	<DL	0.005	1.081	0.371	0.221	0.068	0.227

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Continued:

Sm*	Eu*	Gd*	Tb*	Dy*	Ho*	Er*	Tm*	Yb*	Lu*	Hf*	Ta*	W*	Re*
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000
0.012	0.002	0.013	0.001	0.003	0.000	0.001	0.000	0.001	<DL	<DL	<DL	0.008	0.000
0.045	0.008	0.060	0.004	0.012	0.002	0.004	0.000	0.003	0.000	0.000	0.000	0.005	0.000
0.006	0.002	0.007	0.001	0.003	0.000	0.001	0.000	0.001	<DL	<DL	<DL	<DL	<DL
0.007	0.002	0.006	0.001	0.002	0.000	0.001	0.000	0.001	<DL	<DL	<DL	<DL	<DL
0.004	0.001	0.004	0.000	0.002	0.000	0.001	0.000	0.001	<DL	<DL	<DL	<DL	0.000
0.005	0.001	0.005	0.000	0.002	0.000	0.001	0.000	0.001	0.000	<DL	<DL	<DL	0.000
0.028	0.004	0.033	0.003	0.007	0.001	0.003	0.001	0.001	0.000	<DL	<DL	<DL	0.000
0.030	0.004	0.037	0.003	0.008	0.001	0.003	0.000	0.002	0.000	<DL	<DL	<DL	0.000
0.031	0.004	0.026	0.002	0.008	0.002	0.003	0.000	0.002	0.000	<DL	<DL	<DL	0.000
0.027	0.004	0.025	0.002	0.009	0.001	0.004	0.000	0.002	0.000	<DL	<DL	<DL	0.000

Continued:

Pt*	Au*	Hg*	Tl*	Pb	Bi*	Th*	U*
0.001	0.002	0.003	0.000	0.002	0.001	0.000	0.000
<DL	<DL	<DL	0.003	0.012	<DL	0.012	0.026
<DL	<DL	<DL	0.004	0.062	0.002	0.033	0.081
<DL	<DL	<DL	0.001	0.009	<DL	0.001	0.002
<DL	<DL	<DL	0.001	0.010	<DL	0.001	0.003
<DL	<DL	<DL	0.001	0.003	<DL	0.002	0.064
<DL	<DL	<DL	0.001	0.003	<DL	0.001	0.066
<DL	<DL	<DL	0.002	0.007	<DL	0.013	0.113
<DL	<DL	<DL	0.002	0.026	<DL	0.012	0.127
<DL	<DL	<DL	0.002	0.016	<DL	0.007	0.047
<DL	<DL	<DL	0.001	0.023	<DL	0.006	0.065

Signature

Measured element concentrations in certified reference material (SLRS-6) analysed along with the samples (for QA/QC)

Results are given in µg/l. The detection limit (DL) of the analyses is determined as 3 standard deviations on blank values measured during the analyses. Non-accredited elements are marked with a * in the table. <DL= below the detection limit. ND=Not determined. Numbers in brackets are information/reference values only (i.e. not certified values).

ID no./name	Lab no.	Li	Be	Na	Mg	Al	P	K	Ca*	Sc*
Detection Limit (DL)		0.006	0.002	1	0	0.2	10	1	1	0.004
SLRS-6	2107	0.380	0.004	2709	1977	33.0	<DL	632	8246	0.186
SLRS-6	2108	0.383	0.004	2691	1987	33.1	<DL	640	8323	0.184
SLRS-6	2107	0.517	0.007	2677	1985	32.4	<DL	622	8219	0.179
SLRS-6	2108	0.500	0.007	2689	1980	32.2	<DL	625	8249	0.177
SLRS-6	2107	0.399	0.004	2657	1931	30.9	<DL	616	8133	0.177
SLRS-6	2108	0.372	0.005	2696	1956	31.2	<DL	621	8223	0.174
Certified value		ND	(0.0066)	2760	2133	33.8	ND	651	8760	ND
Certified uncertainty (2 SD)		ND	(0.0022)	220	58	2.2	ND	54	200	ND

Continued:

Ti*	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga*	As	Se	Rb*	Sr	Y*
0.009	0.010	0.025	0.009	0.1	0.001	0.013	0.0	0.080	0.001	0.045	0.006	0.001	0.01	0.001
0.596	0.379	0.230	2.086	82.8	0.057	0.496	24.3	1.896	0.021	0.503	0.087	1.401	39.19	0.139
0.616	0.354	0.239	2.080	82.6	0.052	0.504	24.3	1.793	0.018	0.488	0.083	1.428	39.30	0.145
0.545	0.367	0.209	2.059	80.0	0.054	0.511	24.4	1.826	0.016	0.518	0.087	1.371	38.63	0.133
0.526	0.341	0.208	2.078	80.5	0.055	0.532	24.4	1.804	0.020	0.521	0.089	1.366	38.93	0.140
0.589	0.332	0.227	2.056	76.1	0.057	0.502	23.5	1.813	0.019	0.450	0.087	1.331	37.60	0.139
0.602	0.325	0.231	2.060	77.0	0.055	0.510	23.7	1.747	0.020	0.480	0.084	1.338	37.99	0.140
ND	0.351	0.252	2.12	84.3	(0.053)	0.616	23.9	1.76	ND	0.57	ND	ND	40.66	ND
ND	0.006	0.012	0.1	3.6	(0.012)	0.022	1.8	0.12	ND	0.08	ND	ND	0.32	ND

Continued:

Zr*	Nb*	Mo	Ru*	Pd*	Ag*	Cd	Sb	Te*	Cs	Ba	La*	Ce*	Pr*	Nd*
0.003	0.002	0.005	0.001	0.000	0.000	0.001	0.016	0.010	0.000	0.017	0.000	0.000	0.000	0.000
0.045	0.002	0.167	<DL	0.060	<DL	0.009	0.329	<DL	0.005	13.585	0.243	0.288	0.058	0.220
0.048	0.002	0.177	<DL	0.060	<DL	0.010	0.318	<DL	0.004	13.719	0.244	0.288	0.058	0.215
0.047	<DL	0.172	<DL	0.064	<DL	0.008	0.319	<DL	0.005	13.484	0.241	0.295	0.058	0.212
0.053	<DL	0.172	<DL	0.069	<DL	0.009	0.317	<DL	0.004	13.731	0.246	0.292	0.058	0.221
0.050	<DL	0.177	<DL	0.055	<DL	0.009	0.317	<DL	0.004	13.313	0.241	0.289	0.055	0.214
0.052	<DL	0.178	<DL	0.058	<DL	0.008	0.310	<DL	0.004	13.620	0.246	0.291	0.057	0.213
ND	ND	0.215	ND	ND	ND	0.0063	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	0.018	ND	ND	ND	0.0014	ND	ND	ND	ND	ND	ND	ND	ND

Continued:

Sm*	Eu*	Gd*	Tb*	Dy*	Ho*	Er*	Tm*	Yb*	Lu*	Hf*	Ta*	W*	Re*
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000
0.036	0.019	0.042	0.004	0.021	0.004	0.011	0.002	0.010	0.001	0.002	<DL	0.009	0.014
0.036	0.018	0.042	0.004	0.020	0.004	0.011	0.002	0.012	0.002	0.002	<DL	0.007	0.015
0.038	0.018	0.042	0.005	0.022	0.004	0.012	0.002	0.011	0.002	0.002	<DL	0.010	0.014
0.037	0.020	0.042	0.005	0.022	0.004	0.012	0.002	0.013	0.002	0.002	<DL	0.009	0.014
0.039	0.017	0.040	0.004	0.022	0.004	0.012	0.002	0.011	0.002	0.002	<DL	0.008	0.013
0.034	0.018	0.039	0.005	0.020	0.004	0.012	0.002	0.010	0.002	0.002	<DL	0.007	0.014
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Signature

Continued:

Pt*	Au*	Hg*	Tl*	Pb	Bi*	Th*	U*
0.001	0.002	0.003	0.000	0.002	0.001	0.000	0.000
0.001	<DL	0.172	0.004	0.161	0.002	0.019	0.068
0.001	<DL	0.172	0.004	0.162	0.002	0.018	0.067
0.001	<DL	0.169	0.004	0.157	0.001	0.017	0.067
0.003	<DL	0.174	0.004	0.160	0.001	0.017	0.068
0.002	<DL	0.161	0.002	0.156	0.001	0.007	0.066
0.002	<DL	0.162	0.002	0.157	0.001	0.008	0.066
ND	ND	ND	ND	0.17	ND	ND	0.0698
ND	ND	ND	ND	0.026	ND	ND	0.0034

Responsible for the report:

Date: 4 December 2019

Signature:

Jens Søndergaard

Position: Senior Advisor/Head of Laboratory

Signature

Appendix 1. Uncertainty of measurements

Accredited detection limits and uncertainties for ICP-MS analyses of freshwater:

Expanded uncertainty, k=2 (95% confidence), in µg/l.

Parameter	Detection limit (DL)	Lower uncertainty U_{abs}	Upper uncertainty U_{rel} (%)
Li	1.0	0.67	15
Be	0.2	0.1	5
Na	55	37	10
Mg	10	6.7	10
Al	10	6.7	10
P	15	10	15
K	25	17	10
V	0.2	0.13	5
Cr	0.2	0.13	5
Mn	2.5	1.7	15
Fe	10	6.7	5
Co	0.2	0.1	10
Ni	0.5	0.3	10
Cu	0.8	0.5	10
Zn	10	6.7	15
As	1.0	0.67	20
Se	0.5	0.3	10
Sr	0.5	0.3	5
Mo	2.0	1.3	15
Cd	0.1	0.07	10
Sb	2.0	1.3	10
Cs	0.1	0.07	10
Ba	1.0	0.67	5
Pb	0.3	0.2	10

Signature

Calculation of uncertainties:

Detection limit (DL): The lowest result that is significant different from zero.

The total uncertainty (U_c) can be calculated from the formula:

$$U_C = \sqrt{U_{abs}^2 + U_{rel}^2 C^2}\ ;$$

U_{abs} = Lower uncertainty: The absolute uncertainty dominating at the lower measuring level (here set to 2/3 DL).

U_{rel} = Upper uncertainty: The relative uncertainty for samples with a high concentration.

C = Concentration.

Example:

The calculated total uncertainty U_C of a sample with a concentration of 5.1 mg/kg with U_{abs} = 0.2 and U_{rel} = 24 % based on the formula gives:

$$U_{5,1} = U_C = \sqrt{0.2^2 + \left(\frac{24\%}{100\%}\right)^2 5.1^2} = 1.2$$

This means that there is a 95% probability that the true result is between 3.9 and 6.3.

Signature