QA for Horonobe Phase I Hydrochemical Investigations

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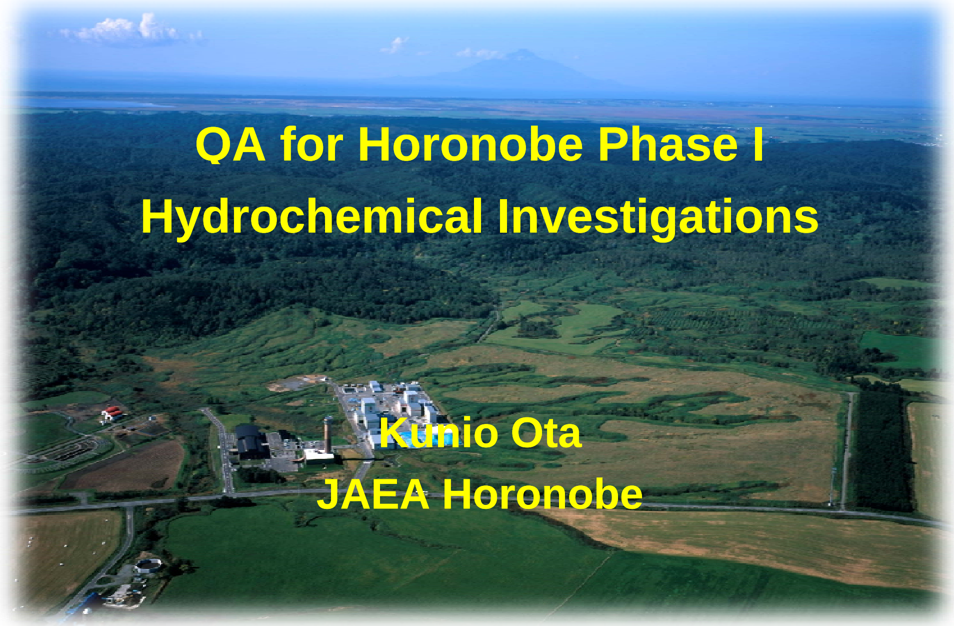
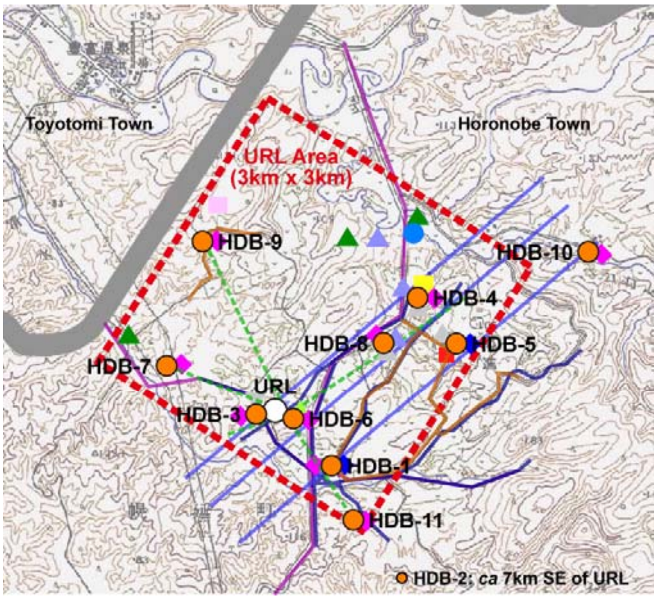
JAEA Horonobe



Background

GW: Groundwater
PW: Porewater

Horonobe Phase I Investigations



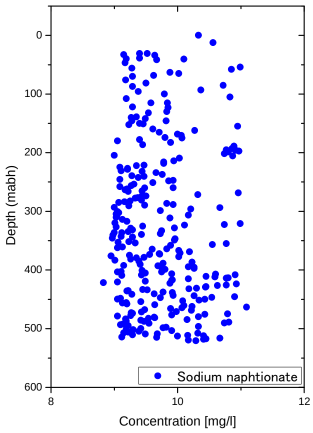
- Mar 2001 – Mar 2006
- 11 deep boreholes
  - 25 GW sampling
  - 145 PW sampling
  - 65 hydraulic testing
- Surface sampling
  - 182 river waters
  - 43 precipitations

➔ Vast datasets

(After Ota et al., 2007)

On-Site GW/Core Sampling QC

- Effort to evaluate the degree of GW contamination with drilling fluid by quantifying tracer concentrations in water samples
- Effort on speedy handling of cores to avoid oxidation

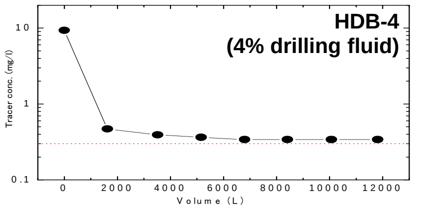


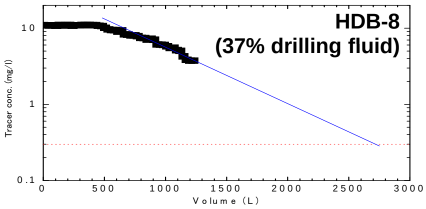
Tracer concentrations during drilling

Core sealing with plastic film, Al-foil, cotton cloth and wax (Ota et al., 2007)

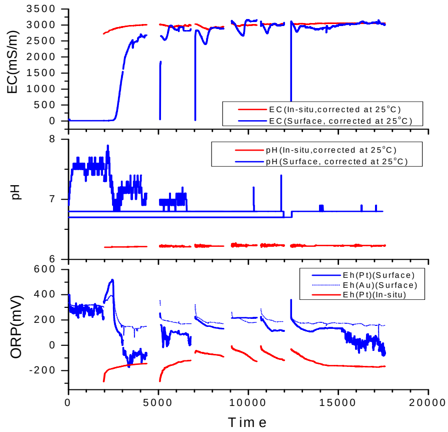
GW/PW Samples

- Some GW with drilling fluid <5%, but not all (up to 60%)
- Many PW with drilling fluid <10%, but high SO_4^{2-} due to oxidation
- *In situ* GW pH/ORP data only from HDB-11





Decrease in drilling fluid contamination

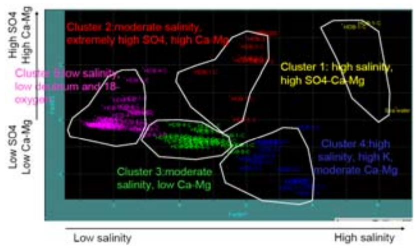


Surface vs *in situ* values in HDB-11

Phase I GW/PW Datasets

Sample ID											
	Borehole No.		HDB-6	HDB-6	HDB-6	HDB-6	HDB-6	HDB-6	HDB-6	HDB-6	HDB-6
	Type		core	core	core	core	core	core	core	core	core
	Point	No.	1	2	3	4	5	6	7	8	9
	Sample	No.									
	ID		6-co-1	6-co-2	6-co-3	6-co-4	6-co-5	6-co-6	6-co-7	6-co-8	6-co-9
	Sampling date										
	Time										
G.L.	upper	[m]	78.00	135.00	279.41	394.30	440.00	492.28	547.00	600.03	610.70
G.L.	lower	[m]	78.38	135.30	279.89	394.52	440.50	492.50	547.48	600.33	611.00
EL.	upper	[m]	-17.79	-74.79	-219.20	-334.09	-379.79	-432.07	-486.79	-539.82	-550.49
EL.	lower	[m]	-18.17	-75.09	-219.68	-334.31	-380.29	-432.29	-487.27	-540.12	-550.79
Location	X	[m]	115831.942	115831.942	115831.942	115831.942	115831.942	115831.942	115831.942	115831.942	115831.942
	Y	[m]	-30359.972	-30359.972	-30359.972	-30359.972	-30359.972	-30359.972	-30359.972	-30359.972	-30359.972
	Z	[m]	-18.17～-17.79	-75.09～-74.79	-219.68～-219.20	-334.31～-334.09	-380.29～-379.79	-432.29～-432.07	-487.27～-486.79	-540.12～-539.82	-550.79～-550.49
	Sampling depth	[m]	78.38～78.00	135.30～135.00	279.89～279.41	394.52～394.30	440.50～440.00	492.50～492.28	547.48～547.00	600.33～600.03	611.00～610.70
Monitoring											
	pH		8.1	8.2	8.3	8.3	7.94	8	8.29	8.3	8.09
	EC	[mS/m]									
	EC(correct)	[mS/m]									
	ORP(Pt)	[mV]									
	ORP(Au)	[mV]									
	DO	[mg/l]									
	Tracer	[mg/l]									
	Temp.	[℃]									
Lab.											
	pH										
	EC	[mS/m]									
	Temp.	[℃]									
	Tracer	[mg/l]									
Major elements											
	Na^+	[mg/l]	3400	2500	1800	4100	5170	5200	8205	6400	8591
	K^+	[mg/l]	160	120	59	74	68	48	135	67	127
	NH_4^+	[mg/l]									
	Li^+	[mg/l]	14	13	7.4	10	9.6	13	15	11	13
	Ca^{2+}	[mg/l]	81	53	43	160	212	120	123	84	329
	Mg^{2+}	[mg/l]	57	33	27	120	130	170	216	190	240
	Sr^{2+}	[mg/l]									
	Se^{2-}	[mg/l]									
	Total-P	[mg/l]									
	I^-	[mg/l]									
	Mn(II)	[mg/l]									
	Total Mn	[mg/l]									
	disolved Si	[mg/l]									
	insolved SiO2	[mg/l]									
	Ti^{4+}	[mg/l]									
	Fe(III)	[mg/l]	-	-	-	-	0 (N.D)	-	0 (N.D)	-	0 (N.D)
	Fe(II)	[mg/l]	-	-	-	-	0 (N.D)	-	0 (N.D)	-	0 (N.D)
	Total-Fe	[mg/l]	-	-	-	-	3.75	-	<1	-	<1
	Al^{3+}	[mg/l]									
	F^-	[mg/l]									
	Cl^-	[mg/l]	4600	2500	1800	5900	6567	8300	11808	9700	12035
	Br^-	[mg/l]									
	NO_3^-	[mg/l]									
	NO_2^-	[mg/l]									
	SO_4^{2-}	[mg/l]	830	800	710	1200	2125	610	1546	79	1934
	S^{2-}	[mg/l]									
	H_2S	[mg/l]									
	Total-B	[mg/l]									
	Total-Be	[mg/l]									
	Total-Cr	[mg/l]									
	Total-Co	[mg/l]									
	Total-Ni	[mg/l]									
	HCO_3^-	[mg/l]	1600	2100	1500	1200	640	900	363	1100	667
	CO_3^{2-}	[mg/l]	<500	<500	<500	<500	<88	<500	120	<500	<88
	M-Alkalinity	[mg/l]									
	P-Alkalinity	[mg/l]									
	TOC	[mg/l]	<100	<100	<100	<100	59	200	0 (N.D)	<100	63
	TIC	[mg/l]	400	400	300	300	116	300	0 (N.D)	300	119
Ionic balance											
Cation											
	Na^+	[meq/l]	147.890	108.743	78.295	178.338	224.880	226.185	356.894	278.382	373.684
	K^+	[meq/l]	4.092	3.069	1.509	1.893	1.739	1.228	3.453	1.714	3.248
	NH_4^+	[meq/l]									
	Li^+	[meq/l]	2.017	1.873	1.066	1.441	1.383	1.873	2.161	1.585	1.873
	Ca^{2+}	[meq/l]	4.042	2.645	2.146	7.984	10.579	5.988	6.138	4.192	16.417

(JAEA-Data/Code 2007-015)



GW categories (Sasamoto et al., 2007)

- To date, several site hydrochemistry studies, geochemical/radionuclide transport modelling *etc* have been carried out using the datasets
- Although a few authors carried out some degree of data QC, none was rigorous or wide-reaching
- Sampling artefacts are a significant problem for some datasets

Phase I Report Conclusions

- *"since tasks in the borehole investigations are fairly diverse, a QC programme was formulated for each individual task. Nevertheless, QA/QC in Phase I proved to be inadequate for some investigation tasks"*
- *"in many cases, failure in QA/QC lies with lack of personal knowledge or experience and is rarely elicited. An important step would be to pass on key know-how and experience from researchers who have experienced mistakes to the next generation through field work"*
- *"for implementation of the investigation programmes, extremely important tasks involve organisation of an appropriate working system (eg team) and establishment of a QA system"*

(JAEA-Research 2007-044)

Ongoing QA Work

QA Background

- Assessing **groundwater quality** and assigning a **QA category of suitability** requires an evaluation of all the available hydrochemical data with reference to known hydraulic conditions in:
  - the borehole
  - the fracture zone sections being sampled
  - the surrounding host bedrock (rock matrix)
- Reliability of these data is judged on prevailing geological and hydraulic conditions during drilling and subsequent monitoring/sampling
- Without the integration of hydrochemistry, geology, hydrogeology and **borehole activities**, there is a great danger that data (quality) can be misrepresented

QA Expectations

- QA methodologies applied in repository programmes are **much more stringent** than those in other research areas because of the strict requirements of repository site assessments and the expectations of various stakeholders
- It therefore makes sense to use the URL programme to **train staff** in the application of an appropriate QA system, allowing the development of a body of staff fully capable of conducting an actual repository site characterisation

QA Formalisation

- To save reinventing the wheel, very good QA methodologies applied in SKB's ongoing site characterisation at Forsmark and Laxemar are referred
- Some very stringent data requirements led to the development of a system of ranking GW data based on a suite of criteria
- Criteria are based on expert judgement of the most significant processes that:
  - can impact on sample quality
  - are evident of analytical quality
  - can aid (or hinder) the data interpretation and modelling

➔ Application of SKB's GW QA system

GW Categorisation

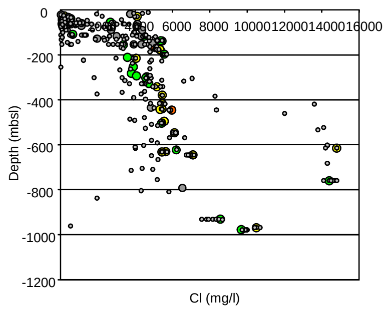
Cored Boreholes	Category				
Aspects/Conditions	*1*	*2*	*3*	*4*	*5*
Drilling water (≤ 1%)	x	x	x	x	x
Drilling water (≤ 5%)		x	x	x	x
Drilling water (≤ 10%)			x	x	x
Drilling water (> 10%)				x	x
Time series (adequate)	x	x	x	x	x
Time series (inadequate)			x	x	x
Time series (absent)				x	x
Suitable section length	x	x	x	x	x
Sampling during drilling				x	x
Sampling during hydraulic testing			x	x	x
Tube sampling					x
Charge balance ±5% (±10% for <50 mg/L Cl)	x	x	x	x	x
Major ions (complete)	x	x	x	x	x
Major ions (incomplete)			x	x	x
Environmental isotopes (complete)	x	x	x	x	x
Environmental isotopes (incomplete)		x	x	x	x
Hydraulic effects (short-circuiting)	x	x	x	x	x

(Smellie and Tullborg, 2008)

- The final weighting of data is based on providing:
  - period of sample collection
  - a complete set of major ion and isotope analytical data (particularly ^{3}H, ^{2}H, ^{18}O and C isotopes when available)
  - an acceptable charge balance
  - a low drilling water content
  - good time-series data coverage
  - reliable redox values
  - a satisfactory coverage of trace element data (including U, Th and REEs)
  - dissolved gas, microbes and organics and colloid data

GW Data QA – Example from SKB

- Categories 1, 2 and 3 primarily meet the requirements of hydrochemical modelling
- Categories 4 and 5 primarily meet hydrogeological requirements (also for more qualitative hydrochemical modelling with caution)



(Smellie and Tullborg, 2008)

- Clearly, the higher the sample category, the more confidence can be placed on the dataset and so the more useful are the data for hydrochemical interpretation
- Nevertheless, overall site understanding is still possible using a combination of all categories, with the obvious proviso that the lower the category used, the more caution is required in their interpretation

PW Categorisation

- For the Horonobe PW data, it is clear that the same set of QA conditions cannot be applied
- Vastly reduced sample size makes it impossible to carry out the full range of analyses
- Some QA aspects can still be addressed, such as the degree of drilling fluid contamination, data set available and indications of perturbations (*eg* oxidation or CO_2 reaction)
- Although QA systems already exist for core recovery, sampling and description in the mining industry, nothing comparable exists for PW

➔ Proposal of PW QA system

GW/PW Data QA – Ongoing at Horonobe

- **Progress**
  - HDB-9 to 11 (6 GW and 51 PW) datasets were examined
  - HDB-1 to 8 (19 GW and 94 PW) datasets are now being Qad
  - All new borehole datasets will also be assessed
- **Results to date**
  - General trends and absolute Cl values vs depth are strikingly similar for both GW and PW datasets
  - General trends and important outliers indicated by all data are strengthened and constrained by higher category data
  - Further QA requirements for data interpretation and on-site investigations are indicated
- **Presentation/Publication**
  - AESJ Annual Meeting (March 2009, Tokyo), Goldschmidt™2009 (June 2009, Davos), JAEA-Research...