Impacts and Stability of Iron in Icelandic Peat Areas

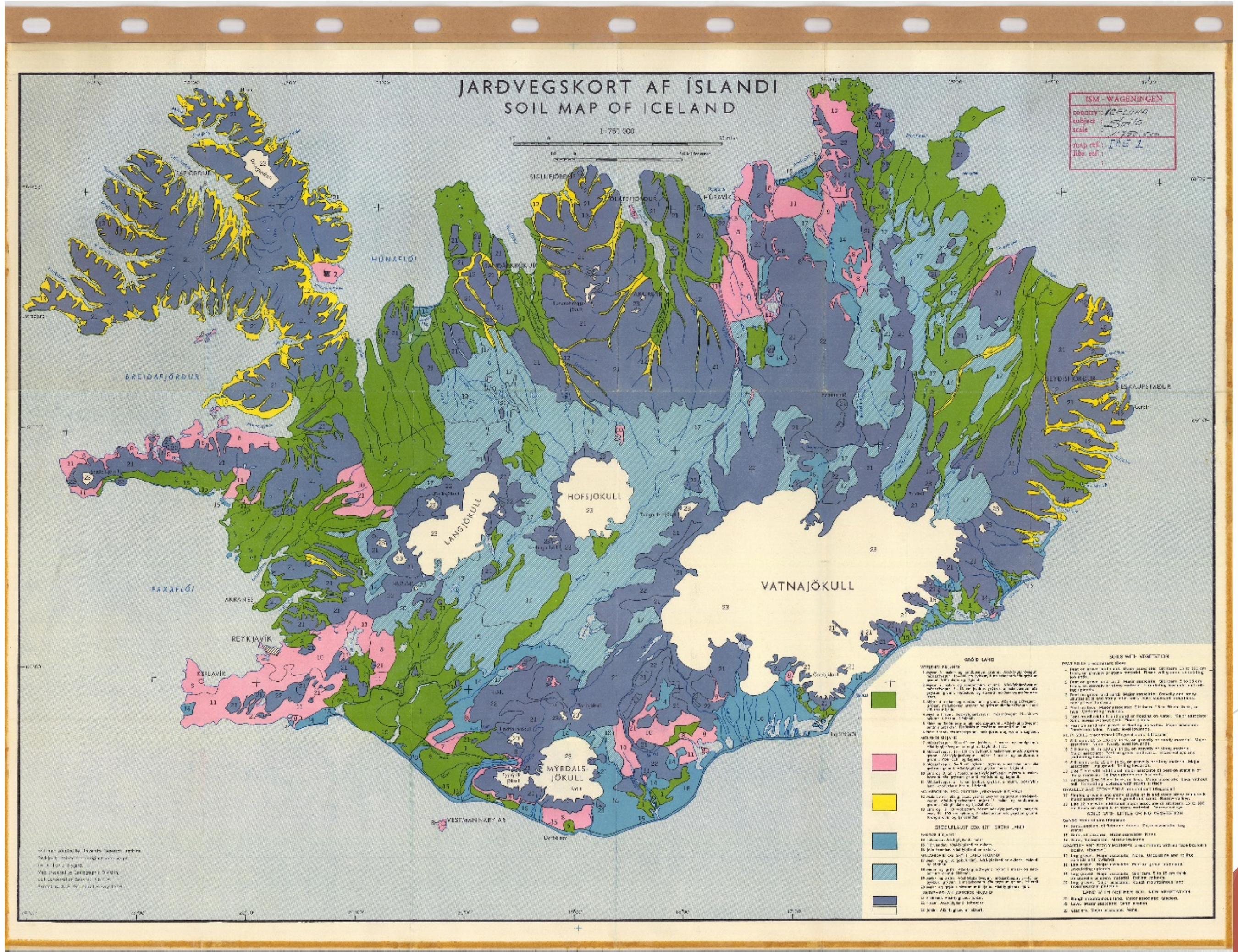
Presented by Kristen Almen

NDSU Geochemistry 2018

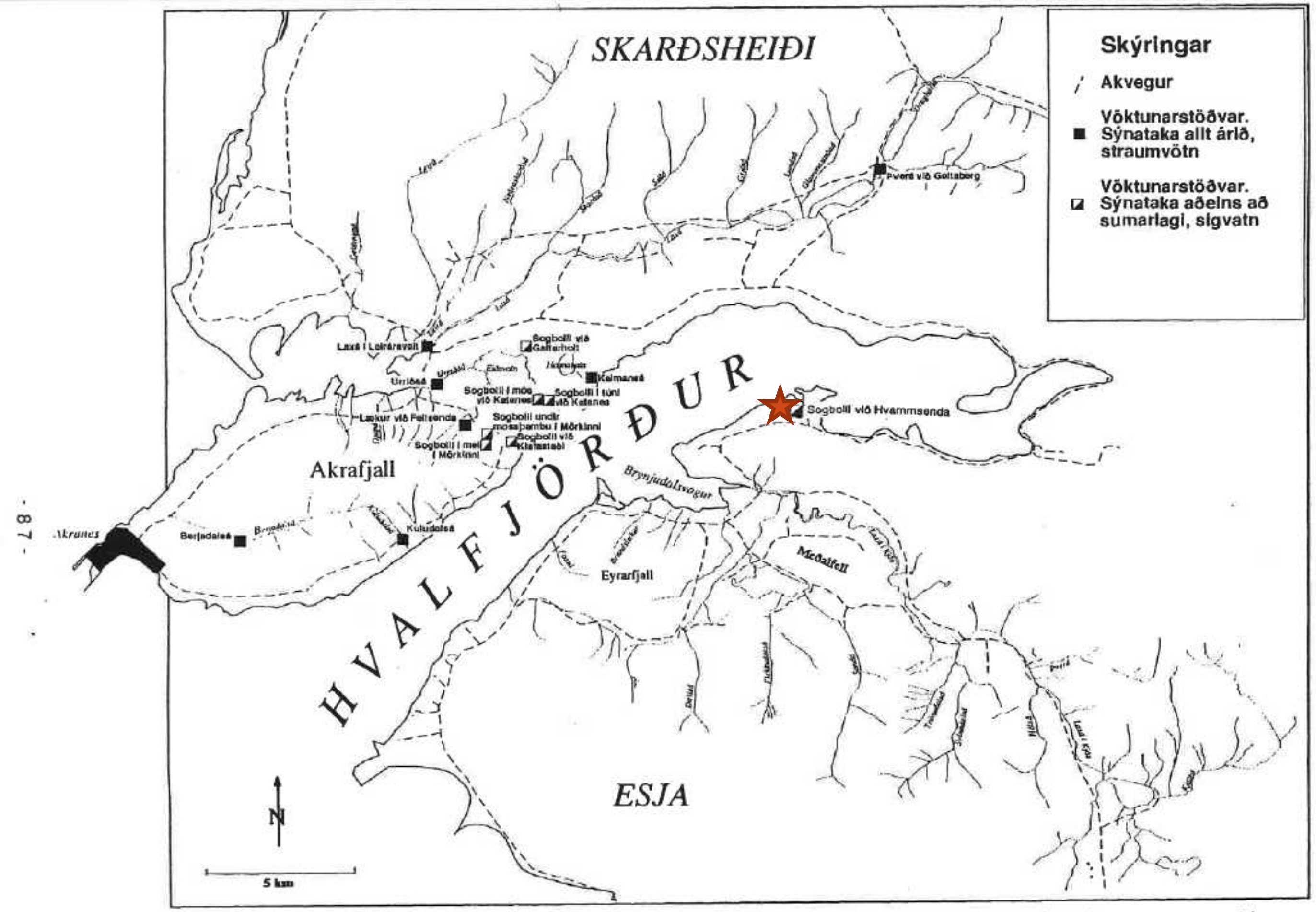
Background

- Peat is mainly made up of partially decomposed plant material
- Peat makes up a large portion of soil in Iceland and has an important impact on pollution
- Basaltic glass often deposits heavy metals within peat areas
- Iron in the form of ferrihydrite is able to adsorb these metals
  - Nearby rivers and streams have safe drinking water supplies

Peat in Iceland



Sample Location



2. mynd. Sýnatökustaðir af straum- og sigvatni í nágrenni iðjuveranna á Grundartanga og í Kjós þar sem voru tekin reglulega (vöktunarstaðir).

Why Chose This Topic?

- Wetlands filter water, but how?
- What would happen to surrounding bodies of water without wetlands?
- How would the deposition of volcanic ash impact the composition of peat water?

Previous Work Done

- Linke and Gislason studied the phases of iron present at various pH, salinity, and oxygen gradients from a water sample in Hvammsendi, Iceland
- They modeled naturally occurring iron phases rather than the most stable
- They also mixed the peat water sample with seawater to model sea level rise due to climate change

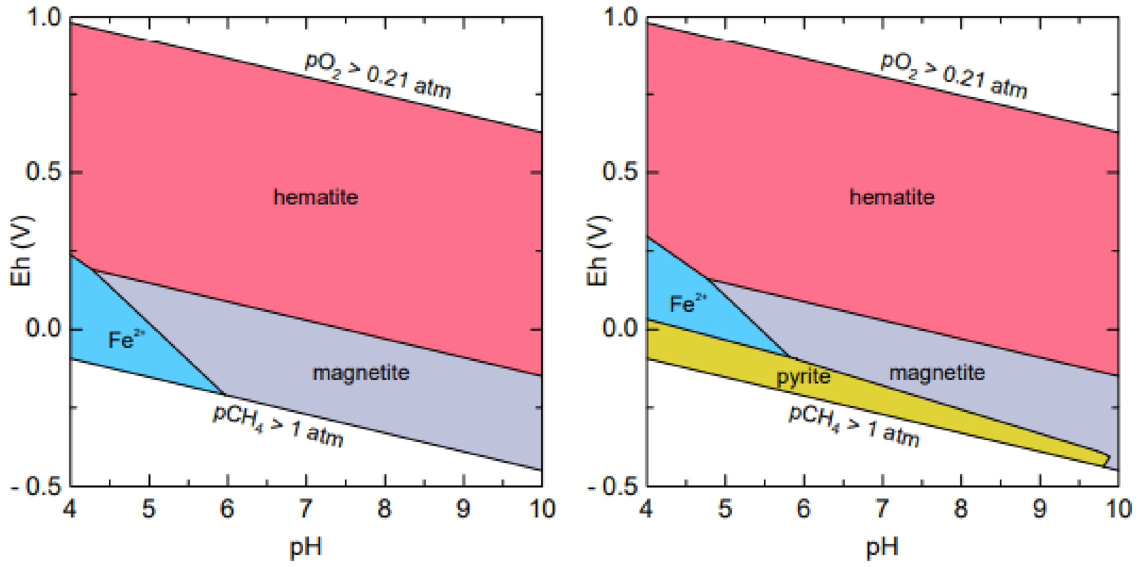


Fig. 1: Predominance diagram of the most stable iron phases in natural soil waters with 500 µmol/l Fe (left) and 50 µmol/l Fe (right), calculated with PHREEQC assuming equilibrium state (see text).

Results of Previous Work Done

- Ferrihydrite was found to be the dominant form of iron in environmental conditions where peat is found
- The heavy metals adsorbed by ferrihydrite were released as a result of mixing with seawater

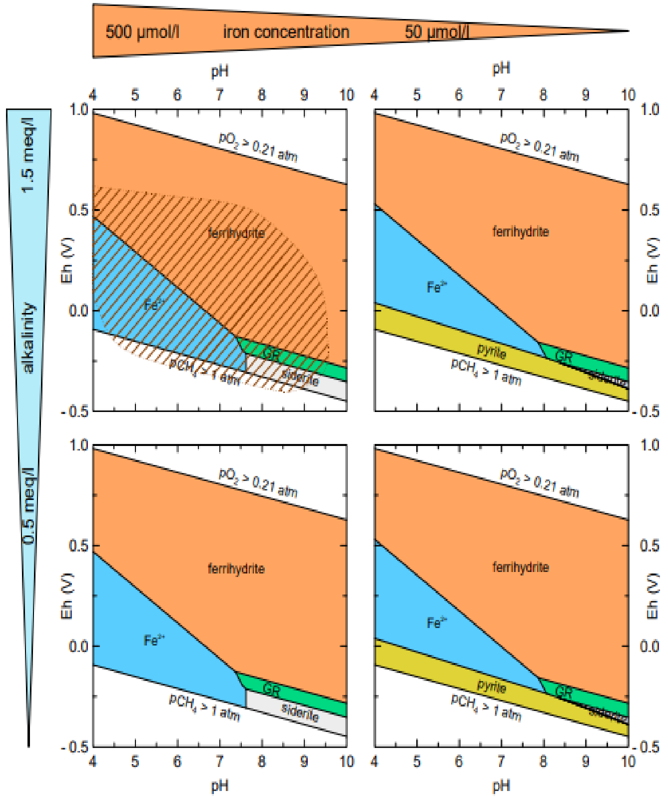
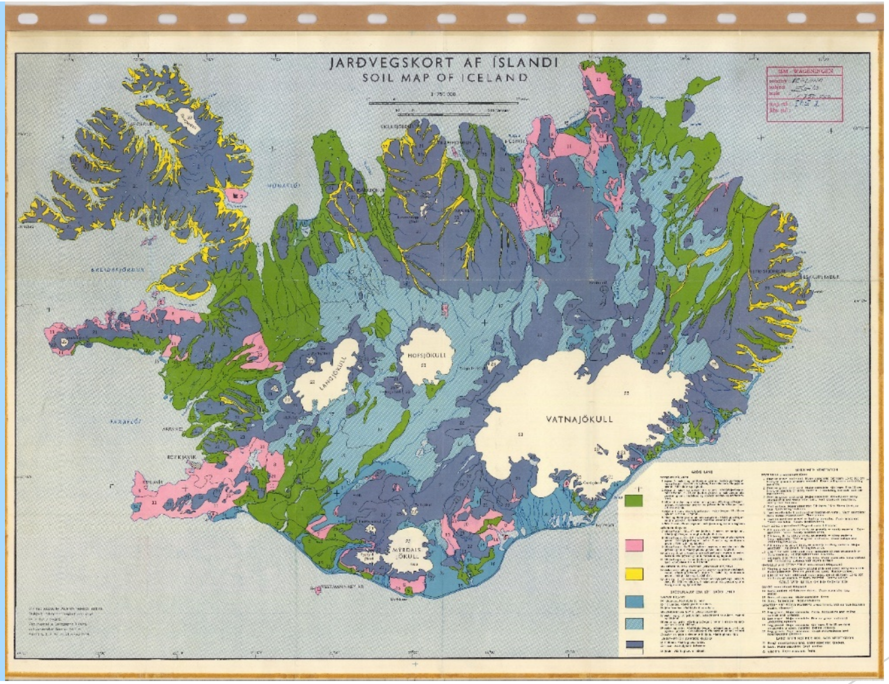


Fig. 2. Predominance diagrams for metastable iron phases under varying iron and carbonate concentrations, shaded field in the upper left diagram represents common pH Eh conditions in peat bogs (data from Baas Becking et al. [14]).

New Work Done

- What would happen in response to a volcanic eruption?
- How would the water sample change?
- Volcanic ash from the Grímsvötn volcano was mixed with the peat water sample and a sample from the Grímsá River
- I expected the peat sample to buffer the addition of heavy metals

Location of Volcanoes and Peat in Iceland



Differences Between the River and Peat Water Samples

- The pH of the peat sample was 6.39 while the pH of the river sample was 8.08
- The peat sample had sulfate, iron, lead, and cadmium present while the river sample did not
- Peat sample was taken from an anoxic environment

PHREEQC Inputs

Peat water

```
SOLUTION 1
temp        25
pH          6.39
pe          4
redox       pe
units       umol/l
density     1
Ca          350
Cl          810
F           2.82
Mg          320
Na          900
Si          480
S(6)        240
Alkalinity 1.17 meq/L
N(-3)       0.000746
N(3)        8.6e-005
N(5)        0.000145
Al          0.634
Fe          138
Mn          7.01
Ba          0.0205
Cd          9e-005
Cu          0.00478
Pb          0.00012
Sr          0.188
Zn          0.0421
water     1 # kg
```

Volcanic ash

```
SOLUTION 2
temp        25
pH          7
pe          4
redox       pe
units       umol/L
density     1
Cd          1.3e-006
Cu          0.00017
F           0.72
Mn          0.0071
Pb          1.5e-006
Zn          0.0011
water     1 # kg
MIX 2 100 to 1 mix with ash
```

River water

```
SOLUTION 1 Grimsa River
temp        25
pH          8.08
pe          4
redox       pe
units       umol/L
density     1
Alkalinity 0.405
Na          324
Mg          64.6
Al          0.313
Si          170
K           9.84
Ca          86.8
Cl          282
water     1 # kg
```

PHREEQC Outputs

Peat water and ash

Phase	SI**	log IAP	log K
Fe(OH)3(a) Fe(OH)3	1.23	6.13	4.89
Gibbsite Al(OH)3	1.65	9.76	8.11
Goethite FeOOH	7.13	6.13	-1.00
Siderite FeCO3	-0.04	-10.93	-10.89

River water and ash

Phase	SI**	log IAP	log K
Diaspore AlOOH	1.18	8.06	6.88
Gibbsite Al(OH)3	-0.05	8.06	8.11
Kmica KAl3Si3O10(OH)2	3.19	15.89	12.70
Leonhardite Ca2Al4Si8O24:7H2O	5.16	-64.60	-69.76

PHREEQC Outputs

Peat sample lead and cadmium species present

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
Pb	1.188e-10					
PbCO3	5.632e-11	5.637e-11	-10.249	-10.249	0.000	(0)
Pb+2	3.398e-11	2.636e-11	-10.469	-10.579	-0.110	-15.46
Cd	8.914e-11					
Cd+2	7.919e-11	6.144e-11	-10.101	-10.212	-0.110	-18.66
CdCl+	4.704e-12	4.415e-12	-11.328	-11.355	-0.028	5.87
CdSO4	2.988e-12	2.990e-12	-11.525	-11.524	0.000	78.05

River sample lead and cadmium species present

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
Pb	1.485e-14					
PbCO3	1.333e-14	1.333e-14	-13.875	-13.875	0.000	(0)
PbOH+	8.737e-16	8.461e-16	-15.059	-15.073	-0.014	(0)
Cd	1.287e-14					
Cd+2	1.230e-14	1.082e-14	-13.910	-13.966	-0.056	(0)
CdCl+	2.885e-16	2.794e-16	-15.540	-15.554	-0.014	(0)
CdHCO3+	1.332e-16	1.290e-16	-15.875	-15.889	-0.014	(0)

Results

- The phases present varied in type and saturation level
- Lead and cadmium levels decreased in the peat sample
- Iron was not present in the river sample
    - Ferrihydrite was not present to adsorb heavy metals

Conclusions

- Peat water is able to act as a buffer against chemical additions
- Without peat areas, rivers and streams in Iceland may be contaminated by volcanic ash
- The decrease in the use of peat for horticulture and energy should continue in hopes of protecting water quality

References

- Linke, T., & Gislason, S. R. (2018). Stability of iron minerals in Icelandic peat areas and transport of heavy metals and nutrients across oxidation and salinity gradients–a modelling approach. *Energy Procedia*, *146*, 30-37.
- Olsson, J., Stipp, S. L. S., Dalby, K. N., & Gislason, S. R. (2013). Rapid release of metal salts and nutrients from the 2011 Grímsvötn, Iceland volcanic ash. *Geochimica et Cosmochimica Acta*, *123*, 134-149.
- von Strandmann, P. A. P., Burton, K. W., James, R. H., van Calsteren, P., Gislason, S. R., & Sigfússon, B. (2008). The influence of weathering processes on riverine magnesium isotopes in a basaltic terrain. *Earth and Planetary Science Letters*, *276*(1-2), 187-197.

Any Questions?