A MINERALOGICAL PERSPECTIVE OF TESTS FOR NEUTRALIZATION POTENTIAL

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NEUTRALIZATION POTENTIAL (NP) OF MINERALS

INITIAL STUDY

- <30 monomineralic samples
- diffractometry, microprobe analyses
- NP determined at CANMET
- results at Fifth ICARD

CURRENT STUDY

- 55 additional monomineralic samples
- diffractometry, microprobe analyses
- NP determined at BCRI

OBJECTIVES OF CURRENT STUDY

1) Expand the number of mineral groups tested
2) Effects of solid solution on NP
3) Effects of particle size on NP
4) Evaluation of test methods for siderite ($FeCO_3$)
5) Reactions during Sobek acidification

INTERPRETATION OF STATIC TESTS

a) which minerals are likely to react to provide NP?

b) how much NP is contributed by a particular mineral?

MEAN LIFETIME OF A 1-MM CRYSTAL AT 25 °C AND pH 5

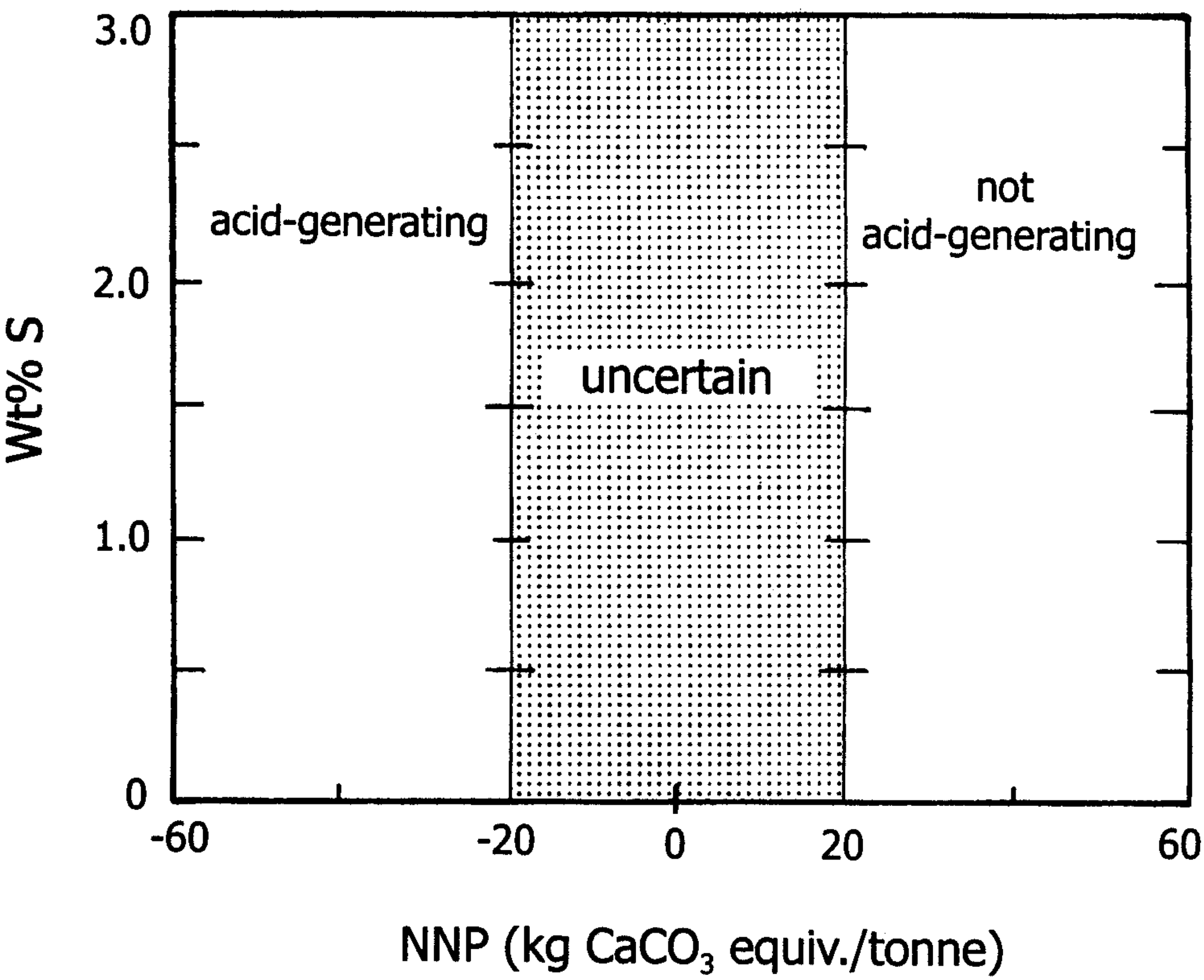
Mineral	Lifetime (year)	Mineral	Lifetime (year)
calcite	0.43	albite	575,000
wollastonite	79	microcline	921,000
forsterite	2300	epidote	923,000
diopside	6800	muscovite	2,600,000
enstatite	10,100	kaolinite	6,000,000
sanidine	291,000	quartz	34,000,000

From Lasaga and Berner (1998)

RELATIVE DISSOLUTION RATES OF NON-SULFIDE MINERALS*

Mineral	$\frac{\text{Rate}}{\text{Rate for calcite}} \times 10^5$	Mineral		$\frac{\text{Rate}}{\text{Rate for calcite}} \times 10^5$
calcite	100,000	plagioclase	An_{76}	0.3
dolomite	6,000		An_{46}	0.1
forsterite	4		An_{13}	0.02
diopside	1		An_{0}	0.02
enstatite	1	sanidine		0.03
talc	0.04	microcline		0.01
chrysotile	0.04			
biotite	0.01-0.02			
phlogopite	0.01			
chlorite	0.01			
kaolinite	0.01			
muscovite	0.004			
montmorillonite	0.001			
quartz	0.0004			

*In laboratory experiments at pH 5, far from equilibrium. Rates relative to calcite were converted from data in Drever and Clow (1995) and from Nagy (1995).



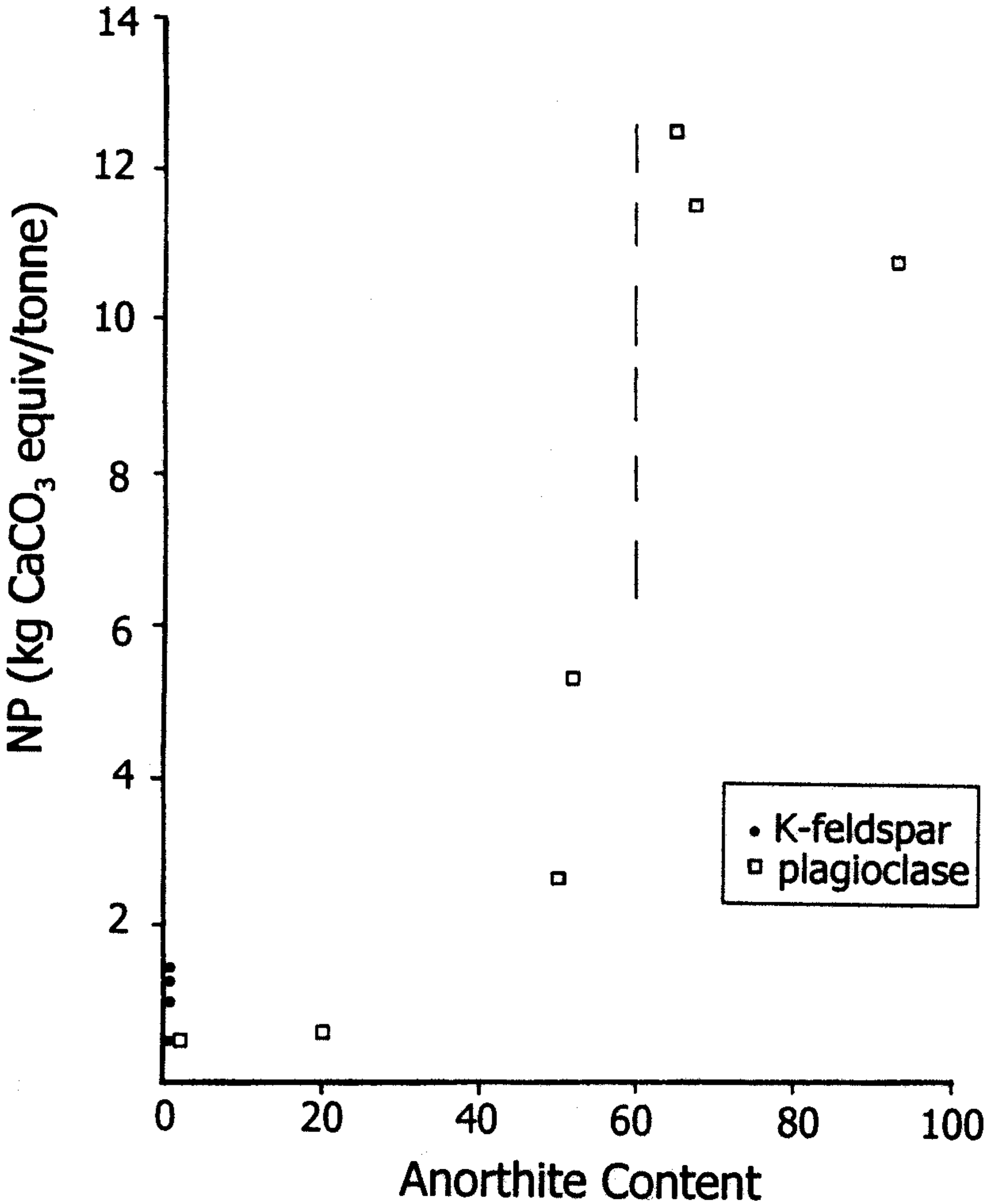
3.0
2.0
1.0
0
Wt% S
acid-generating
uncertain
not
acid-generating
-60
-20
0
20
60
NNP (kg $CaCO_3$ equiv./tonne)

NEUTRALIZATION POTENTIAL (NP) OF INDIVIDUAL MINERALS*

Mineral	Sobek results	Mineral	Sobek results
Feldspars		*Micas*	
anorthite An_{93}	10.7	muscovite	0.3
anorthite An_{50}	2.6	phlogopite	2.7
albite Ab_{80}	0.6	phlogopite	8.5
albite Ab_{98}	0.5		
K-feldspar	1.4	*Chlorite*	
K-feldspar	1.0	clinochlore	10.3
K-feldspar	1.3	clinochlore	0.8
microcline	0.5		
		Clays	
		kaolinite	0.0
Pyroxenes		montmorillonite	13.8
enstatite	3.2		
diopside	4.5	*Serpentines*	
hedenbergite	6.6	antigorite	15.1
augite	4.6	lizardite	16.1
Amphiboles		*Others*	
tremolite	5.2	talc	1.7
pargasite	4.4	forsterite	23.9
		siderite	34.4

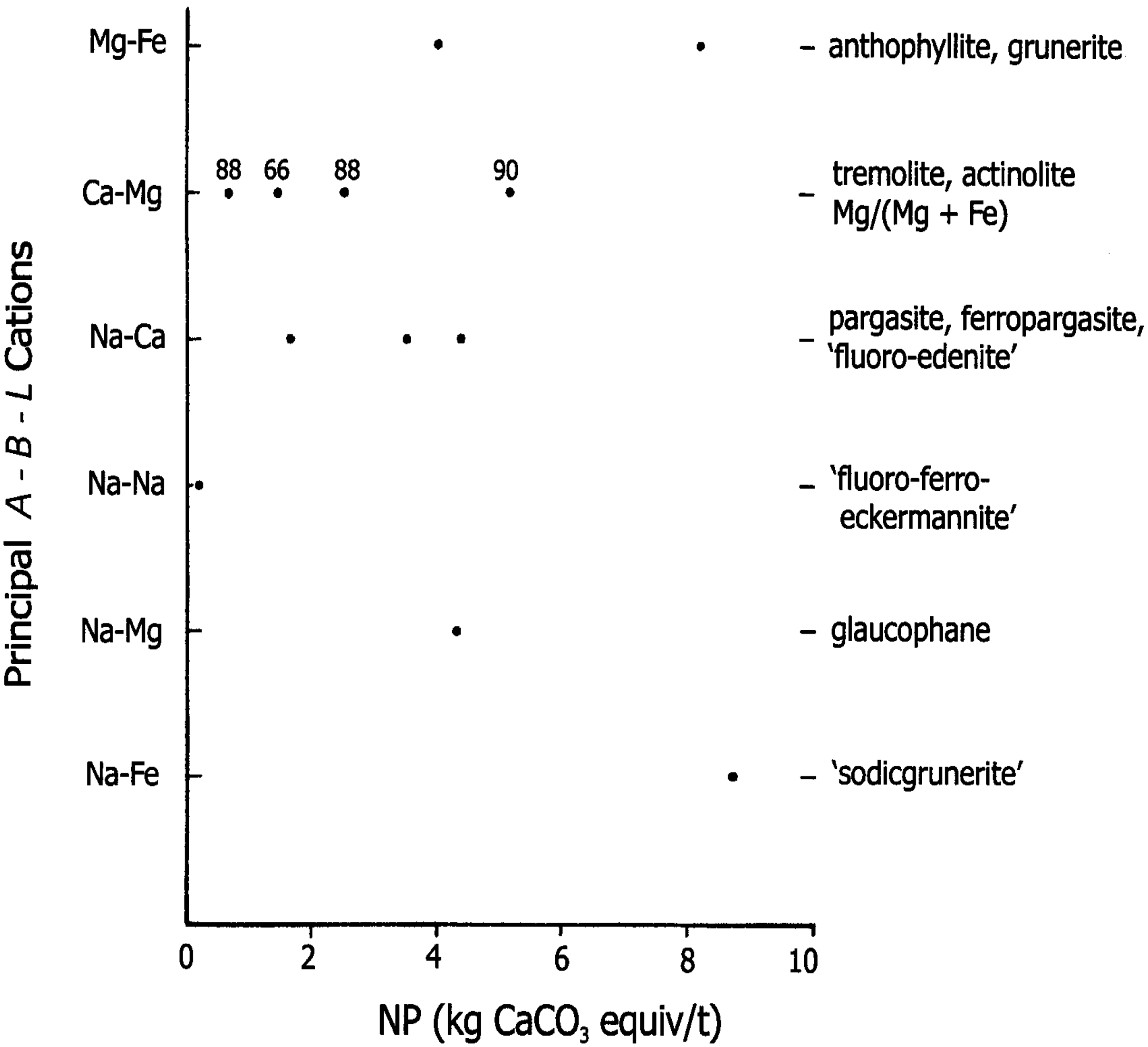
*Values are in tonnes of $CaCO_3$ equivalent per tonne of material.

Feldspars

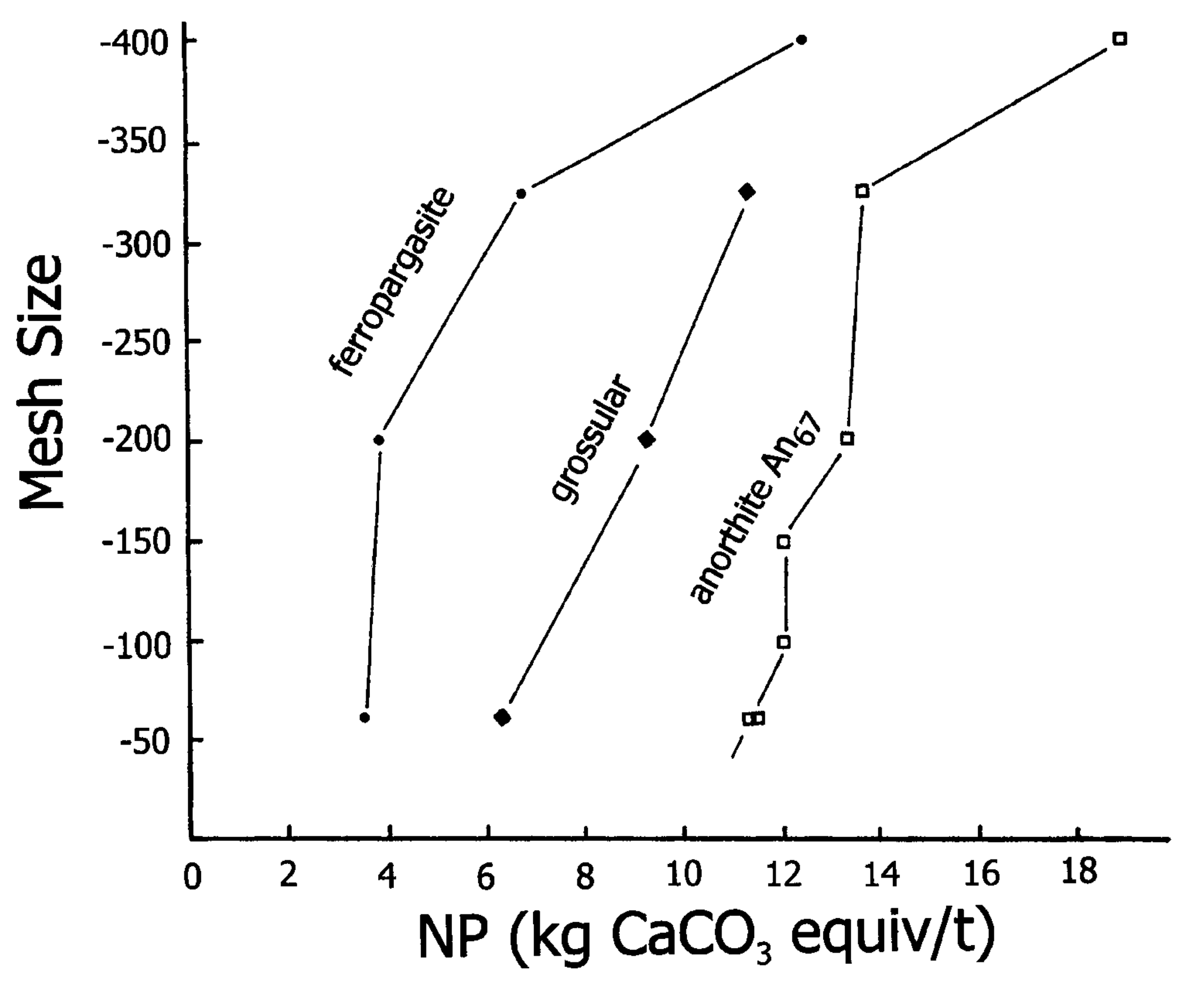


NP (kg $CaCO_3$ equiv/tonne)
14
12
10
8
6
4
2
0
20
40
60
80
100
Anorthite Content
K-feldspar
plagioclase

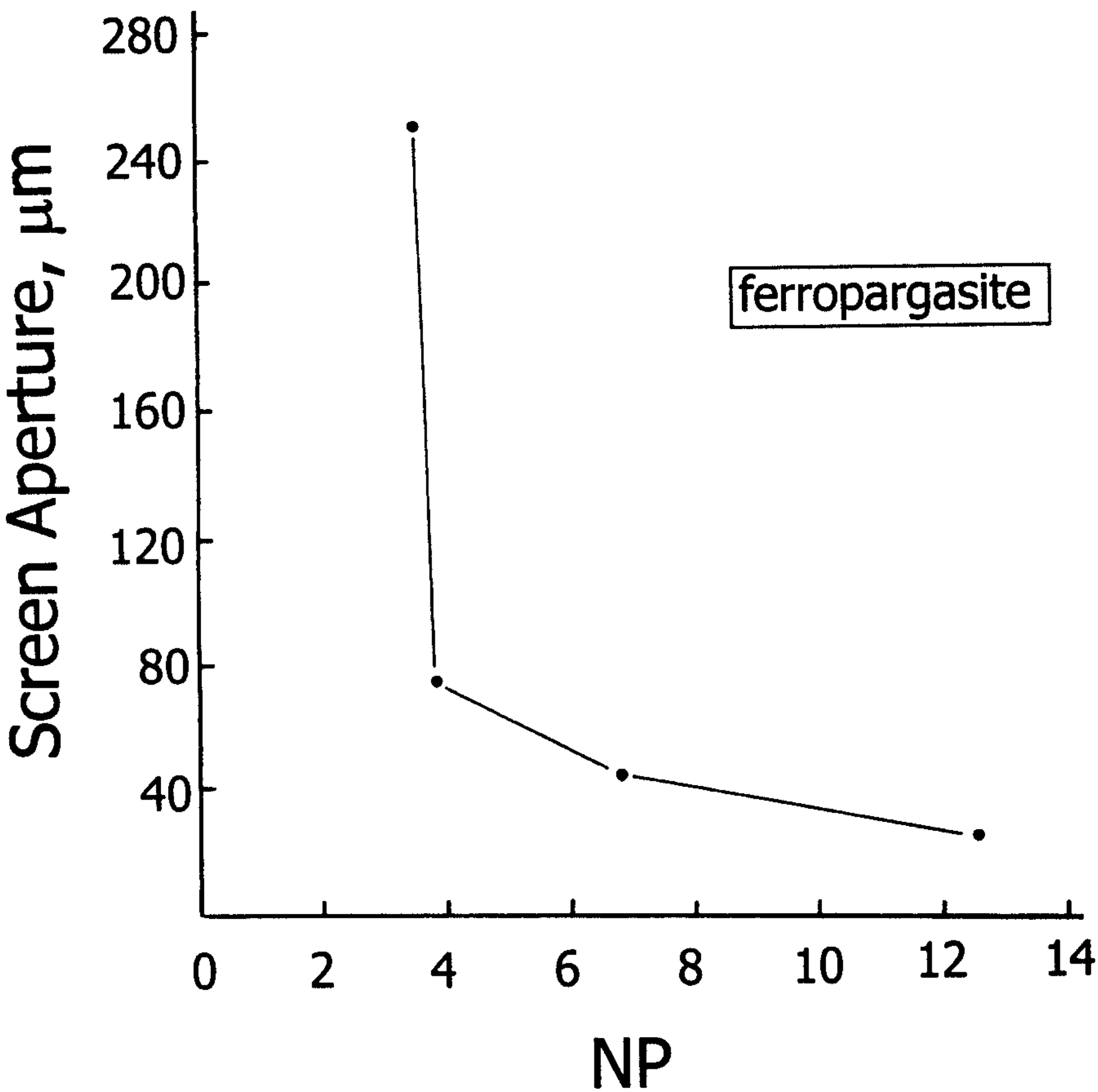
Amphiboles

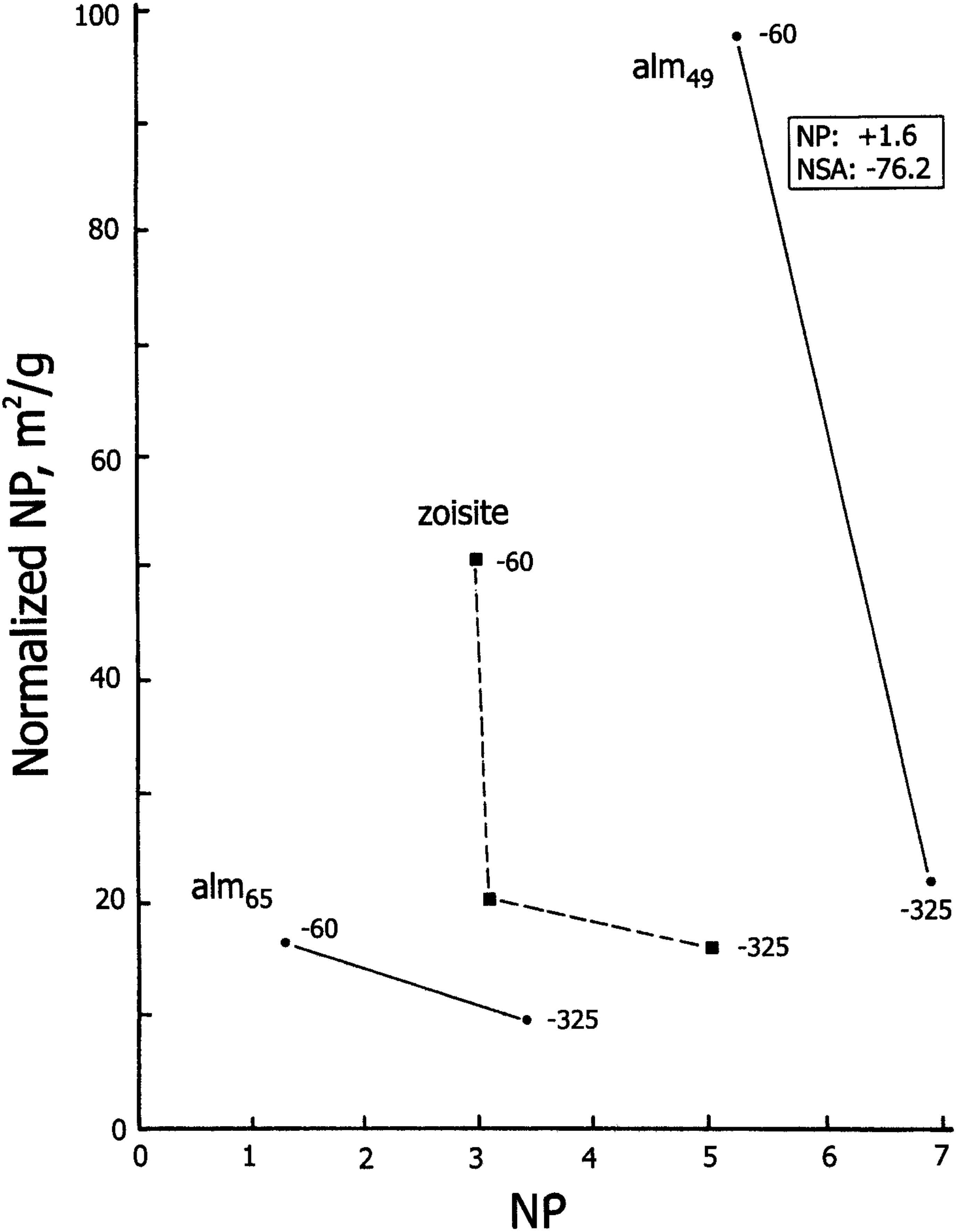


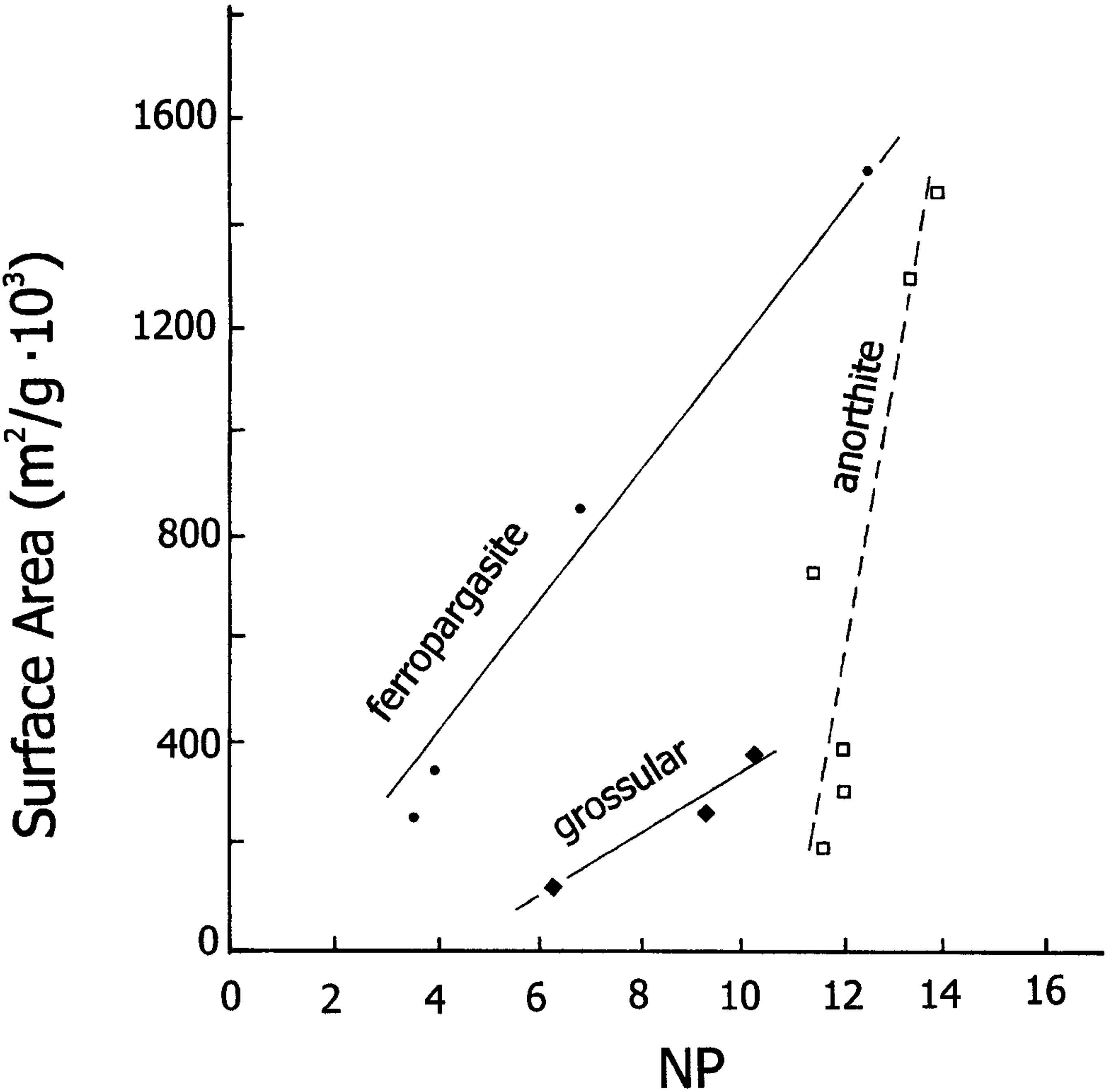
Principal A - B - L Cations
Mg-Fe
Ca-Mg
Na-Ca
Na-Na
Na-Mg
Na-Fe
88
66
88
90
– anthophyllite, grunerite
– tremolite, actinolite
Mg/(Mg + Fe)
– pargasite, ferropargasite,
'fluoro-edenite'
– 'fluoro-ferro-
eckermannite'
– glaucophane
– 'sodicgrunerite'
0
2
4
6
8
10
NP (kg CaCO3 equiv/t)



Mesh Size
-400
-350
-300
-250
-200
-150
-100
-50
ferropargasite
grossular
anorthite An_{67}
0
2
4
6
8
10
12
14
16
18
NP (kg $CaCO_3$ equiv/t)


Screen Aperture, μm
280
240
200
160
120
80
40
ferropargasite
0
2
4
6
8
10
12
14
NP


Normalized NP, m²/g
NP
alm49
alm65
zoisite
-60
-325
NP: +1.6
NSA: -76.2
0
20
40
60
80
100
0
1
2
3
4
5
6
7


Surface Area ($m^2/g \cdot 10^3$)
1600
1200
800
400
0
0
2
4
6
8
10
12
14
16
NP
ferropargasite
anorthite
grossular

NP VALUES OF CARBONATE MINERALS

		Peroxide		
Mineral	Sobek	MEND	SobPer	Non-Fe Theor.
dolomite $Ca_{1.03}Mg_{0.97}$	1046			1083
dolomite $Ca_{1.00}Mg_{0.91}Fe_{0.08}$	1021		954	1033
dolomite $Ca_{1.02}Mg_{0.88}Fe_{0.10}$	1031		956	978
rhodochrosite $Mn_{0.93}Mg_{0.05}Ca_{0.02}$	868		857	885
rhodochrosite $Mn_{0.94}Mg_{0.05}Fe_{0.01}$	797		776	879

Sobek NP: 120 mL 0.5 *N* HCl

*SobPer: Skousen et al. (1997) – *J. Environ. Qual.*

NP VALUES OF CARBONATE MINERALS

Mineral	Sobek	Peroxide MEND	Peroxide SobPer	Non-Fe Theor.
siderite $Fe_{0.86}Mg_{0.08}Mn_{0.04}$	510		165	110
siderite $Fe_{0.77}Mg_{0.07}Mn_{0.14}$	801		213	183
siderite $Fe_{0.74}Mg_{0.03}Mn_{0.22}$	758		283	222
siderite $Fe_{0.64}Mg_{0.33}Mn_{0.03}$	736		359	342
siderite $Fe_{0.60}Mg_{0.11}Mn_{0.28}$	840		360	390
smithsonite $Zn_{0.74}Fe_{0.21}Ca_{0.04}$	177		128	651

Sobek NP: 120 mL 0.5 *N* HCl

*SobPer: Skousen et al. (1997) – *J. Environ. Qual.*

NP OF Fe-BEARING MINERALS

Mineral	Generalized Formula	Sobek NP	SobPer NP
grunerite (amph.)	$(Mg_{1.49}Fe^{2+}_{0.46})Fe^{2+}_{5}Si_8O_{23}$	8.2	3.7
fayalite (Que.)	$(Fe^{2+}_{1.79}Mg_{0.20})SiO_4$	30.6	7.8
fayalite (Swed.)	$(Fe^{2+}_{1.31}Mg_{0.57})SiO_4$	42.2	22.5

CONCLUSIONS

1) – NP increases with decreasing particle size

2) – NP variation over ‘normal’ screened ranges is only a few units of NP

3) – normalization of NP may give misleading results

4) – most silicate-aluminosilicate minerals are slow to react

5) – most silicate-aluminosilicate minerals have low NP

CONCLUSIONS

6) – most non-ultramafic rocks would have fallen into the 'uncertain' category even if completely sulfide-barren; NP = <20

7) – will the waste produce ARD? Determine $NP_{carbonate}$

8) – is NP overstated for Fe^{2+}-bearing silicates – aluminosilicates?

9) – SobPer method may give a reasonable correction for siderite