



# Karakterisering av syredannende bergarter

Forkostseminar NG 11.05.16

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# NGIs arbeid med syredannende bergarter

- Karakterisering og identifisering av syredannende bergarter, NGI-rapport 20120842-01-R  
<http://www.miljodirektoratet.no/no/Publikasjoner/2015/Juni/Identifisering-og-karakterisering-av-syredannende-bergarter/>
- Deponering av syredannende bergarter. NGI-rapport 20140693-01-R  
<http://www.miljodirektoratet.no/no/Publikasjoner/2015/Juni/Deponering-av-syredannende-bergarter-Grunnlag-for-veileder/>
- Grunnlagsdokumenter for Miljødirektoratets utarbeidelse av to nye veiledere

# Hva sier loven om syredannende bergarter?

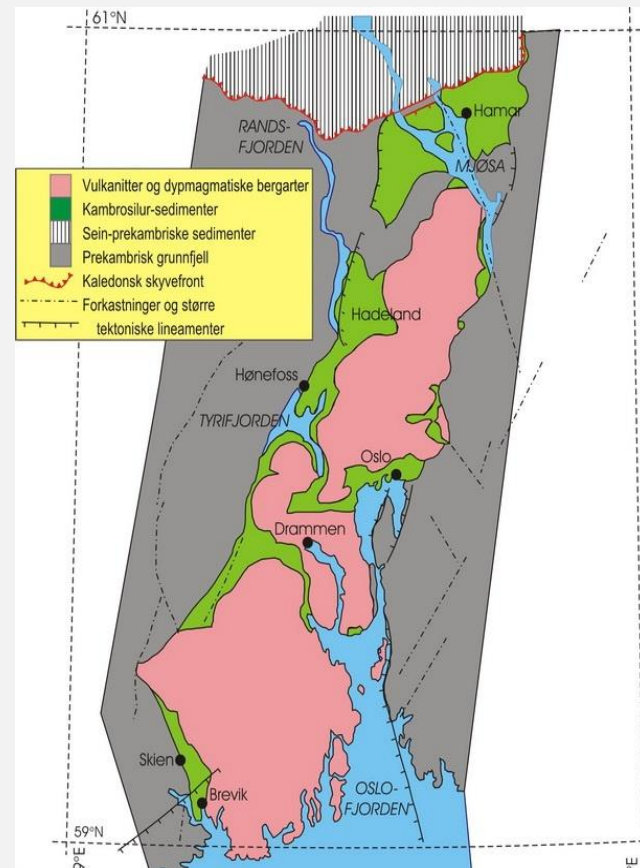
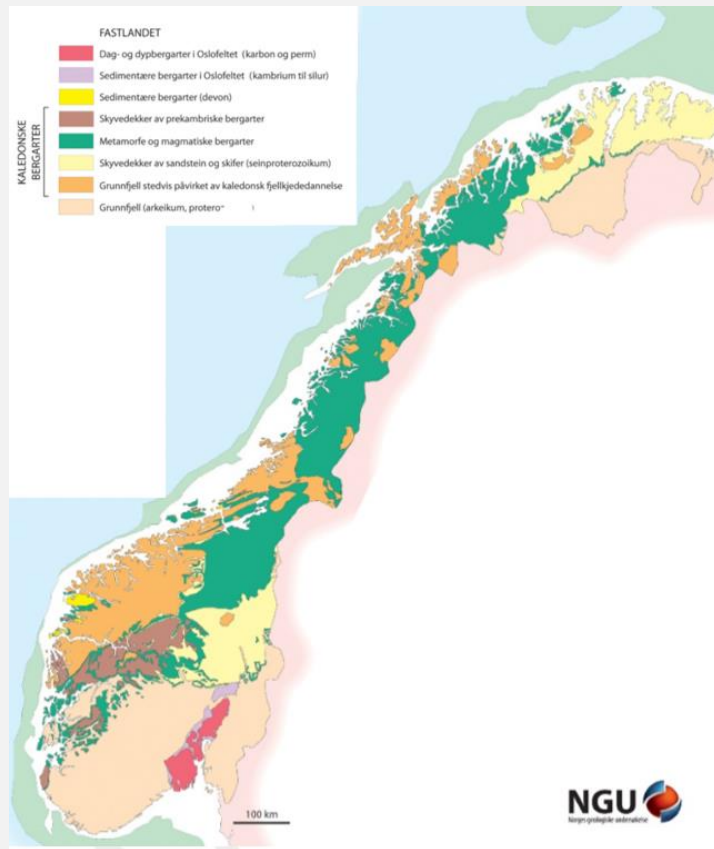
Forurensningsforskriften § 2-3a:

*«grunn som danner syre eller andre stoffer som kan medføre forurensning i kontakt med vann og/eller luft, regnes som forurenset grunn dersom ikke annet blir dokumentert»*

# Miljøpåvirkning fra syredannende bergarter

- ↗ ***Syredannelse***
- ↗ ***Avrenning av tungmetaller***
- ↗ *Radioaktivitet*
- ↗ *Radongass*

# Hvor i landet finner vi syredannende bergarter?



# Kambro-silur-lagrekken

Etasje	Oslo-Asker Formasjon	Hadeland Formasjon	Hamar Formasjon	Mektighet (m)	Alder	
4d					Sen ordovicisk	471-443 mill. år
4cα	Venstøp			7-10		
4bδ	Solvang			12-20		
4bγ	Nakkholmen			13-20		
4bβ	Frognerkilen			10-20		
4bα	Arnestad		Arnestad	22-40		
4aβ	Vollen		Vollen	> 45		
4aα	Elnes	Elnes	Elnes/Bjørge	60-80	Midt ordovicisk	
3c	Huk3	Huk3	Huk 1/2	2-5 m	Tidlig Ordovicisk	488-471 mill. år
3cβ	Huk2	Huk2		2-5 m		
3cα	Huk1	Huk1		2-5 m		
3bβ	Galgeberg	Galgeberg	Galgeberg	5-10 m		
3bα	Hagaberg	Hagaberg	Hagaberg	3-8 m		
3aγ	Bjørkås-holmen	Bjørkås-holmen	Bjørkås-holmen	1-2 m		
3aα, 3aβ	Alunskifer-3	Alunskifer-3	Alunskifer-3	~80 m men stor variasjon		
2a-2e	Alunskifer-2	Alunskifer-2	Alunskifer-2		Sen kambrium	501-488
1	Alunskifer-1	Alunskifer-1	Alunskifer-1		Midt kambrium	513-501
	-	-	Biri Brøttum	1500 m	Eokambrium	<542



# Hvordan ser en svartskifer ut?



Galgebergskifer  
Etasje 3b $\beta$



Alunskifer  
Etasje 2  
og 3a



# Karakterisering av syredannende bergarter

- ↗ Prøvetaking
  - ↗ Representative prøver
- ↗ Geokjemiske analyser
  - ↗ Spormetaller, hovedelementer, uran, thorium, TIC og TOC



# Karakterisering av syredannende bergarter

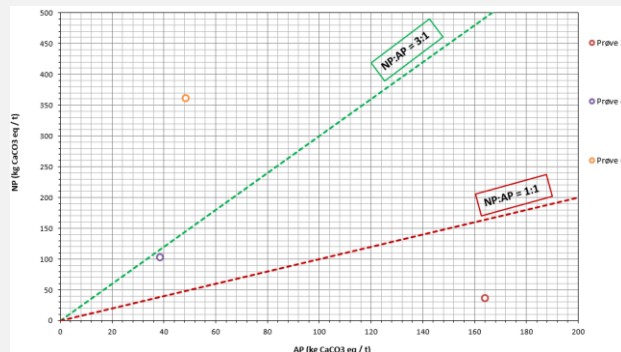
- ↗ Eksempel på tolkning av analyseresultater
  - ↗ Hentet fra vedlegg til kommende veileder
- ↗ 2 eksempelprøver (Prøve 2 og 4)
- ↗ Del 1
  - ↗ Grunnleggende tolkning (konservativ)
- ↗ Del 2
  - ↗ Avansert tolkning

# Tolkning av analyseresultater – Del 1

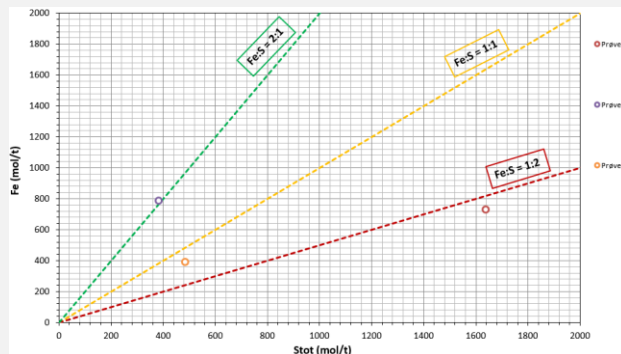
## Analyseresultater

Parameter	Prøve 2	Prøve 4
As (mg/kg)	73,4	13,1
Ba (mg/kg)	791	689
Cd (mg/kg)	3,80	0,11
Co (mg/kg)	27,8	22,2
Cr (mg/kg)	69,5	463
Cu (mg/kg)	103	53,8
Mo (mg/kg)	144,0	1,9
Nb (mg/kg)	11,5	11,8
Ni (mg/kg)	203	198
Pb (mg/kg)	36,1	13,4
S (mg/kg)	52500	12300
Sc (mg/kg)	11,9	16,9
Sn (mg/kg)	2,69	2,46
Sr (mg/kg)	150	79,4
Th (mg/kg)	11,3	9,34
U (mg/kg)	86,2	3,85
V (mg/kg)	619	124
Y (mg/kg)	33,4	30,4
Zn (mg/kg)	146	103
Zr (mg/kg)	120	198
Al <sub>2</sub> O <sub>3</sub> (%)	10,7	15,5
CaO (%)	2,66	2,42
Fe <sub>2</sub> O <sub>3</sub> (%)	5,82	6,28
K <sub>2</sub> O (%)	3,66	4,28
MgO (%)	0,94	3,58
MnO (%)	0,0259	0,0355
Na <sub>2</sub> O (%)	0,523	0,769
P <sub>2</sub> O <sub>5</sub> (%)	0,174	0,0873
SiO <sub>2</sub>	38,6	53,9
TiO <sub>2</sub> (%)	0,727	0,673
TOC (%)	9,41	0,612
TIC (%)	0,444	1,24

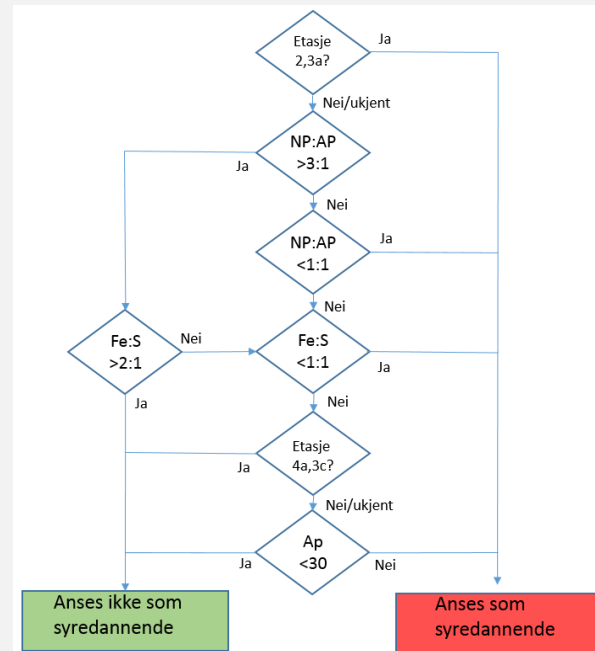
## NP:AP



## Fe:S

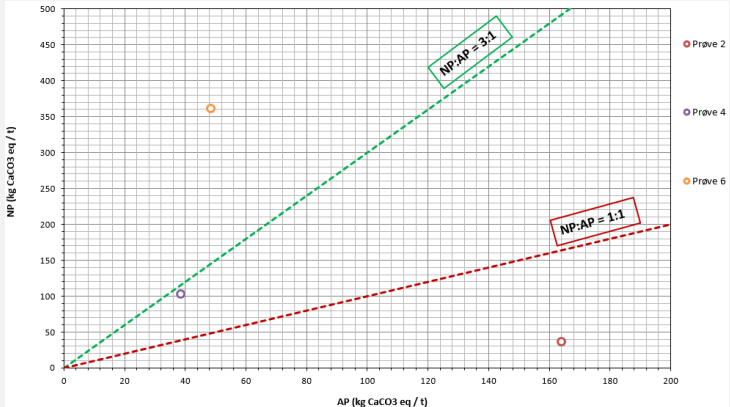


## Flytskjema

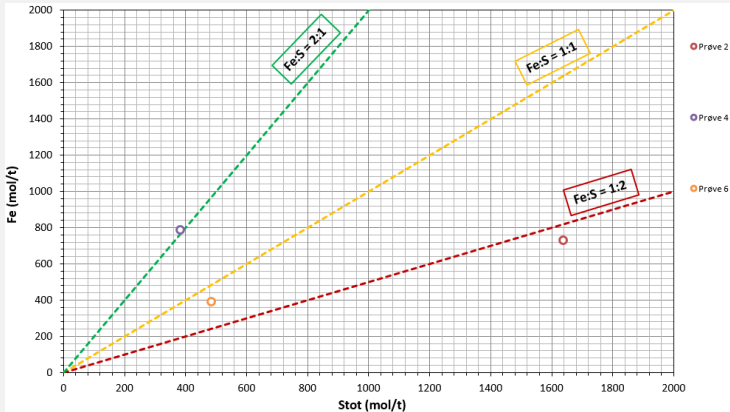


# Potensial for syredannelse og jern-svovel forhold

NP:AP



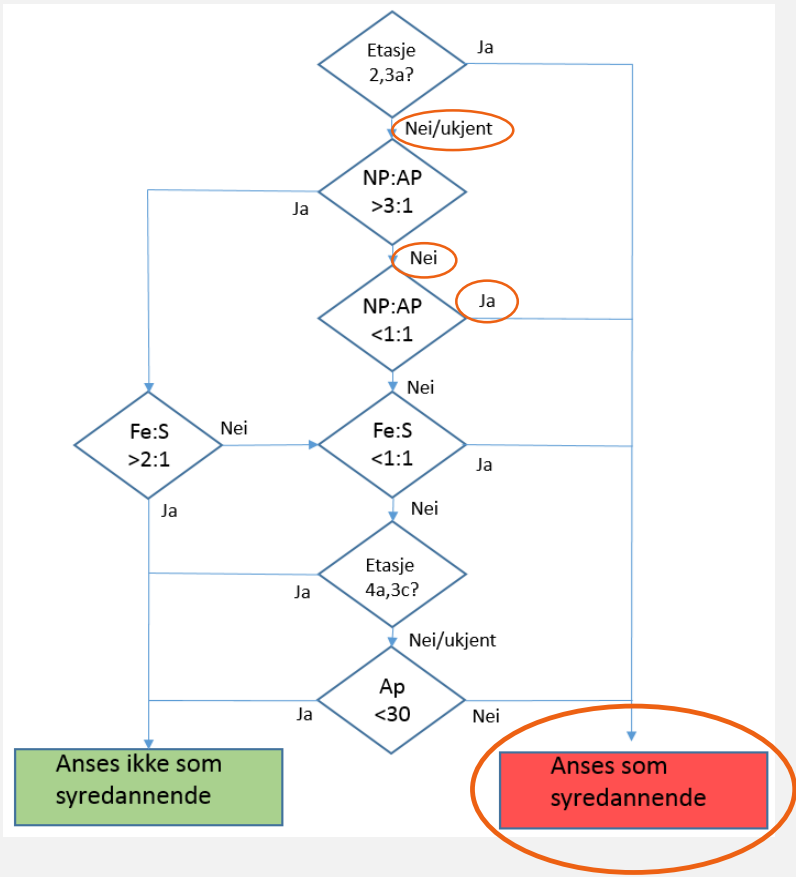
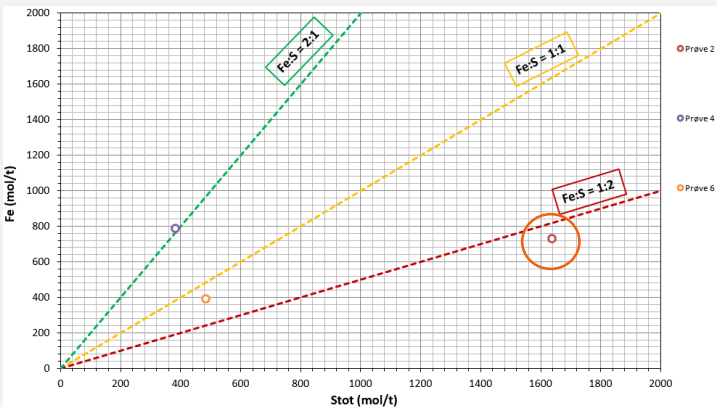
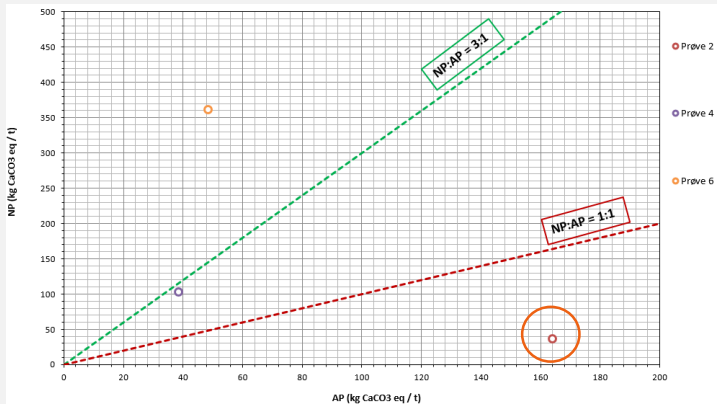
Fe:S



Parameter (%)	Prøve 2
S	5,25
Fe <sub>2</sub> O <sub>3</sub>	5,82
TIC	0,444

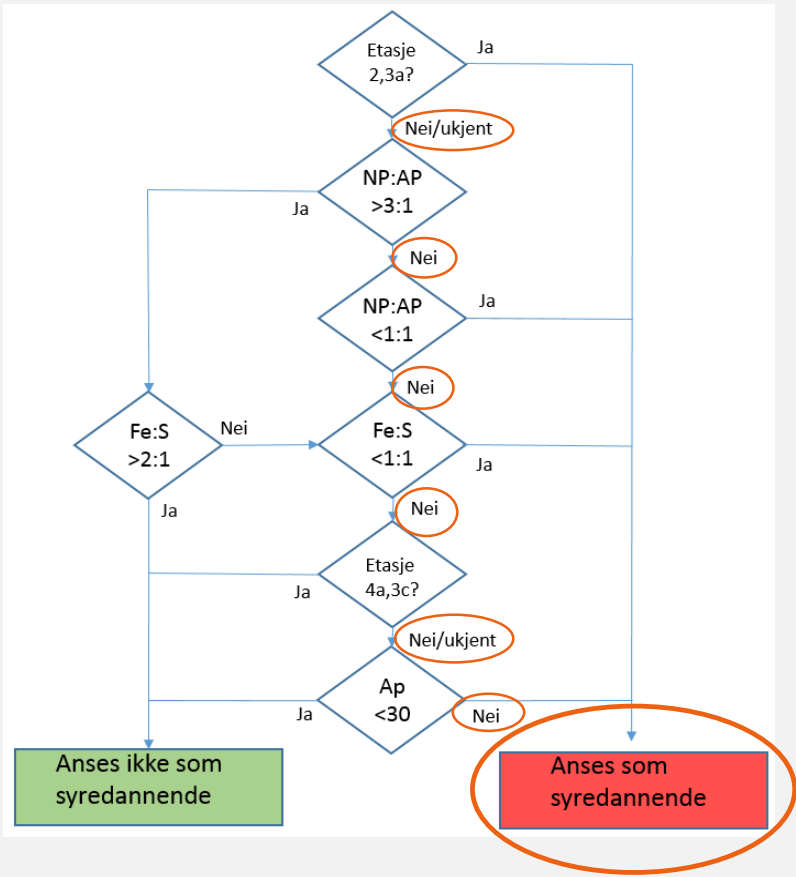
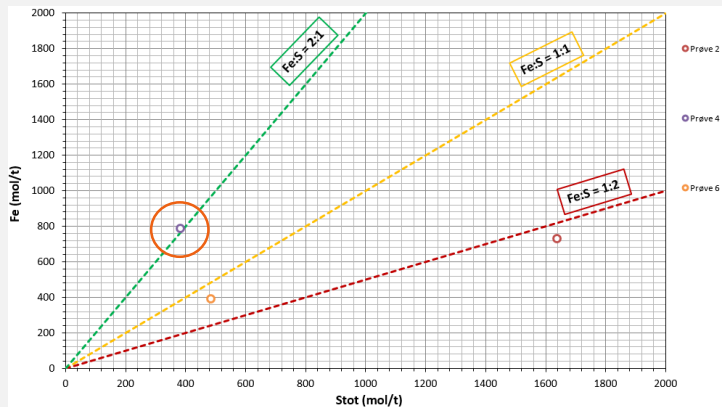
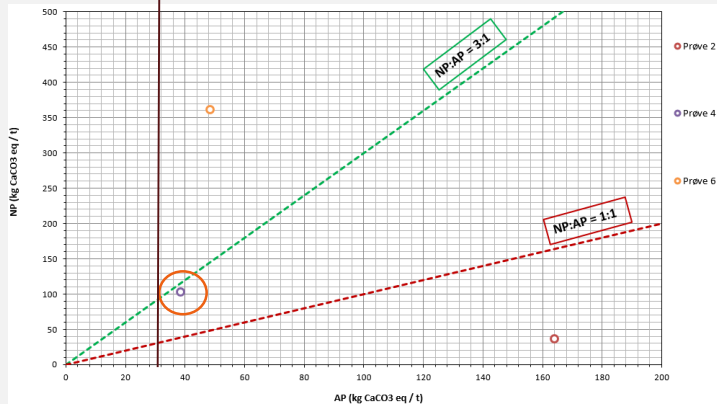
Parameter	Prøve 2
As (mg/kg)	73,4
Ba (mg/kg)	791
Cd (mg/kg)	3,80
Co (mg/kg)	27,8
Cr (mg/kg)	69,5
Cu (mg/kg)	103
Mo (mg/kg)	144,0
Nb (mg/kg)	11,5
Ni (mg/kg)	203
Pb (mg/kg)	36,1
S (mg/kg)	52500
Sc (mg/kg)	11,9
Sn (mg/kg)	2,69
Sr (mg/kg)	150
Th (mg/kg)	11,3
U (mg/kg)	86,2
V (mg/kg)	619
Y (mg/kg)	33,4
Zn (mg/kg)	146
Zr (mg/kg)	120
Al <sub>2</sub> O <sub>3</sub> (%)	10,7
CaO (%)	2,66
Fe <sub>2</sub> O <sub>3</sub> (%)	5,82
K <sub>2</sub> O (%)	3,66
MgO (%)	0,94
MnO (%)	0,0259
Na <sub>2</sub> O (%)	0,523
P <sub>2</sub> O <sub>5</sub> (%)	0,174
SiO <sub>2</sub> (%)	38,6
TiO <sub>2</sub> (%)	0,727
TOC (%)	9,41

# Prøve 2:



# Prøve 4:

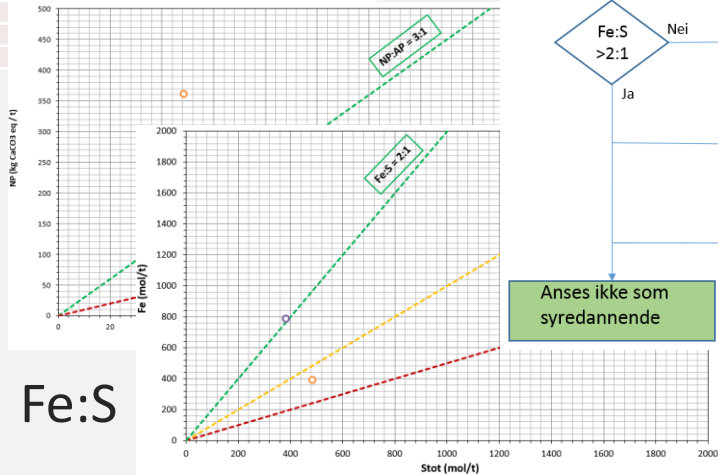
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# Tolkning av analyseresultater – Del 2

## Analyseresultater

Parameter	Prøve 2	Prøve 4	Prøve 6
As (mg/kg)	73,4	13,1	56,2
Ba (mg/kg)	791	689	886
Cd (mg/kg)	3,80	0,11	3,80
Co (mg/kg)	27,8	22,2	9,24
Cr (mg/kg)	69,5	463	63
Cu (mg/kg)	103	53,8	67,2
Mo (mg/kg)	144,0	1,9	120,0
Nb (mg/kg)	11,5	11,8	9,12
Ni (mg/kg)	203	198	95,3
Pb (mg/kg)	36,1	13,4	32,7
S (mg/kg)	52500	12300	15500
Sc (mg/kg)	11,9	16,9	9,35
Sn (mg/kg)	2,69	2,46	2,63
Sr (mg/kg)			
Th (mg/kg)			
U (mg/kg)			

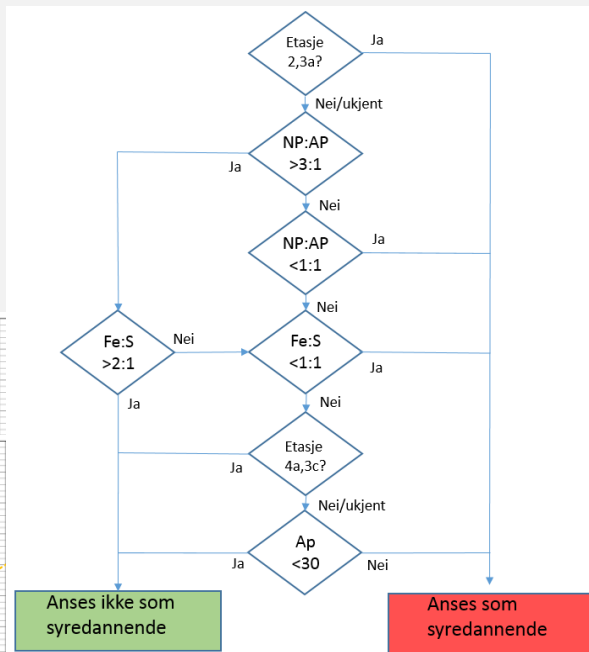


NP:AP

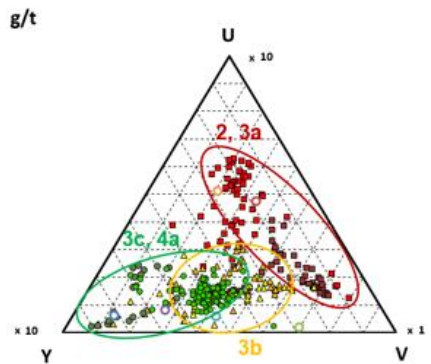
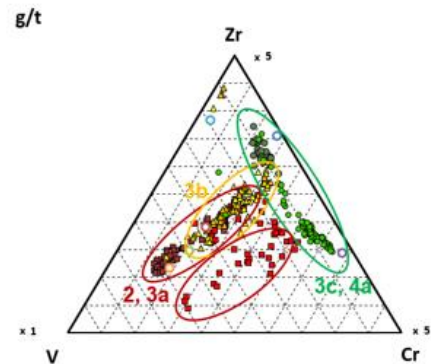
Fe:S

NGI

## Flytskjema

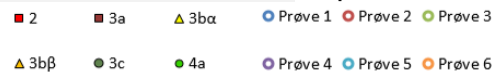
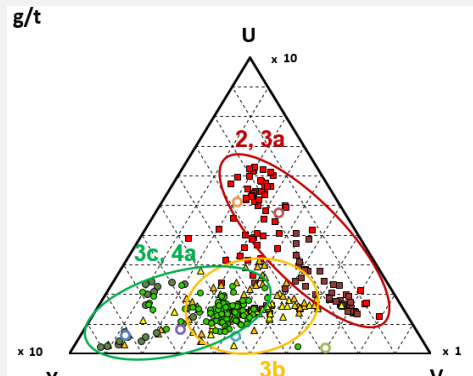
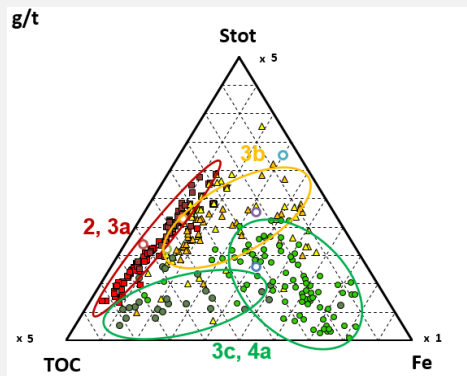
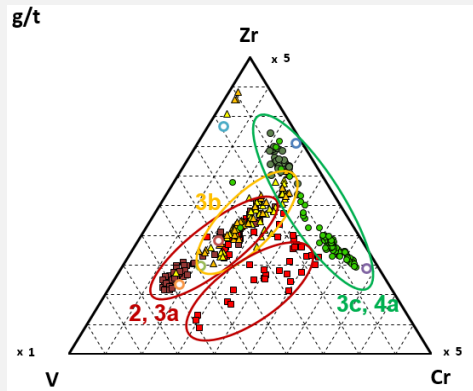
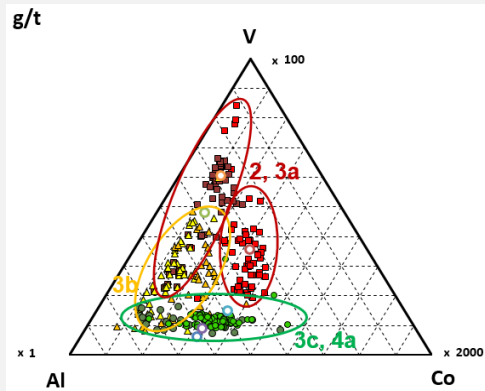


## Trekantdiagrammer



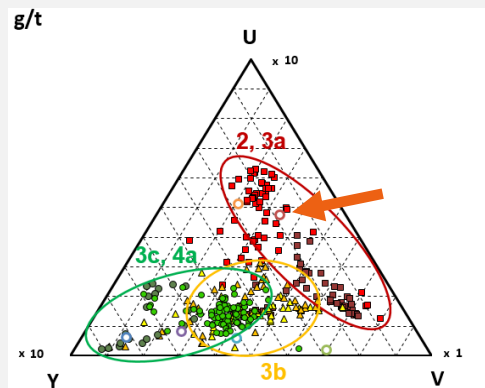
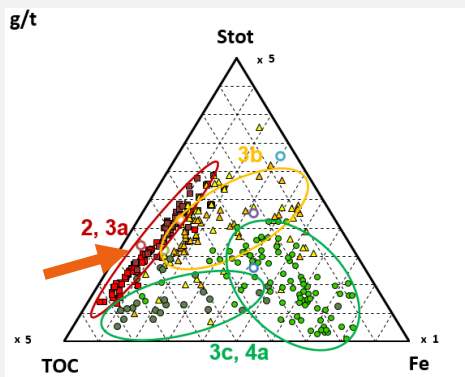
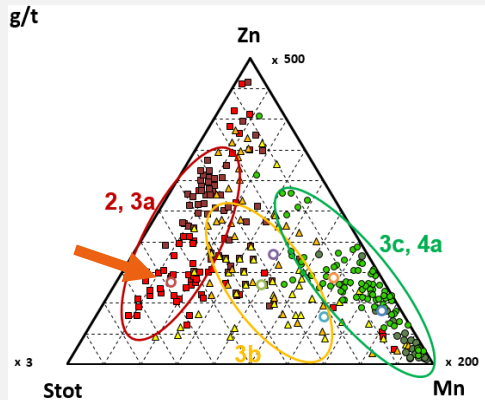
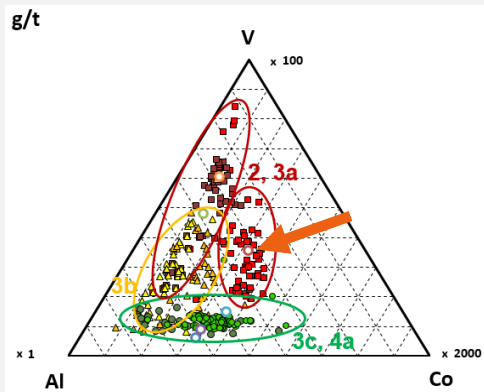


# Trekantdiagrammer



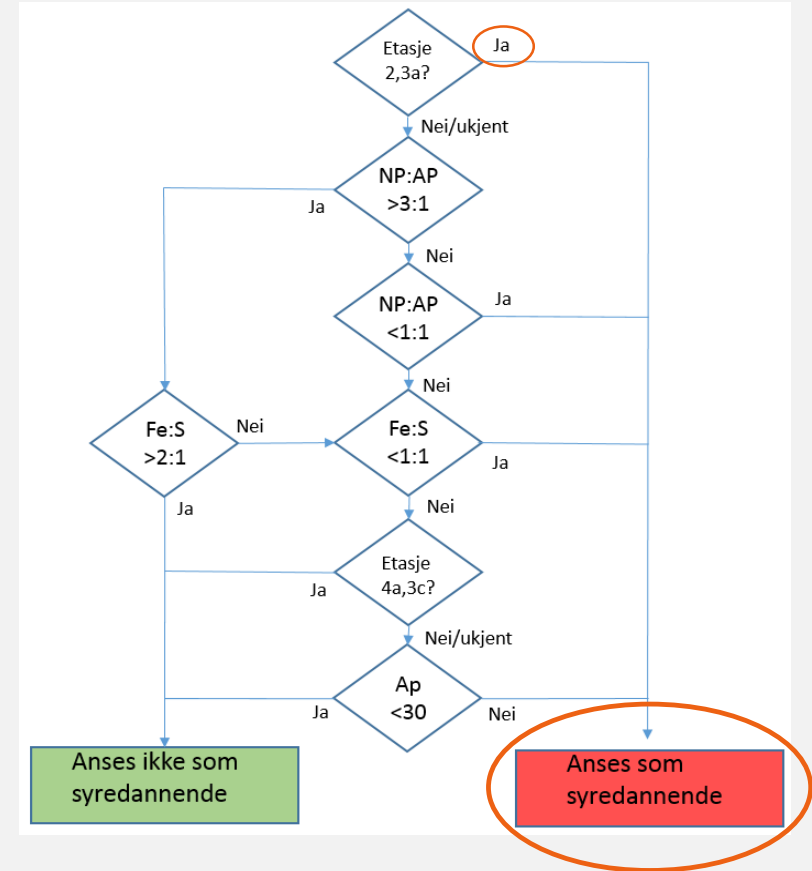
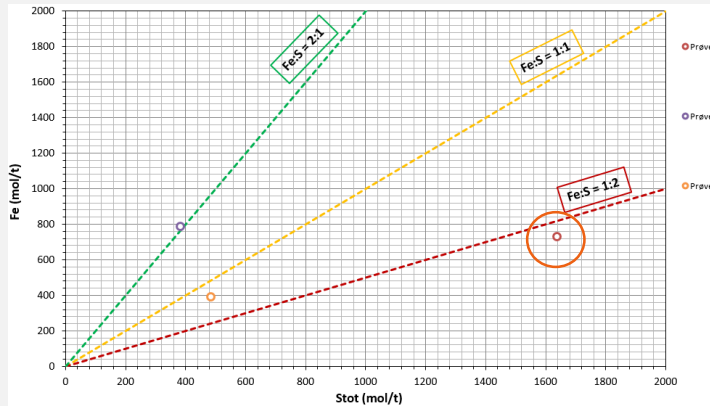
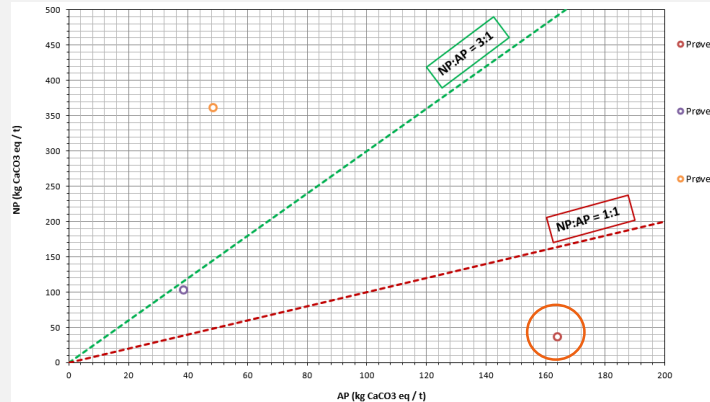
Parameter	Prøve 2
As (mg/kg)	73,4
Ba (mg/kg)	791
Cd (mg/kg)	3,80
Co (mg/kg)	27,8
Cr (mg/kg)	69,5
Cu (mg/kg)	103
Mo (mg/kg)	144,0
Nb (mg/kg)	11,5
Ni (mg/kg)	203
Pb (mg/kg)	36,1
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U (mg/kg)	86,2
V (mg/kg)	619
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Zr (mg/kg)	120
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CaO (%)	2,66
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K <sub>2</sub> O (%)	3,66
MgO (%)	0,94
MnO (%)	0,0259
Na <sub>2</sub> O (%)	0,523
P <sub>2</sub> O <sub>5</sub> (%)	0,174
SiO <sub>2</sub> (%)	38,6
TiO <sub>2</sub> (%)	0,727
TOC (%)	9,41
TIC (%)	0,444

# Prøve 2:

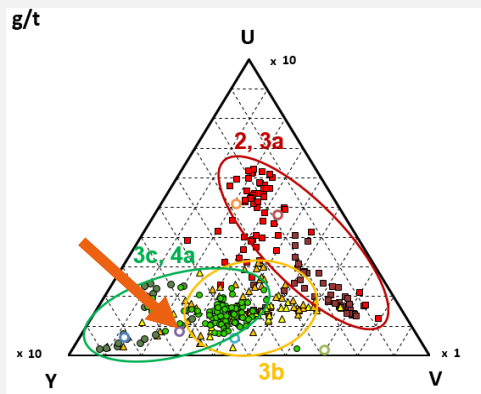
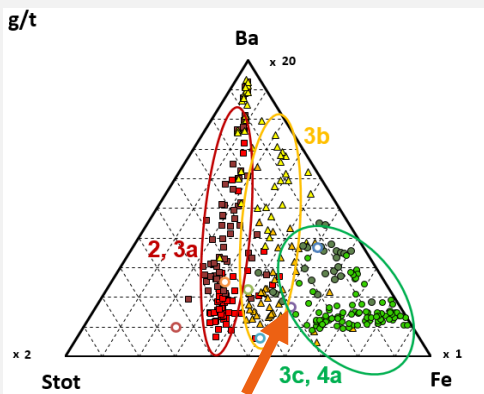
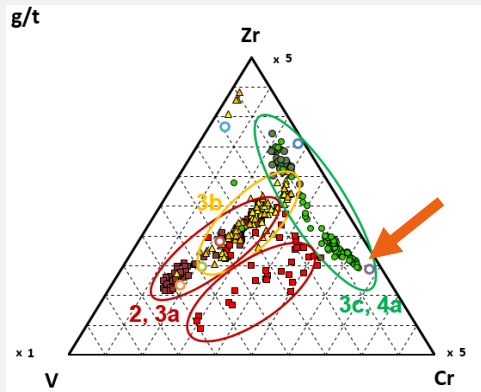
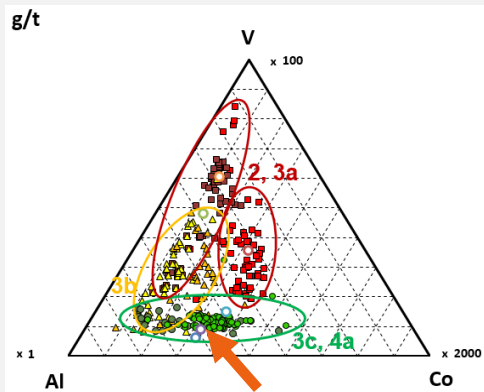


Etasje 2 - alunskifer

# Prøve 2: (etasje 2)



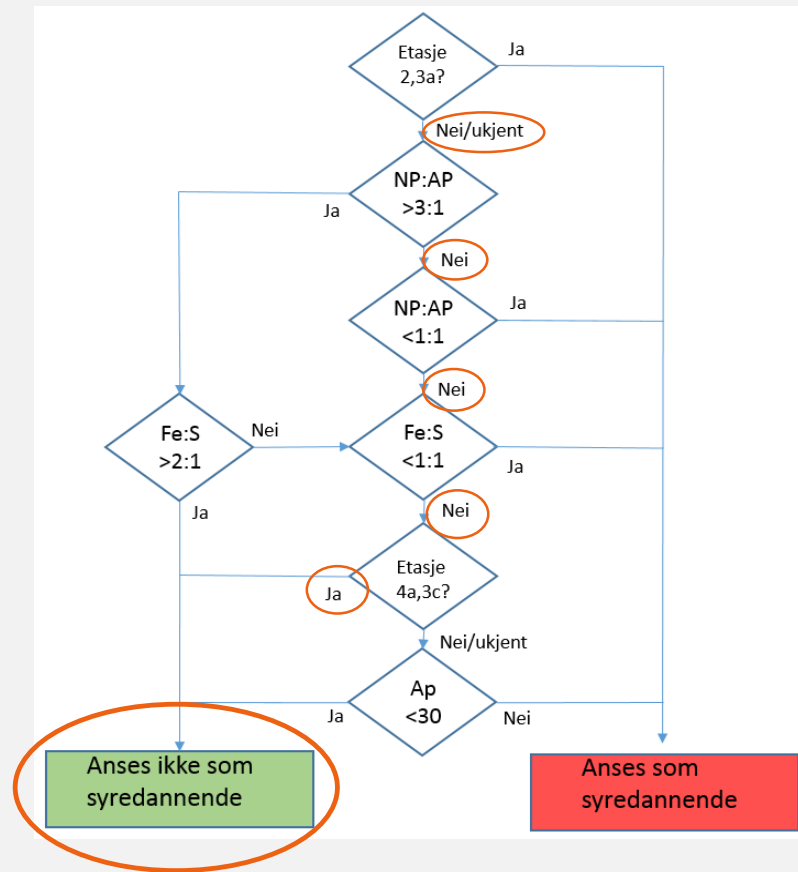
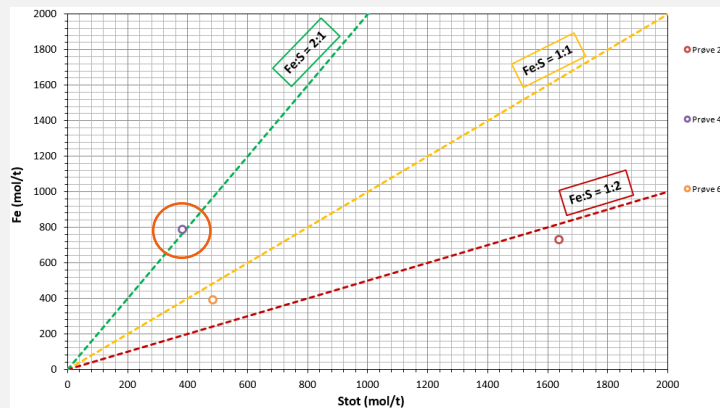
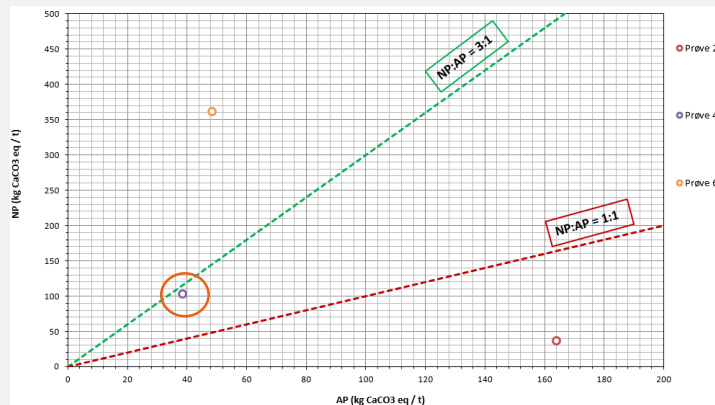
# Prøve 4:



Etasje 4a - Elnesskifer

- |       |      |       |           |           |           |
|-------|------|-------|-----------|-----------|-----------|
| ■ 2   | ■ 3a | ▲ 3bα | ● Prøve 1 | ● Prøve 2 | ● Prøve 3 |
| ▲ 3bβ | ● 3c | ● 4a  | ● Prøve 4 | ● Prøve 5 | ● Prøve 6 |

# Prøve 4: (etasje 4a)





Takk for  
oppmerksomheten!





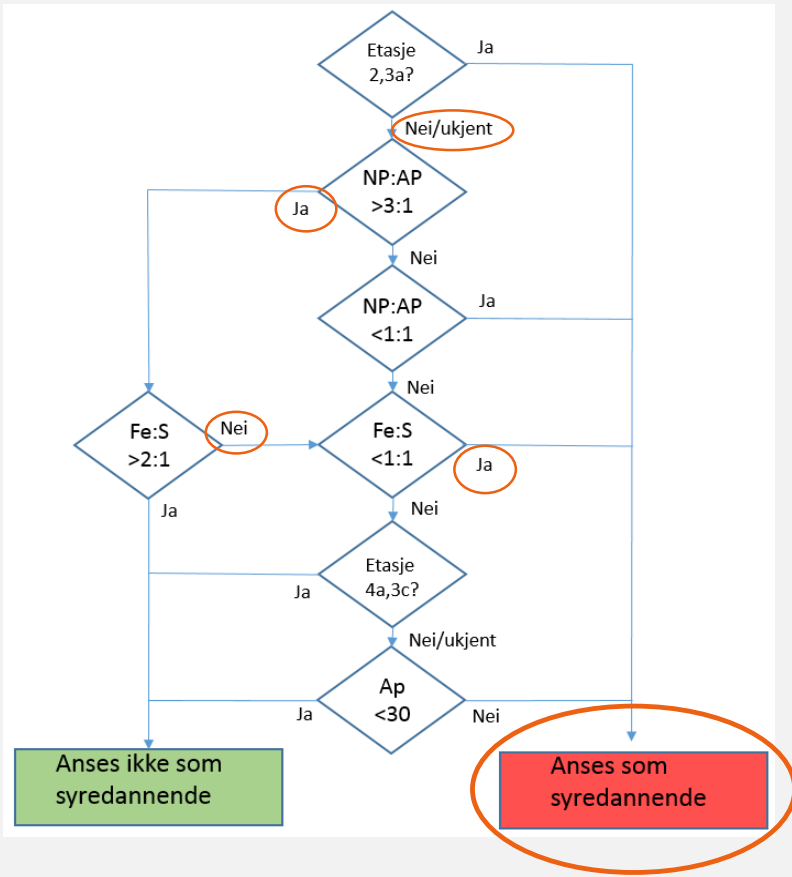
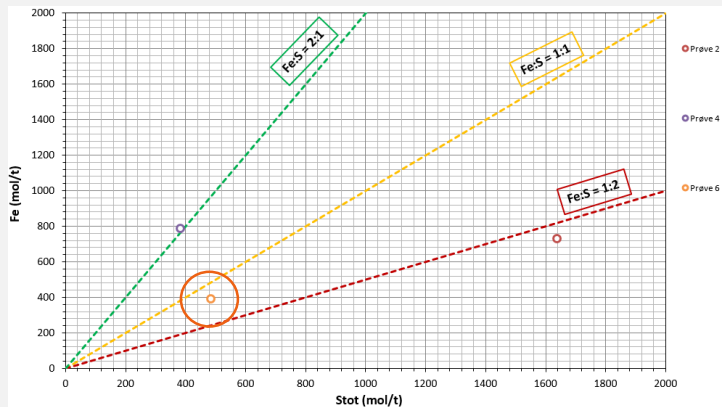
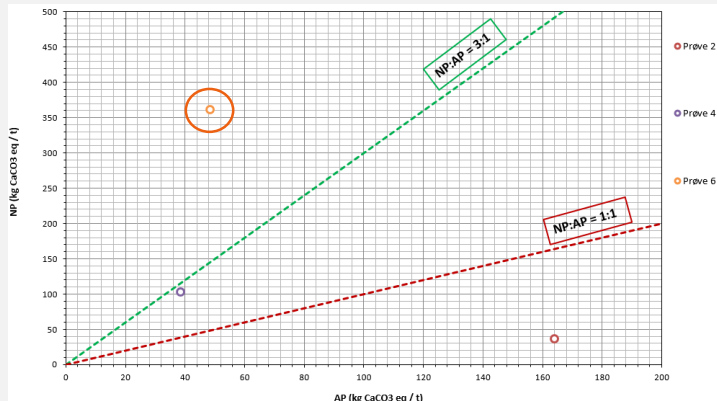
@infoNGI

NORGES GEOTEKNISKE INSTITUTT  
NGI.NO

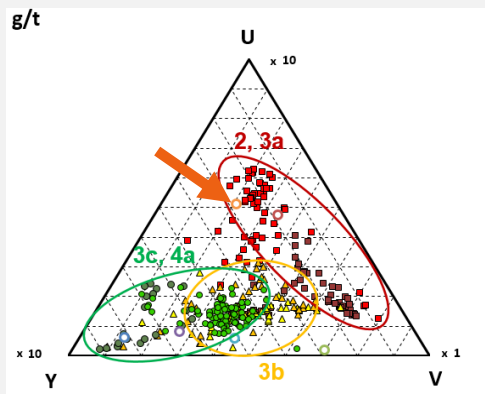
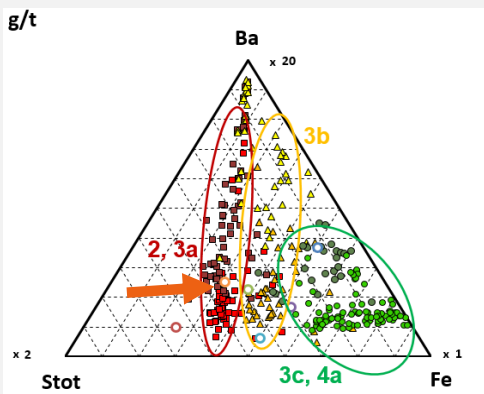
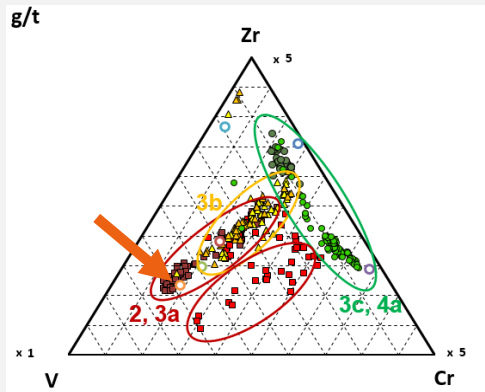
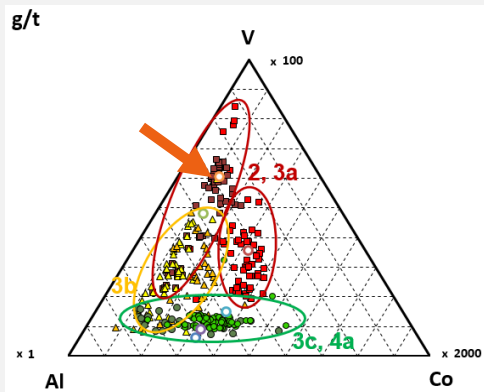


Ekstra eksempel

# Prøve 6:

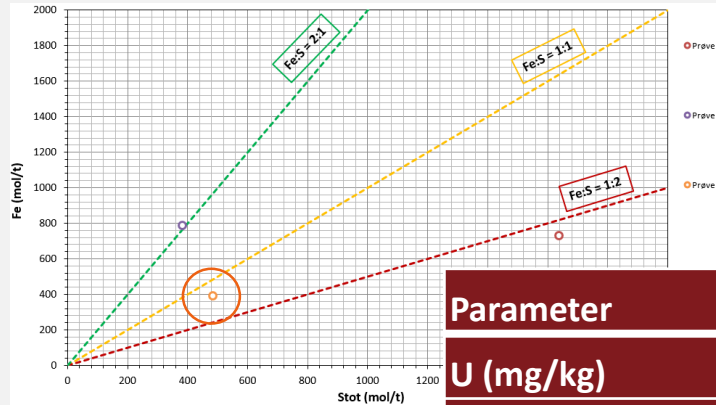
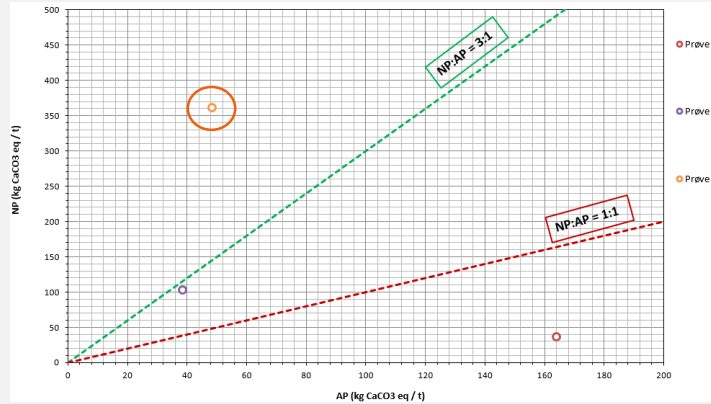


# Prøve 6:



Etasje 3a - alunskifer

# Prøve 6: (etasje 3a)



Parameter	Prøve 6
U (mg/kg)	244
S (%)	1,55
TIC (%)	4,34

