Environmental impact from an alum shale deposit, Kvarntorp, Sweden – present and future scenarios

Mattias Bäckström[1,2]

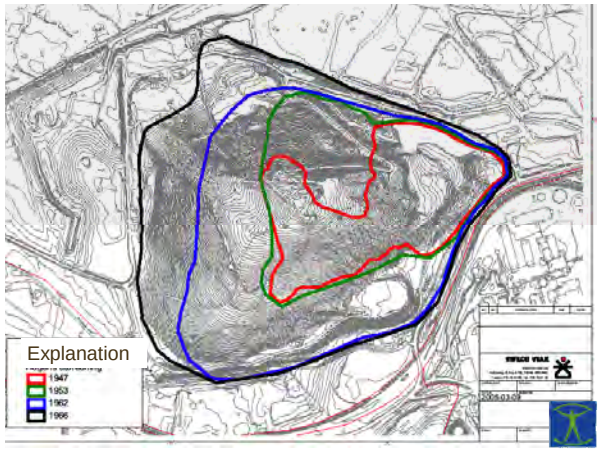
[1]Man-Technology-Environment Research Centre, Örebro University, Örebro, Sweden
[2]SWECO Environment AB, Örebro, Sweden

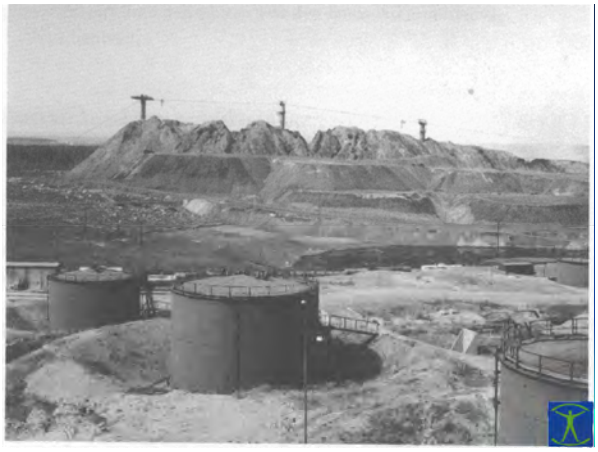
History

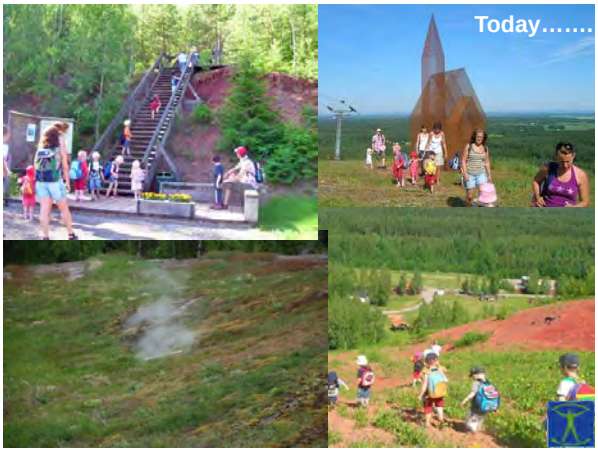
- During WW2 fuel shortages in Sweden it was decided to produce oil through pyrolysis of alum shale
- Alum shale was mined in open pits and oil was produced through pyrolysis
- In 1942 the first drops were produced in Kvarntorp, Sweden
- Production continued until 1966
- Both pyrolysis residues (”ash”) and finer fractions of shale were deposited in the open pits and in a large waste pile (40 million m^3)

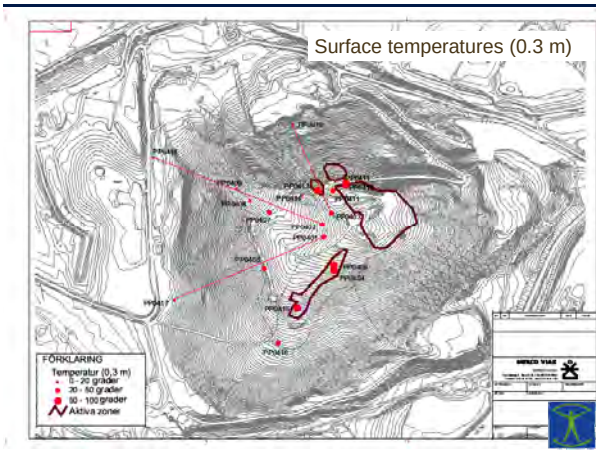
Field site

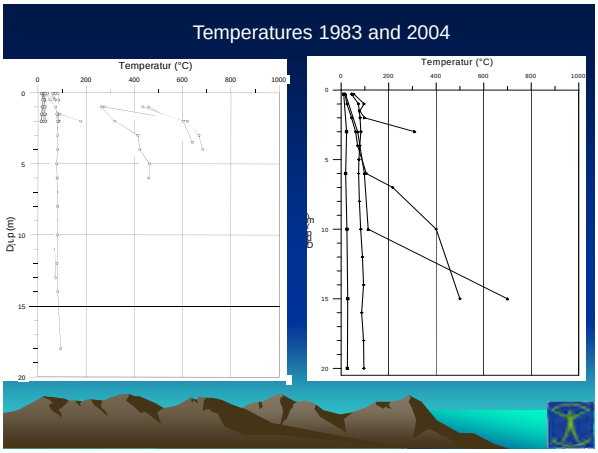
- 200 km W of Stockholm, Sweden
- Extraction of alum shale for production of oil between 1942 and 1966 (liquid fuel production during WW2)
- The shale contained pyrite and kerogen (12 % S)
- Waste deposited in a single waste pile (44 ha, 40 million m^3)
- Still very high temperatures (exceeding 500 ºC)
- Both acidic and alkaline leachates

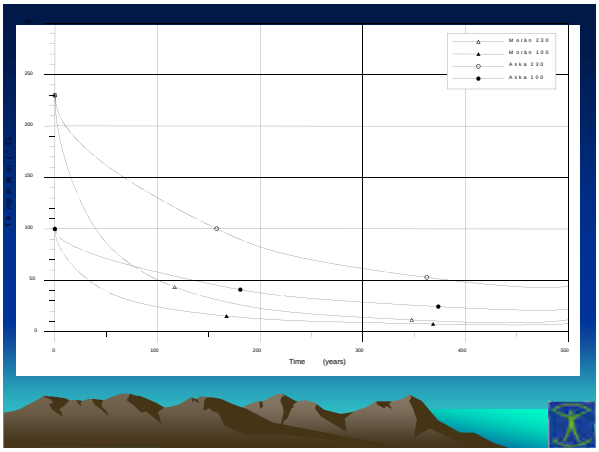












Waste composition

	Alum shale	Ash
Calcite ($CaCO_3$) (%)	1.6	2.1
Pyrite (FeS_2) (%)	12	-
Hematite (Fe_2O_3) (%)	-	10
Illite (%)	31	42
K-feldspars (%)	13	17
Quartz (%)	23	29
Kerogene (%)	18	-

Waste composition (acid leachable)

	Total (mg/kg)		Total (mg/kg)
Ca	16 200	Zn	98.2
V	300	As	121
Cr	24.7	Mo	104
Fe	29 400	Cd	6.27
Co	15.7	Tl	9.64
Ni	66.5	Pb	35.8
Cu	84.5	U	67.2

Trace element emissions

		Ni	U	As	V	Cd	Tl	Mo
Leachable now	mg/kg dw	2.7	0.61	1.6	1.0	0.28	0.22	1.6
	tons	76	17	46	29	7.8	6.2	46
Max leachable	mg/kg dw	11	29	15	71	1.8	2.3	28
	tons	310	820	410	2 000	51	63	780

Trace element emissions

kg/year	Ni	U	Cd
Mass flow today	45	7	0.3
Mass flow at cool deposit	1 900	3 300	19
Ratio	42	470	63

Ground waters (examples)

	0402 Acidic	0406 Neutral	0404 Alkaline		0402 Acidic	0406 Neutral	0404 Alkaline
pH	3.20	7.70	12.2	Cu (µg/l)	6.50	1.00	1.00
El cond. (µS/cm)	5 510	3 050	6 690	Mo (µg/l)	1.00	935	142
SO_4 (mg/l)	4 260	2 100	656	Ni (µg/l)	1 190	6.95	8.12
Ca (mg/l)	484	511	698	Pb (µg/l)	1.50	0.20	0.30
Fe (mg/l)	328	0.01	0.00	Tl (µg/l)	0.13	0.31	0.03
As (µg/l)	2.00	113	2.09	U (µg/l)	129	1 760	0.50
Cd (µg/l)	4.02	0.31	0.24	V (µg/l)	1.47	12.3	0.77
				Zn (µg/l)	2 170	2.26	1.00

Future scenario

- Increased runoff due to lowered temperatures (from 0.5 L/s to 5 L/s)
- Increased leaching of trace elements due to changed chemical conditions (lowered pH and more oxidizing conditions)
- Increased transport of trace elements due to both greater volumes of lechates and higher trace elements concentrations (several orders of magnitude higher massflow)

Acknowledgement

- The Geological Survey of Sweden (SGU)
- SWECO Environment AB
- Kumla municipality