



26.februar 2021

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Ferskvandsmonitoring ved Greenland Ruby rubinmine ved Aappaluttoq i 2020

Dette notat præsenterer resultaterne af myndighedernes ferskvandsmonitoring ved Greenland Ruby rubinmine ved Aappaluttoq i 2020. Programmet blev gennemført d. 25. og 26. august.

Minen, dvs. selve bruddet, er anlagt på en tidligere halvø midt i søen Ukkaata Qaava. Søen modtager især vand fra to tilløb til det sydøstre bassin, mens afløbet sker fra det nordvestre bassin. 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 fra minen, 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 de to tilløb til søens sydøstre bassin
- W1 i elven ca. 200 meter nedstrøms udløbet fra søens nordvestre bassin
- W21 i elven nedstrøms sprængstoflager og camp og ca. 300 meter opstrøms udløbet i fjorden
- W22 i en elv ca. 8 km sydvest for minen. (= referencestation).

Derudover blev der taget en vandprøve i elven i nærheden af campen, hvor der er etableret en ny monitoringsstation. Resultater fra denne er ikke medtaget i nedenstående oversigt.

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. Forskellen mellem de filtrerede og ufiltrerede prøver giver også et mål for mængden af suspenderet partikulært stof.

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

Resultater

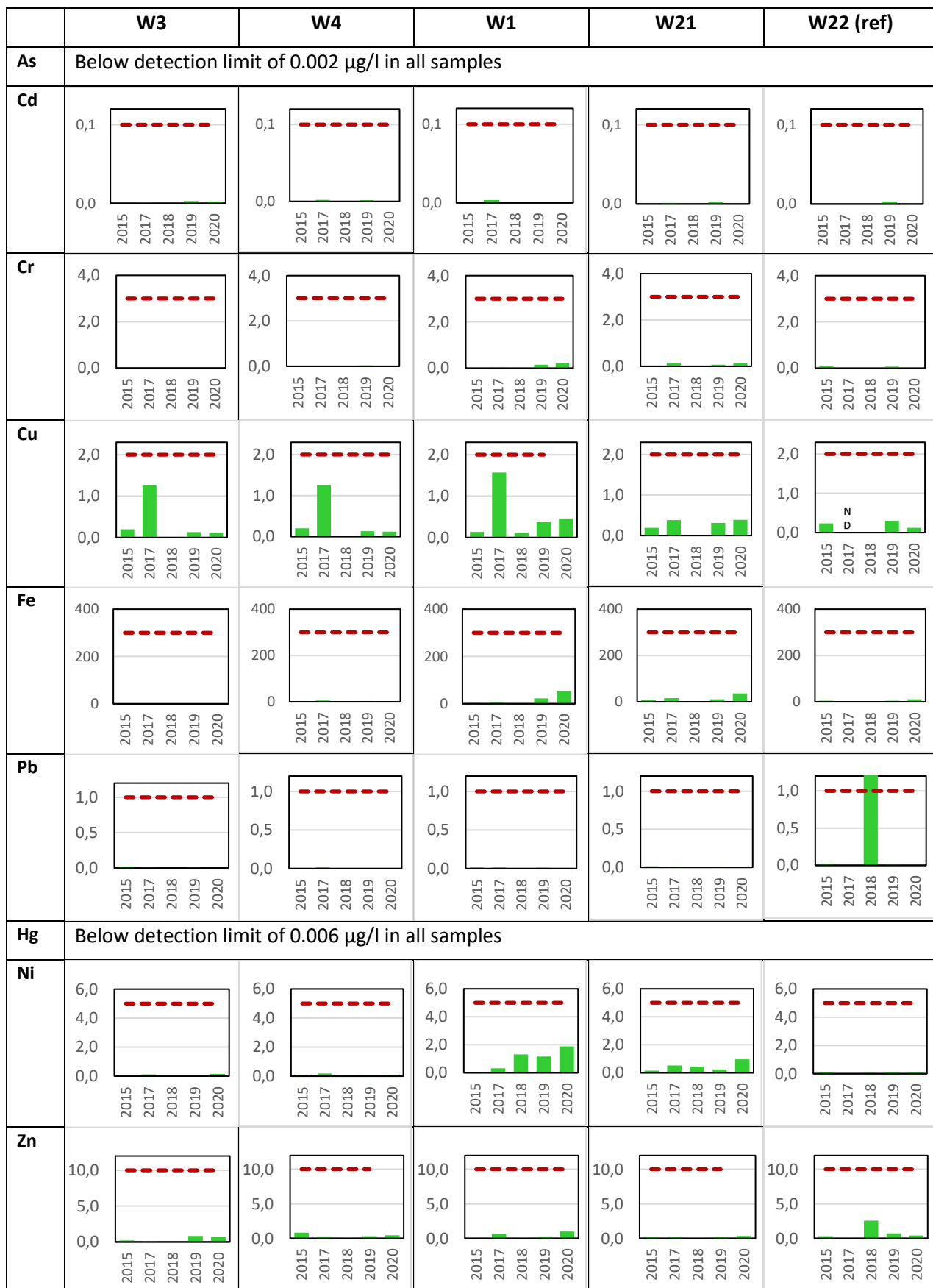
Resultaterne fra 2020 er vist i Figur 1, side 3, (filtrerede prøver) og Figur 2, side 4, (ufiltrerede prøver) sammen med resultaterne fra de samme lokaliteter i 2015, 2017, 2018 og 2019. Figurerne viser resultaterne for de metaller, for hvilke der er etableret grønlandske vandkvalitetskriterier. Kriterieværdierne er angivet på figurerne.

Der sker en berigning med en lang række stoffer, bl.a. Aluminium, Titanium, Krom, Mangan, Jern, Nikkel, Kobber og Bly, i den opløste (filtrerede) fraktion ved vandets passage gennem søen, og for de fleste stoffer en endnu stærkere berigning i den partikulære fraktion. Berigningen af den opløste fraktion skyldes givetvis især udledning af tailings bestående af frisk knust materiale, mens dele af den partikulære fraktion også kan stamme fra den stærke erosion af søbredden, der er opstået som følge af vandstandssænkningen.

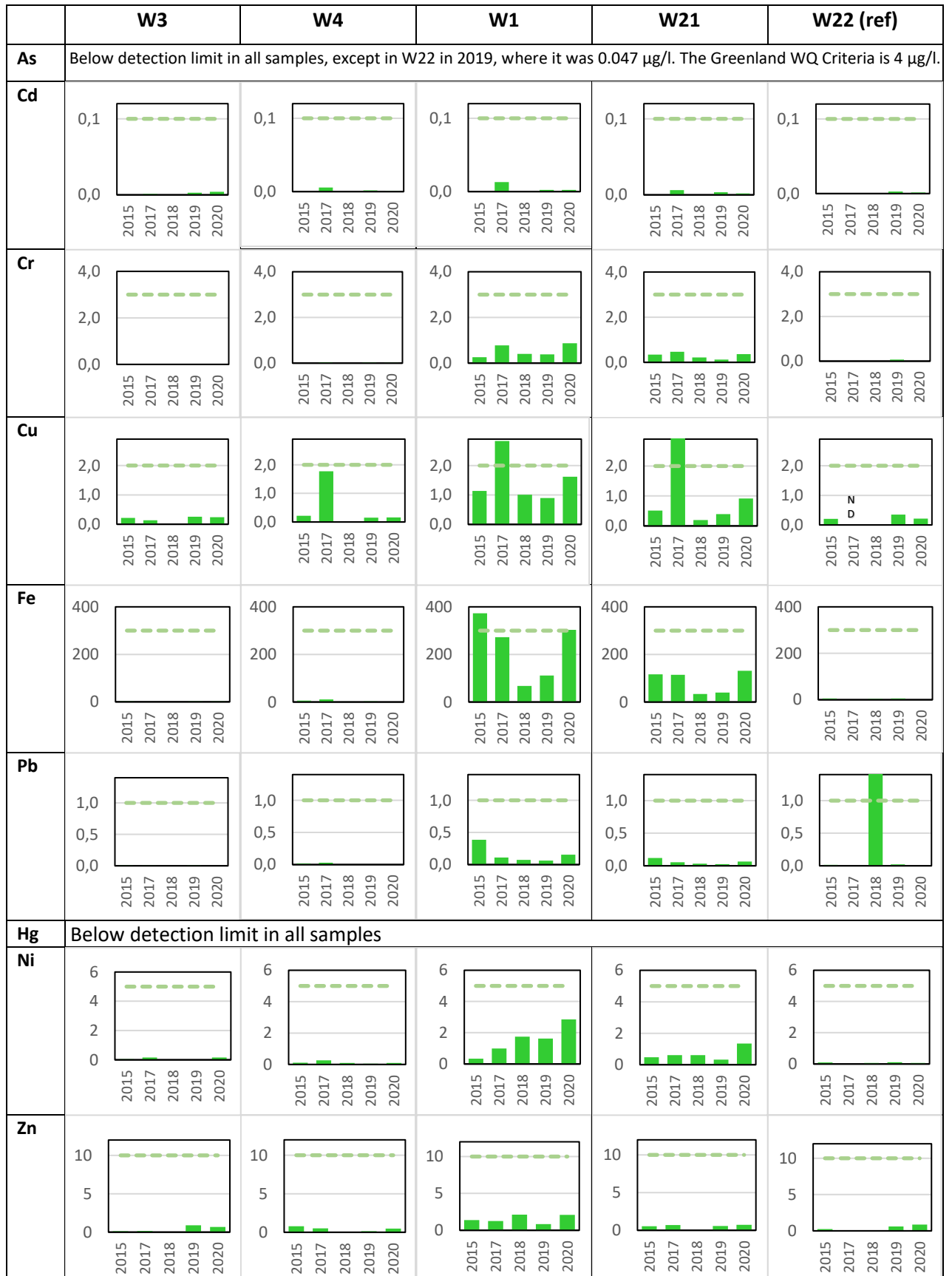
Ingen af stofferne i den opløste fraktion i 2020 optræder i koncentrationer, der overskrider vandkvalitetskriterierne fastsat af de grønlandske myndigheder. Koncentrationerne i afløbet fra søen (W1 og W21) er for de flere af de målte stoffer, både i den opløste og partikulære fraktion, højere i 2020 end i de to foregående år. Det vides ikke om dette skyldes en øget aktivitet i minen og følgende øget udledning af tailings, eller om det skyldes det kraftige regn- og stormvejr med efterfølgende omrøring og udvaskning til og fra søen, der nyligt havde været.

Grænseværdierne gælder, som nævnt, kun for den opløste fraktion og er kun fastsat for de vigtigste og for de mest almindelige metaller.

Figur 1. Indholdet af udvalgte metaller i filtrerede vandprøver i 2015, 2017, 2018, 2019 og 2020. 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. Koncentrationerne er angivet i µg/l.



Bilag 1

Testrapport 1065 fra DCE, Aarhus Universitet,

Watersamples from the Aappaluttoq Ruby Mine, Southwest Greenland 2020.

Analyseresultater og detektionsgrænser for samtlige 61 analyserede grundstoffer.

**Test report no. 1065****Water samples from the Aappaluttoq Ruby Mine, Southwest Greenland in 2020**

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

Sample collection:

Sampling place: Near the Aappaluttoq Ruby Mine, Southwest Greenland

Sampling time: September 2020

Sample type: Freshwater

Sampling performed by: Greenland Institute of Natural Resources (GINR).

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: October 2020

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. The values for the Greenland Water Quality Criteria for mining activities (GWQC) are shown for reference.

Sample ID		Li	Be	Na	Mg	Al	P	K	Ca*	Sc*
<i>Detection limit (DL) (3 SD on blanks)</i>		0.006	0.0008	1	0.1	1.9	7	4	1	0.003
GWQC							20			
63869	W22 filtered	0.119	<DL	1370	167.0	11.1	<DL	154	472	0.020
83870	W22 unfiltered	0.101	0.0013	1373	170.1	13.5	<DL	161	485	0.014
63871	W4 filtered	0.258	<DL	1529	202.0	10.8	<DL	290	1875	0.069
63872	W4 unfiltered	0.235	<DL	1506	199.5	10.9	<DL	308	1853	0.069
63873	W1 filtered	0.439	0.0011	1588	625.6	97.0	<DL	1138	2140	0.069
63874	W1 unfiltered	0.742	0.0061	1647	757.2	558.2	7	1263	2314	0.154
63876	W. camp filtered	0.372	<DL	1625	603.5	86.9	<DL	1076	2057	0.063
63875	W. camp unfiltered	0.720	0.0041	1699	743.0	554.4	<DL	1229	2212	0.143
63878	W3 filtered	0.075	<DL	991	124.5	12.6	<DL	98	286	0.035
63877	W3 unfiltered	0.074	<DL	1013	127.2	22.0	<DL	98	290	0.033
63880	W21 filtered	0.296	<DL	1668	481.1	65.8	<DL	852	1728	0.062
63879	W21 unfiltered	0.433	0.0022	1709	537.1	236.4	<DL	914	1804	0.090

Continued:

Ti*	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga*	As	Se	Rb	Sr	Y*
0.011	0.010	0.016	0.003	0.9	0.001	0.005	0.007	0.148	0.002	0.042	0.002	0.003	0.003	0.001
		3		300		5	2	10		4				
0.024	0.011	0.040	0.207	10.8	0.006	0.089	0.123	0.409	<DL	<DL	0.026	0.335	2.268	0.008
0.066	0.013	0.017	0.350	1.4	0.008	0.075	0.215	0.854	0.003	<DL	0.016	0.329	2.260	0.010
0.063	0.139	0.027	0.041	<DL	0.010	0.113	0.117	0.449	0.010	<DL	0.030	0.377	6.571	0.007
0.057	0.144	0.025	0.086	<DL	0.007	0.103	0.157	0.476	0.007	<DL	0.030	0.381	6.520	0.007
4.517	0.252	0.222	1.638	52.6	0.053	1.883	0.460	1.003	0.038	<DL	0.053	3.219	8.345	0.025
19.655	0.699	0.874	5.847	302.9	0.237	2.862	1.620	2.107	0.210	<DL	0.057	4.142	9.828	0.142
3.650	0.195	0.199	0.919	48.8	0.035	1.554	0.452	0.384	0.045	<DL	0.046	3.160	8.215	0.048
17.420	0.650	0.835	5.810	309.6	0.239	2.584	1.703	2.918	0.212	<DL	0.048	4.245	9.463	0.145
0.040	0.049	<DL	0.540	<DL	0.067	0.152	0.223	0.720	0.003	<DL	0.026	0.222	1.963	0.012
0.181	0.056	<DL	0.566	2.3	0.066	0.156	0.243	0.683	0.010	<DL	0.021	0.237	2.023	0.015
2.616	0.158	0.142	1.760	36.5	0.032	0.956	0.387	0.357	0.026	<DL	0.031	2.535	6.561	0.020
7.733	0.308	0.365	3.392	131.1	0.102	1.341	0.913	0.723	0.092	<DL	0.042	2.967	7.114	0.067

Continued:

Zr*	Nb*	Mo	Ru*	Pd*	Ag*	Cd	Sb	Te*	Cs	Ba	La*	Ce*	Pr*	Nd*
0.003	0.003	0.006	0.0007	0.0003	0.0005	0.0010	0.0116	0.0000	0.0003	0.0032	0.0004	0.0003	0.0001	0.0002
						0.1								
<DL	<DL	0.111	<DL	0.0036	<DL	<DL	0.0252	0.0026	0.0031	0.5060	0.0524	0.0346	0.0108	0.0368
<DL	<DL	0.107	<DL	0.0029	<DL	0.0016	<DL	<DL	0.0029	0.5501	0.0674	0.0491	0.0133	0.0477
<DL	<DL	0.572	<DL	0.0103	<DL	<DL	0.0124	<DL	0.0026	0.8576	0.0338	0.0241	0.0079	0.0244
<DL	<DL	0.557	<DL	0.0102	<DL	0.0012	<DL	<DL	0.0023	0.9132	0.0380	0.0290	0.0080	0.0226
0.052	0.007	0.587	<DL	0.0134	<DL	<DL	0.0140	0.0051	0.0191	1.8844	0.2602	0.2959	0.0534	0.1783
0.042	0.029	0.328	<DL	0.0157	<DL	0.0025	<DL	0.0051	0.0728	7.7612	1.9302	2.4006	0.3708	1.1685
0.051	0.006	0.600	<DL	0.0125	<DL	<DL	0.0116	0.0026	0.0246	1.7276	0.2955	0.3490	0.0633	0.2075
0.036	0.021	0.309	<DL	0.0152	<DL	0.0023	<DL	0.0050	0.0853	7.2051	1.9918	2.6857	0.3904	1.2070
<DL	<DL	0.034	<DL	0.0037	<DL	0.0023	<DL	<DL	0.0024	1.2730	0.0823	0.0851	0.0162	0.0563
<DL	<DL	0.032	<DL	0.0021	<DL	0.0041	<DL	<DL	0.0027	1.2923	0.0912	0.1121	0.0198	0.0693
0.006	0.005	0.683	<DL	0.0095	<DL	<DL	<DL	0.0101	0.0223	1.3638	0.2344	0.2684	0.0483	0.1579
0.017	0.008	0.484	<DL	0.0112	<DL	0.0018	<DL	<DL	0.0488	3.8293	0.9265	1.1584	0.1799	0.5647

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Continued:

Sm*	Eu*	Gd*	Tb*	Dy*	Ho*	Er*	Tm*	Yb*	Lu*	Hf*	Ta*	W*	Re*
0.0001	0.00005	0.0002	0.0003	0.0002	0.00002	0.0001	0.00003	0.0001	0.0002	0.0004	0.0009	0.005	0.0004
0.0042	0.00112	0.0038	0.0006	0.0012	0.00025	0.0005	0.00009	0.0003	<DL	<DL	<DL	<DL	<DL
0.0072	0.00120	0.0051	0.0006	0.0019	0.00029	0.0006	0.00004	0.0005	<DL	<DL	<DL	<DL	<DL
0.0030	0.00127	0.0034	<DL	0.0015	0.00025	0.0007	<DL	0.0005	<DL	<DL	<DL	<DL	<DL
0.0020	0.00160	0.0039	0.0004	0.0015	0.00029	0.0006	0.00010	0.0003	<DL	<DL	<DL	<DL	<DL
0.0238	0.00384	0.0245	0.0017	0.0054	0.00095	0.0019	0.00023	0.0016	<DL	<DL	<DL	0.008	<DL
0.1368	0.02201	0.1765	0.0130	0.0346	0.00529	0.0125	0.00167	0.0088	0.0010	0.0015	0.0016	<DL	<DL
0.0307	0.00427	0.0330	0.0029	0.0104	0.00175	0.0038	0.00059	0.0034	0.0005	0.0010	<DL	0.007	<DL
0.1505	0.02254	0.1859	0.0129	0.0372	0.00534	0.0120	0.00151	0.0089	0.0011	0.0013	<DL	<DL	<DL
0.0050	0.00188	0.0078	0.0006	0.0022	0.00040	0.0012	0.00010	0.0010	<DL	<DL	<DL	<DL	<DL
0.0101	0.00228	0.0107	0.0009	0.0023	0.00046	0.0015	0.00016	0.0012	<DL	<DL	<DL	<DL	<DL
0.0218	0.00325	0.0215	0.0019	0.0052	0.00082	0.0020	0.00014	0.0016	<DL	<DL	<DL	0.009	<DL
0.0682	0.01022	0.0864	0.0062	0.0180	0.00241	0.0062	0.00076	0.0036	0.0005	0.0008	<DL	<DL	<DL

Continued:

Pt*	Au*	Hg*	Tl*	Pb	Bi*	Th*	U*
0.0004	0.001	0.006	0.0006	0.002	0.0008	0.0001	0.0001
		0.05		1			
0.0011	<DL	<DL	0.0008	<DL	<DL	0.0019	0.0158
<DL	<DL	<DL	<DL	<DL	<DL	0.0011	0.0227
0.0005	<DL	<DL	0.0007	<DL	<DL	0.0010	0.0347
<DL	<DL	<DL	0.0007	<DL	<DL	0.0022	0.0714
0.0012	<DL	<DL	0.0034	0.007	<DL	0.0252	0.0592
0.0006	<DL	<DL	0.0068	0.155	0.0019	0.0704	0.1988
0.0017	<DL	<DL	0.0034	0.006	<DL	0.0224	0.0846
<DL	<DL	<DL	0.0069	0.174	0.0009	0.0653	0.2327
0.0027	<DL	<DL	0.0006	<DL	<DL	0.0010	0.0030
<DL	<DL	<DL	0.0006	<DL	<DL	0.0013	0.0043
<DL	<DL	<DL	0.0028	<DL	<DL	0.0234	0.0738
0.0029	<DL	<DL	0.0042	0.066	<DL	0.0377	0.1512

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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).

Sample Name	Li	Be	Na	Mg	Al	P	K	Ca*	Sc*
Detection limit (DL) (3 SD on blanks)	0.006	0.0008	1	0.074	1.9	7	4	1	0.003
SLRS-6	0.517	0.0064	2574	2024	33.3	7	623	7901	0.190
SLRS-6	0.501	0.0068	2611	2057	34.7	<DL	631	7960	0.185
SLRS-6	0.465	0.0062	2664	2060	33.3	<DL	634	7910	0.177
SLRS-6	0.444	0.0039	2644	2077	34.7	<DL	637	7918	0.186
SLRS-6 (certificate value)	ND	(0.0066)	2760	2133	33.8	ND	651	8760	ND
SLRS-6 (certificate uncertainty (2.5SD))	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*
0.011	0.010	0.016	0.003	0.9	0.001	0.005	0.007	0.15	0.002	0.04	0.002	0.003	0.00	0.001
0.592	0.359	0.241	2.039	79.4	0.055	0.554	23.8	1.63	0.017	0.54	0.084	1.397	38.8	0.135
0.567	0.332	0.240	2.078	80.5	0.057	0.558	23.9	1.68	0.017	0.51	0.082	1.379	38.7	0.140
0.637	0.333	0.249	2.058	80.4	0.056	0.556	23.9	1.44	0.018	0.54	0.089	1.370	38.4	0.136
0.598	0.328	0.247	2.096	79.7	0.056	0.586	23.8	1.51	0.016	0.57	0.089	1.365	38.5	0.141
ND	0.351	0.252	2.12	84.3	(0.053)	0.616	23.9	1.76	ND	0.57	ND	ND	40.7	ND
ND	0.006	0.012	0.1	3.6	(0.012)	0.022	1.8	0.12	ND	0.08	ND	ND	0.3	ND

Continued:

Zr*	Nb*	Mo	Ru*	Pd*	Ag*	Cd	Sb	Te*	Cs	Ba	La*	Ce*	Pr*	Nd*
0.003	0.003	0.006	0.001	0.000	0.000	0.001	0.0116	0.0000	0.0003	0.0032	0.0004	0.0003	0.0001	0.0002
0.097	0.010	0.194	<DL	0.053	<DL	0.0095	0.3139	0.0026	0.0048	13.1739	0.2400	0.2874	0.0572	0.2170
0.086	0.009	0.190	<DL	0.055	<DL	0.0077	0.3229	<DL	0.0048	13.1693	0.2434	0.2952	0.0601	0.2149
0.104	0.004	0.202	<DL	0.055	<DL	0.0076	0.3175	0.0051	0.0035	13.1160	0.2434	0.2919	0.0555	0.2181
0.097	0.003	0.199	<DL	0.055	<DL	0.0081	0.3142	0.0051	0.0043	13.0756	0.2435	0.2894	0.0554	0.2171
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*
0.0001	0.0000	0.0002	0.0003	0.0002	0.0000	0.0001	0.0000	0.0001	0.0002	0.0004	0.0009	0.0048	0.0004
0.0350	0.0186	0.0430	0.0045	0.0206	0.0039	0.0117	0.0018	0.0110	0.0016	0.0046	0.0065	0.0119	0.0128
0.0399	0.0181	0.0436	0.0045	0.0198	0.0042	0.0122	0.0013	0.0109	0.0017	0.0039	0.0047	0.0105	0.0137
0.0378	0.0189	0.0402	0.0048	0.0203	0.0041	0.0114	0.0019	0.0102	0.0014	0.0039	0.0020	0.0085	0.0129
0.0385	0.0184	0.0384	0.0041	0.0216	0.0042	0.0113	0.0016	0.0099	0.0018	0.0034	0.0014	0.0078	0.0137
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*
0.0004	0.0014	0.0065	0.0006	0.002	0.0008	0.0001	0.0001
0.0024	<DL	<DL	0.0032	0.140	0.0013	0.0152	0.0693
0.0023	<DL	<DL	0.0036	0.139	0.0015	0.0161	0.0699
0.0030	<DL	<DL	0.0033	0.141	<DL	0.0150	0.0700
0.0047	<DL	<DL	0.0032	0.139	0.0008	0.0134	0.0685
ND	ND	ND	ND	0.170	ND	ND	0.0698
ND	ND	ND	ND	0.026	ND	ND	0.0034

Responsible for the report:

Date: 18 November 2020

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 $\mu\text{g/l}$.

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

