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210016,

, 36 4 -5305,

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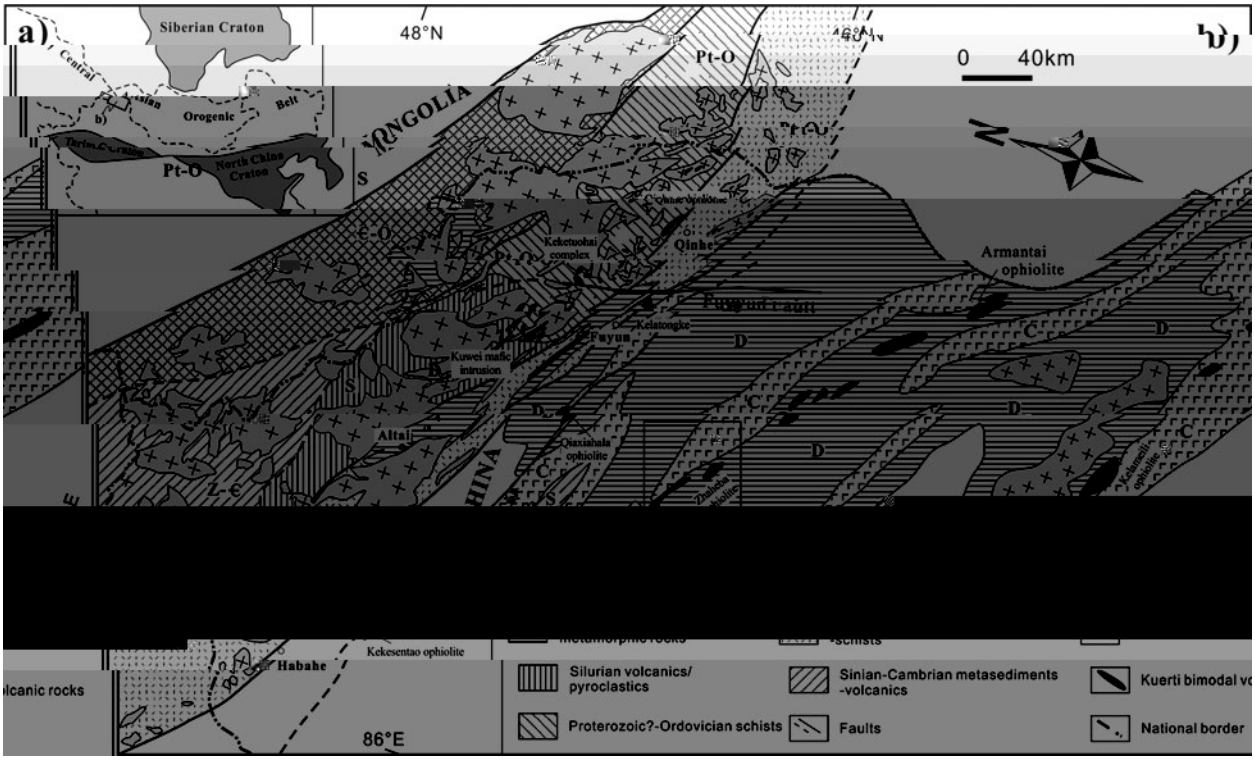
Abstract

[illegible] ~4 5 [illegible] ~400 [illegible] ε(t) (13–20) [illegible] δ (+5.3 ‰) [illegible]

1. I c

[illegible] et al. 200 [illegible] et al. 2012 [illegible] et al. 2012, 2013 [illegible] et al. 2013), [illegible] et al. 200 [illegible] et al. 200 a). [illegible] et al. 2000 [illegible] 2003 [illegible] et al. 200 [illegible], 2014). [illegible] (2011) [illegible] (2014) [illegible]

[illegible] 2000 [illegible] et al. 2002 [illegible] et al. 2004, 200 a) [illegible] et al. 200 d,b [illegible], 2012). [illegible] et al. 2003 [illegible] et al. 2003 [illegible] et al. 200 a) [illegible]



1. ( ) ( ) ( )
et al. 200).

(1)
(2)

2. R a , a a a

a

/ (1, 2). 15 (. 3). (. 2,). 1 5 1

> 0 % (. 3 ,). (. *et al.* 2013).

(40 0 %) (30 50 %) (5 10 %) (. 3).

( ) / ( ) ( ) (*et al.* 2006).

(. 2).

(, 1 . 3).

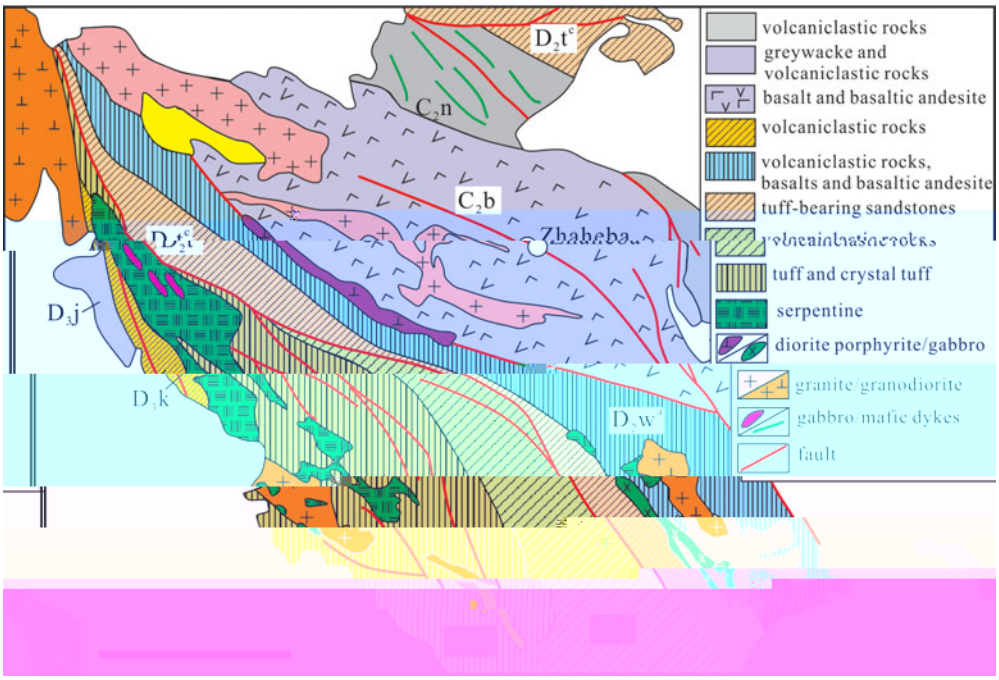


Fig. 2. ( ) et al. 200 , 200 a , 1 , 3).

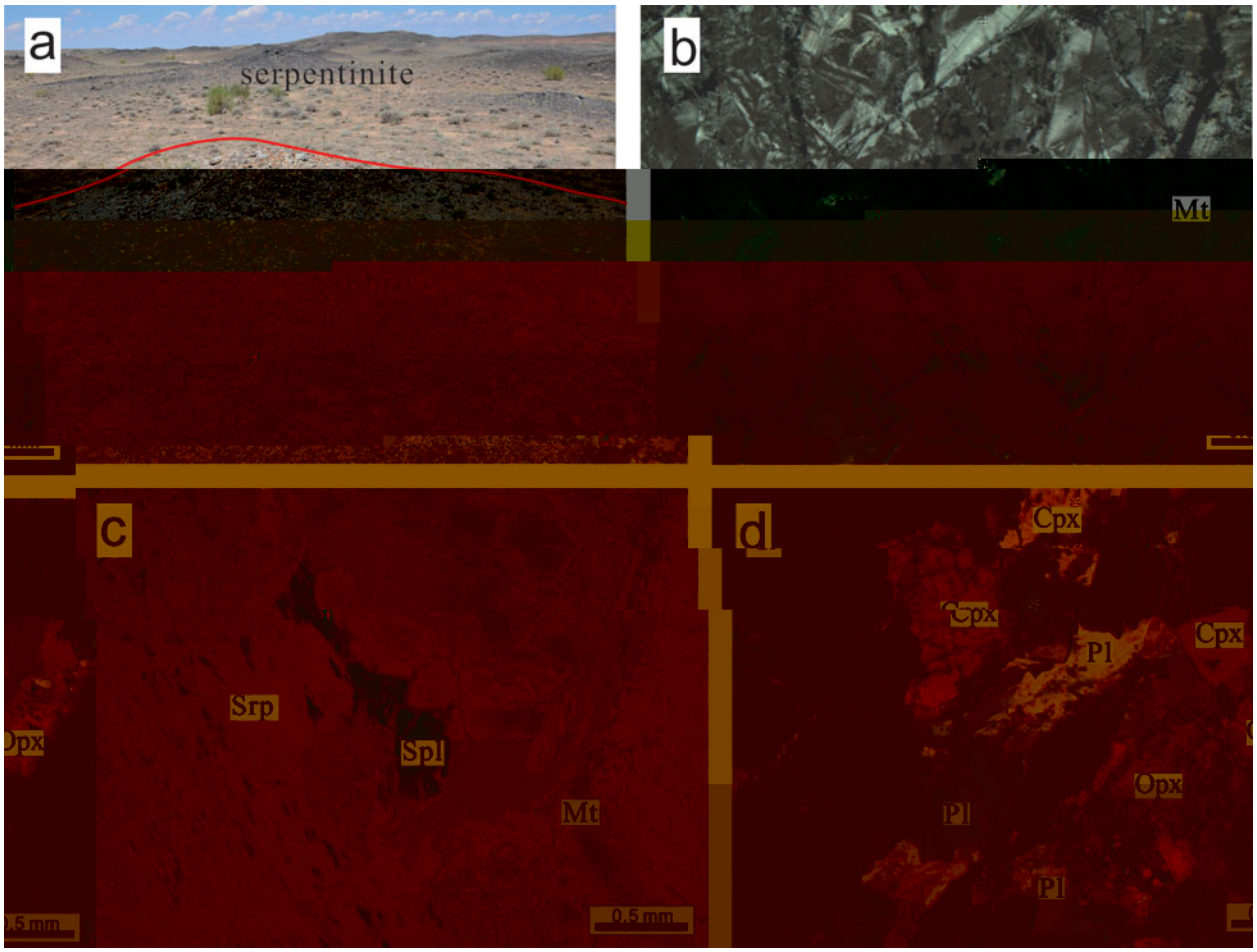


Fig. 3. ( ) . ( ) 0%

3. A a ca c

3.a. Z c U–Pb a a H– a a

(2013 01, 46° 32 51 , ° 2 4)
(2013 02, 46° 33 2 , ° 2 36.)

( )

( )

et al. (2011).

(*et al.* 2010) (, 2003).
5 %

1
2, /
12 0
et al. (2010*a*). 1 /16
/ (/ , 1 /16 =0.0020052),
( )
δ1 5.31 ‰ (*et al.* 2010*b*).
δ1 5.44 ± 0.21 ‰ (2),
5.4 ± 0.2 ‰
(*et al.* 2013).
3
/

3.b. M a a a

I 00
15 15

20
4 5
/

3.c. W - c a a

100
et al. (2004).
2 %.
6000 I
et al. (2004). 50
+ 3
1, / -2 -2,
-1
3,
3 5 %.
1.
+ 3
I (
)
et al. (2004). / 6
143 /144 6 / =
0.11 4 146 /144 = 0. 21 ,
/ 6 0. 102
0. 0506 -1,
143 /144 0.512104 I
I 0.5126 1 -1.
2.

4. A a ca

4.a. Z c U–Pb a

100 150 μ
1 1 2 1.
(. 4).
(22 123) (
5) 0.4
0. 30
4 5. ± 2.5

Table 1. [illegible]

[illegible]	2013 [illegible] 01-1	2013 [illegible] 01-3	20132 [illegible] 01-4	2013 [illegible] 01-5	2013 [illegible] 01-6	2013 [illegible] 01-	2013 [illegible] 01-	2013 [illegible] 01 1	2013 [illegible] 01 2	2013 [illegible] 01 4
					Major elements (%)					
[illegible] 2	3 . 0	4 .20	3 .41	3 .62	3 .22	3 . 2	3 .05	4 .22	46.4	51.2
[illegible] 2	0.05	0.20	0.05	0.05	0.04	0.05	0.04	0.14	0.12	0.2
[illegible] 2 3	0.61	1. 6	1.04	0.6	0. 0	0. 4	0. 0	1 .2	1 .64	1 .33
[illegible] 2 3	.44	4.6	.	.36	.5	.16	. 4	3.6	3.24	3.
	0.0	0.10	0.11	0.11	0.11	0.0	0.11	0.0	0.0	0.0
	3 .21	24.5	3 . 2	3 .	3 .0	3 .31	3 .44	10.04	. .03	5.
	0.12	15.42	0.15	0.14	0.2	0.10	0.14(	)-5 316121 0		

	2013 [illegible] 01-1	2013 [illegible] 01-3	20132 [illegible] 01-4	2013 [illegible] 01-5	2013 [illegible] 01-6	2013 [illegible] 01-	2013 [illegible] 01-	2013 [illegible] 01 1	2013 [illegible] 01 2	2013 [illegible] 01 4
	0.005	0.064	0.00	0.005	0.00	0.003	0.003	0.051	0.044	0.222
	0.021	0.34	0.044	0.042	0.0 2	0.031	0.033	0.310	0.25	1.450
	0.004	0.04	0.00	0.00	0.011	0.005	0.005	0.04	0.043	0.21
	0.011	0.232	0.036	0.044	0.012	0.034	0.00	0.123	0.0 0	0. 3
	0.0 0	0.036	0.03	0.03	0.06	0.026	0.025	0.046	0.031	0.06
	0.26	1. 10	6.600	1. 0	0. 3	0.233	1.150	1.5 0	0.516	0.1 5
	0.406	0.0 2	0.12	0.112	0.0	0.1	0.054	0.16	0.1 1	0.6 5
	0.046	0.034	0.014	0.02	0.050	0.030	0.010	0.050	0.02	0.130
	0.1 1	0.144	0.203	0.364	0.042	0.0 4	0.0	0.066	0.042	0.0 3
	2013 [illegible] 01 5	2013 [illegible] 01 6	2013 [illegible] 01 (1)	2013 [illegible] 01 (1)	2013 [illegible] 01 (1)	2013 [illegible] 03 2 (1)	2013 [illegible] 03 3 (1)	2013 [illegible] 03 4 (1)	2013 [illegible] 03 5 (1)	2013 [illegible] 01 3 (2)
					Major elements (%)					
2	4 .1	45.	4	53.1	51. 1	50.40	50.54	50.52	51.22	52.3
2	0.34	0.15	1.40	1.24	1.31	1. 0	1.63	1.31	1.1	0.33
2 3	1	1 .5	16.5	16.1	15. 3	15.	16. 6	15.55	15.4	1 .61
2 3	4.52	3.34	.	.1	.43	.0	.50	.42	. 2	3.44
	0.0	0.0	0.11	0.10	0.11	0.13	0.11	0.14	0.12	0.0
	6.	.42	4. 0	4.2	4.41	5.	3.2	6.06	.14	4.
	11.03	12.61	6.22	5. 5	6.3	6. 5	4.52	.4	.26	. 0
2	4. 6	.3	. 2	.3	.00	4.52	.31	4. 0	4.0	.11
2	0.13	0.11	0.3	0.31	0.42	2.04	0.33	1.2	2.03	0.1
2 5	0.04	0.02	0.62	0.62	0.65	0. 4	0.6	0.4	0.44	0.04
	3. 2	3.26	4.24	2.54	2. 3	2.2	5.14	2.65	1. 3	2.
	. 5	. 2	. 6	. 0	.4	.40	. 1	.6	.6	. 1
	4.	.4	.11	. 0	.42	6.56	.64	6.0	6.11	.2
#	5	1	55	54	54	56	41	56	64	4
					Trace elements (ppm)					
	.0	4. 5	1.16	1.12	1.4	.0	40.4	5.2	6. 2	5. 1
	0.22	0.135	1.2 4	1.6 3	1.316	1. 53	1.034	1.100	0.5 5	0.62
	25.0	23.	1 .6	1 .5	1 .5	.5	1 .2	25.2	1	1 .0
	11	3.	1 6	166	1 2	22	22	254	1	5.
	34.	163	60.5	62.6	64.1	116	1	0.	203	23.
	24.2	21.6	26.	23.6	24.6	2 .	2 .5	2 .0	2 .0	16.4
	4.	1 5	63.6	50.	51.4	6.	2 .	5 .3	132	1.1

1.

	2013 01 5	2013 01 6	2013 01 (1)	2013 01 (1)	2013 01 (1)	2013 03 2 (1)	2013 03 3 (1)	2013 03 4 (1)	2013 03 5 (1)	2013 01 3 (2)
	3	1.20	3 .60	46. 0	4 .30	23.40	43.00	25.20	32 0	6.56

1.

	2013 [illegible] 01 11 (n 2)	2013 [illegible] 02 1 (n 2)	2013 [illegible] 02 2 (n 2)	2013 [illegible] 03 1 (n 1)	2013 [illegible] 03 6 (n 1)	2013 [illegible] 01 10 (n 2)	04 06 (n 1)	04 24 (n 1)	04 2 (n 1)	03 1 (n 1)
				Trace elements (ppm)						
	1 .4	36.	42.4	26.0	32.4	1	/	/	/	/
	0.3 5	0.153	0.35	1.1	0. 4	0.46	/	/	/	/
	32.5	33.2	34.5	25.1	26.3	32.1	13.4	20.5	1 .	20.3
	1 4	203	21	33	341	1 5	144	1 4	214	265
	56.5	44.2	4 .	1 .	22.2	53.	15	162	214	265
	34.	3 .5	3 .3	23.1	24.	33.	20.6	30.	2	20.2
	66.4	4.6	6.4	25.4	2 .1	66.6	.1	114	5.5	.02
	6.4	236.4	256.	205.4	20	114.20	/	/	/	/
	4 .0	44.1	4 .0	4.	103	44.1	/	/	/	/
	12.0	11.1	11.2	14.	13.6	12.0	/	/	/	/
	0.5	1.420	1.0 0	3.130	3.2 0	0.5 3	4.	1 .1	22.0	1 .2
	1	1 50	5	2 0	24	6 6	1	31	111	6
	13.0	13.0	13.2	21.1	22.	12.5	13.2	13.2	14.	20.1
	54.	42.3	41.5	144	154	52.	243	133	164	151
	1.2	0. 4	0. 55	11.315	11. 5	1.25	20.2	12.	21.	12.2
	0.025	0.030	0.02	0.051	0.052	0.02	/	/	/	/
	0.3 1	0.2 6	0.32	1.560	1.450	0.360	/	/	/	/
	0.2	1. 20	1.030	0.365	0.406	0.336	/	/	/	/
	11	3 2	346	25	50	4.3	/	/	/	/
	10. 0	. 40	.610	26.40	26. 0	10.50	30.6	32.2	40.1	26.4
	23.00	1 . 0	1 .40	51.50	54. 0	22.30	5 .	62.	2.3	52.5
	2. 0	2.520	2.510	5. 50	6.1 0	2.6 0	6.	. 4	10.5	6.4
	11. 0	11. 0	11.60	22.30	24.30	11.60	2 .5	31.2	43.1	24.4
	2.540	2. 00	2.6 0	4.4 0	4. 00	2.3 0	4.5	5.2	6.	4. 5
	0. 6	0. 1	0. 0	1.163	1.25	0. 3	1.45	1.5	2.0	1.03
	2.4 0	2. 13	2. 54	4.14	4.46	2.522	3.56	4.01	5.35	4.23
	0.3 6	0.3	0.3	0.612	0.660	0.3 4	0.4	0.54	0.64	0.63
	2.1 0	2.150	2.220	3.420	3.6 0	2.130	2.5	2.	3.24	3. 5
	0.46	0.446	0.444	0. 2	0. 5	0.46	0.4	0.52	0.5	0.
	1.350	1.230	1.240	2.120	2.2 0	1.310	1.32	1.3	1.45	2.25
	0.1 0	0.16	0.1 5	0.304	0.32	0.1 4	0.1	0.2	0.2	0.34
	1.210	1.050	1.120	1. 60	2.110	1.210	1.25	1.23	1.24	2.13
	0.1 4	0.164	0.165	0.2 1	0.323	0.1 3	0.20	0.1	0.1	0.34
	1.3 0	0. 41	1.040	3.2 0	3.510	1.460	5.3	3.2	4.16	3. 2
	0.0 4	0.062	0.051	0.5	0.644	0.0	1.35	0.6	1.16	0.6
	0.151	2.0	1.50	2. 5	1.	0.33	/	/	/	/
	0.3 4	0.206	0.200	45.20	35.10	0.41	.13	.0	4.1	21.06
	1. 0	0. 61	0. 1	. 60	.2 0	1. 0	4.50	2.63	3.20	.41
	0.500	0.304	0.302	2. 30	3.4 0	0.501	1.	0.6	1.46	2.5

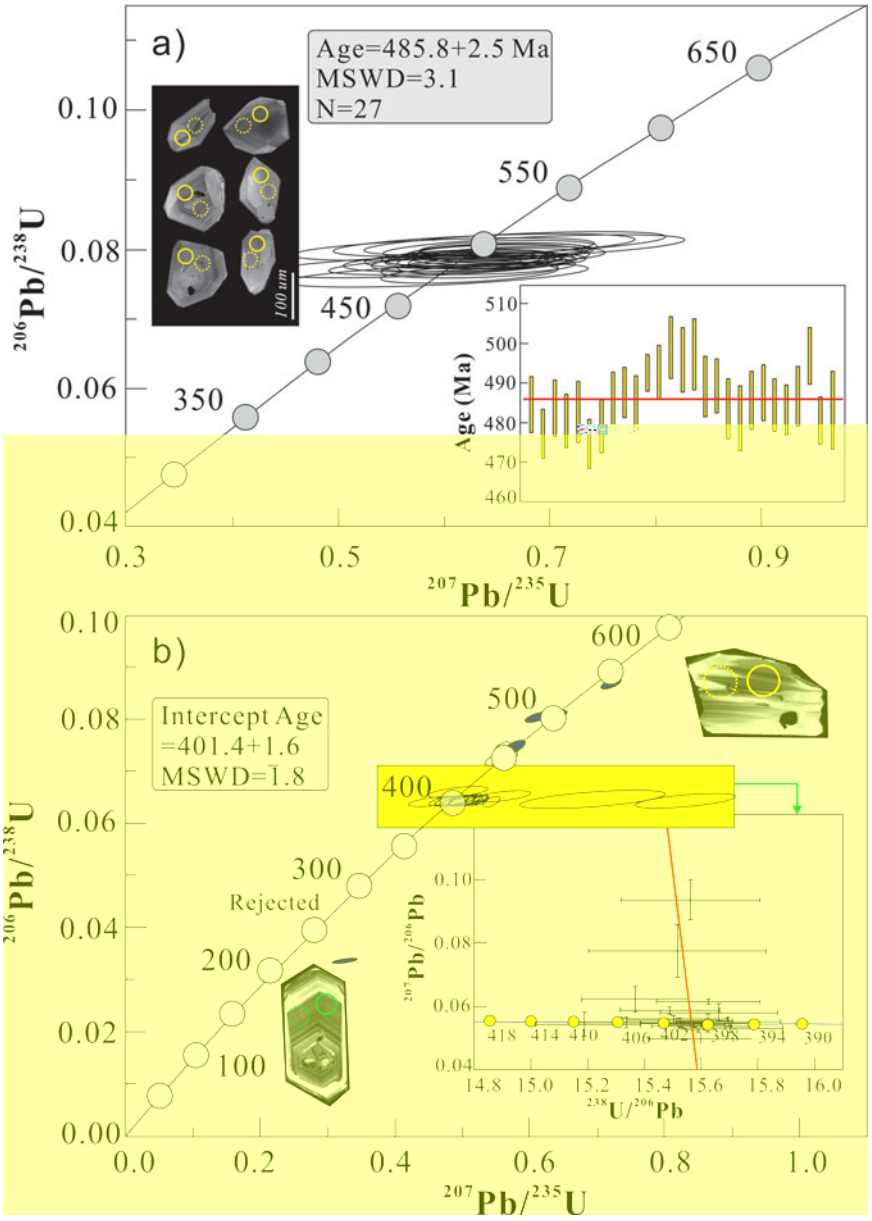
[illegible] 04 06, 04 26, 04 2 [illegible] 04 1 [illegible] *et al.* (200 *a*).

2.

2013	01	3	(2)	0.36	3 2	0.002	0. 04030(2)	0. 04015	2.4	10.	0.13 4	0.512 3 (40)	0.5124 4	6.
2013	01	10	(2)	0.5	6 6	0.0024	0. 04 5 (23)	0. 04 45	2.3	11.6	0.1235	0.512 0 (43)	0.5124 6	.1
2013	03	1	(1)	3.13	2 0	0.0335	0. 06324(20)	0. 06133	4.4	22.3	0.121	0.512533(4)	0.512214	1.
2013	03	2	(1)	2.	1320	0.0063	0. 042 (20)	0. 04255	4. 5	2 .6	0.1046	0.512 1 (51)	0.512445	6.3
2013	03	3	(1)	.06	516	0.0452	0. 0536 (43)	0. 05111	5.	36.	0.0	0.512 0 (30)	0.512450	6.4
2013	03	4	(1)	.65	14 0	0.01	0. 0422 (51)	0. 04120	4.55	24.5	0.1123	0.512 03(53)	0.51250	.5

$\varepsilon_{}(t) = 10\,000((^{143}/^{144})_{}(t)/(^{143}/^{144})$ $(t)-1)$ $\varepsilon_{}(t)$ $(\ /\ ^{6})$

401



4. ( ) 1σ 2σ ( ).

(. 4 = 2 , / = 3.1). 4 ± 4 ( ) (*et al.* 2003).

100 200 μ

/ 1 3 1 (1) 0 %

(2)

(2, . 4).
2
450
500
21 1,
206 23
401 ± 2 (/ = 3.3).
206 23 20 235
401.4 ± 1.6 (/ = 1.) (
206
. 4),
23
(, 1 3).

4.b. M a c

4.b.1. Spinel composition

. 3). 100 300 μ
4 / /)
2 3 2 3
2
(100 /(+))
44 60 (100 /(+))
25 61.
(*et al.* 2010).
( )
(*et al.* 2013).

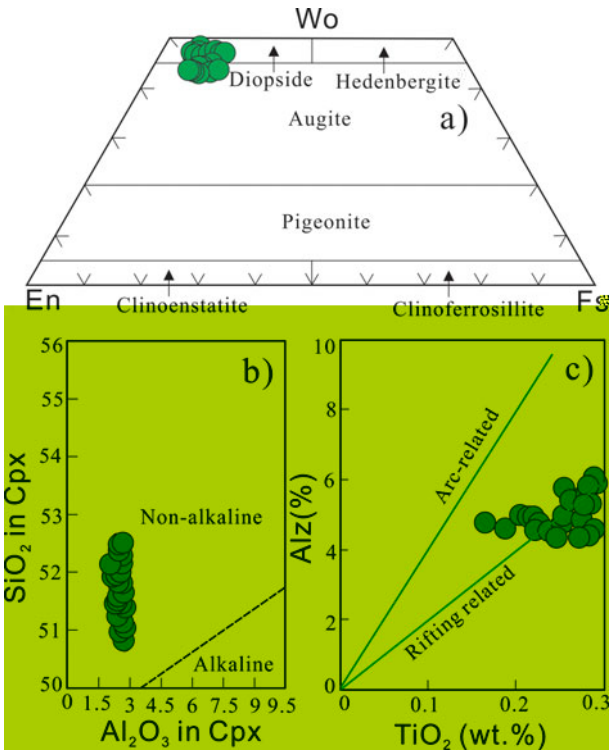
4.b.2. Pyroxene compositions

(= 4 6).
(0.5 %) (
5 / /
).
41 4 . / , 46 55 . 1
. 5).
2 3, 2 2
. 5 ,).

4.c. W - c a c

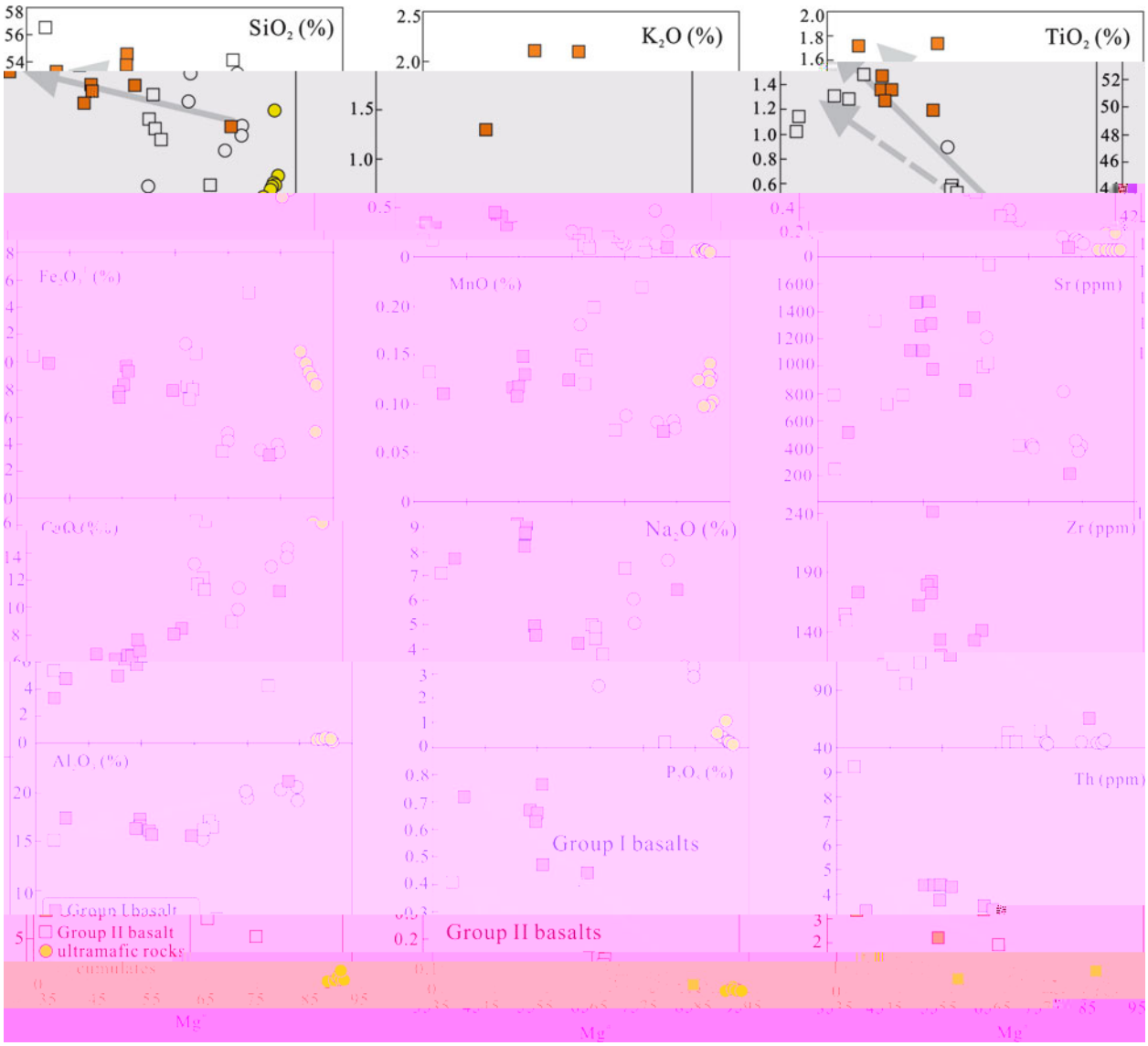
4.c.1. Serpentinites and cumulates

(I)
(> 12 %,
) 2 (40 %) 2 3 (
1.0 %), J 2 (0.03 0.06 %), 2 (0.04
0. 2 %) 2 (0.04 0.05 %). 2 3 -



5. ( ) ( ) /
. ( ) 2 (%) 2 3 (%) ( )
( ) . 2 (%)

1 (1).
(. 6).
(3 103)
(5) (1). I (> 12 %)
2 ,J 2 (,J)
( ) (. ,
).
I , 2 3 2 3 2,
( )
( ) (1).
(.), (, 2014
& ,
1 ,).
2
45. % 51.2 %,
2 3 (3.24 4.6 %), 2 3 (1 .3 1 .6 %,
2013 01-3), (.54 15.42 %), 2
(0.12 0.34 %), 2 (2. 1 .3 %,
2013 01-3) J 2 (0.11 0.46 %)
(1).



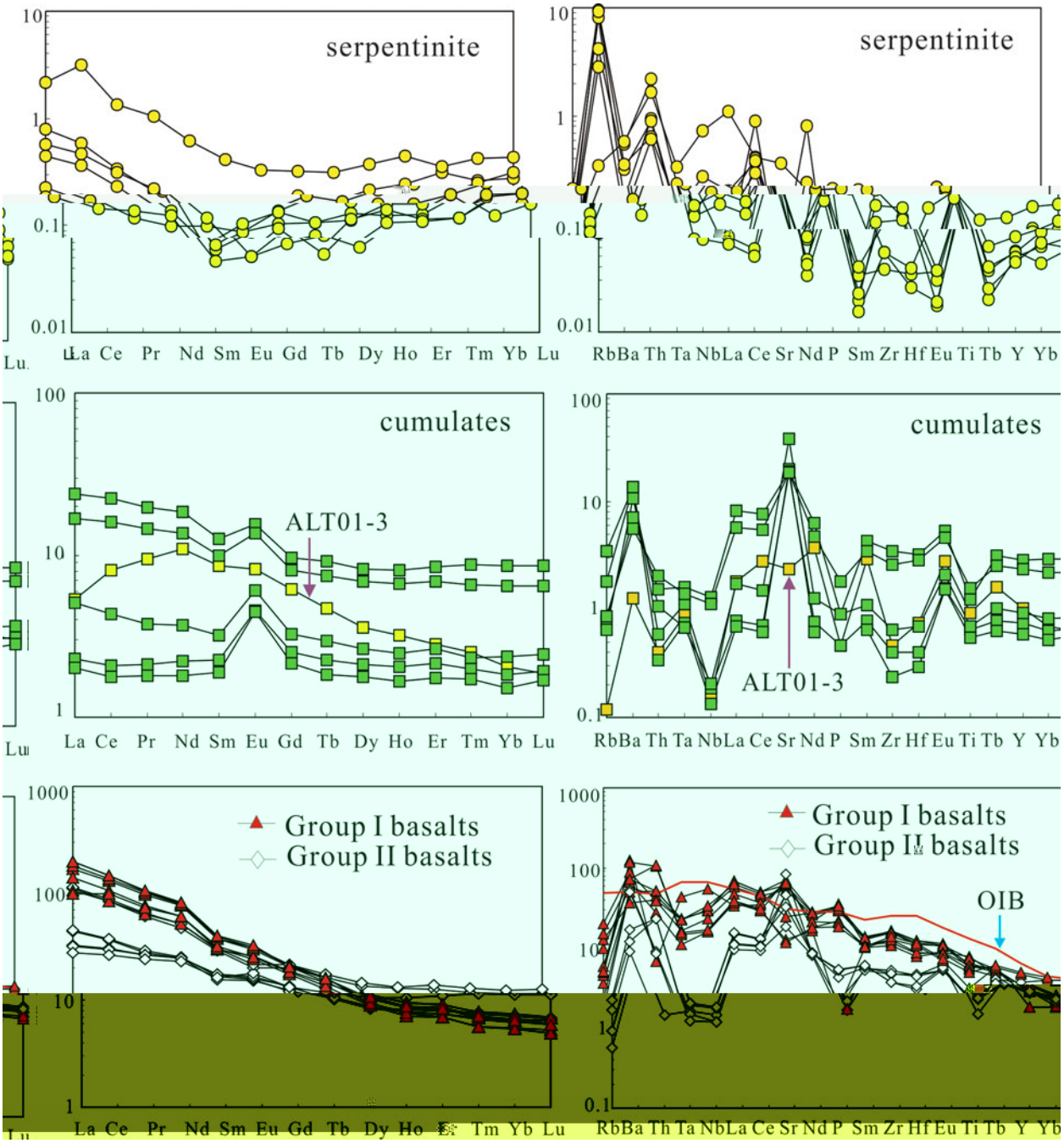
6. ( ) ( ) (*et al.* 200 *a* ( ).

1). 6). 5 41 ( ) ( ) = 1.3 2.) (/ = 1.1 2.2). 2013 01-3 ( ), (= 0.2 0.4)

1 (1) 2 (2). 2 ( ). 1 2 ( ). 1 2 3 2 1 2 . 6). 1 124 205 2 50 60 1 (/) 10 30 (20)

4.c.2. Basalts

43.15 % 5 .65 % (2 52 %,

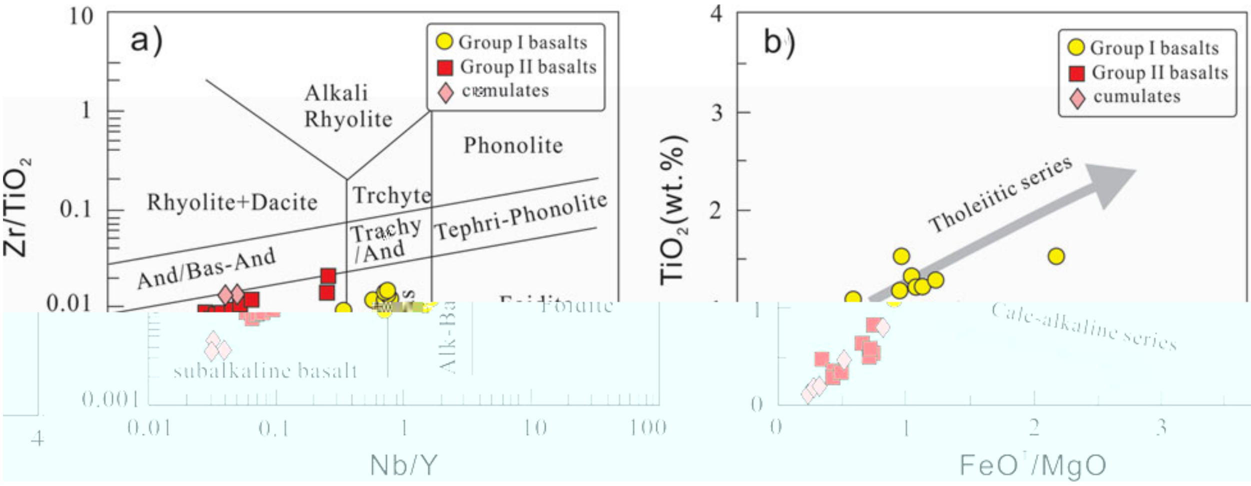


( ) & (1).

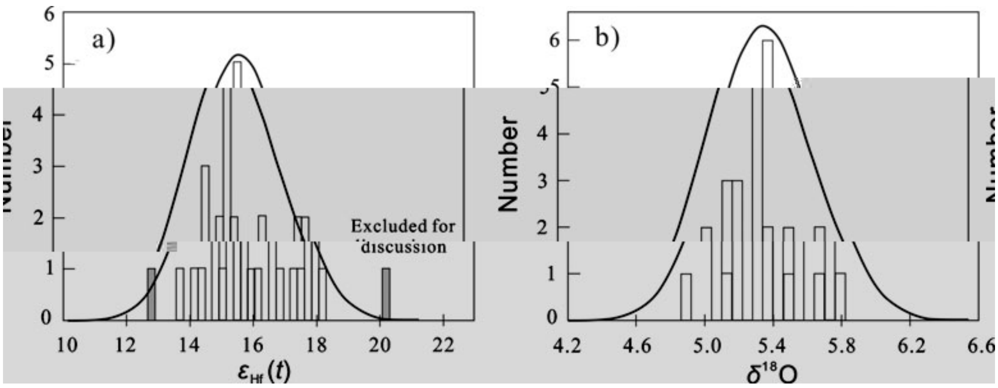
(/ = 0. 0 1.14) ( ). 2 (/) 4 6 (/ = 1.02 1.21) ( ). 1 0.44 0. 2 1 (~0.11). ( ).

4. . W - c S –N a z c H –O

2. 1 2 (0.0024 0.0452) / (0. 04030 0. 0536), / (0. 04015 0. 05111, 2013 03 1). ^{14} / ^{144} 0.0 0.13 4 ^{143} / ^{144} 0.512 0 0.512 3 ε (*t*) +6.3 + .5 (2013 03 1 +1.).



( ). ( ) (/) & 1). ( ) 2 (1 4).



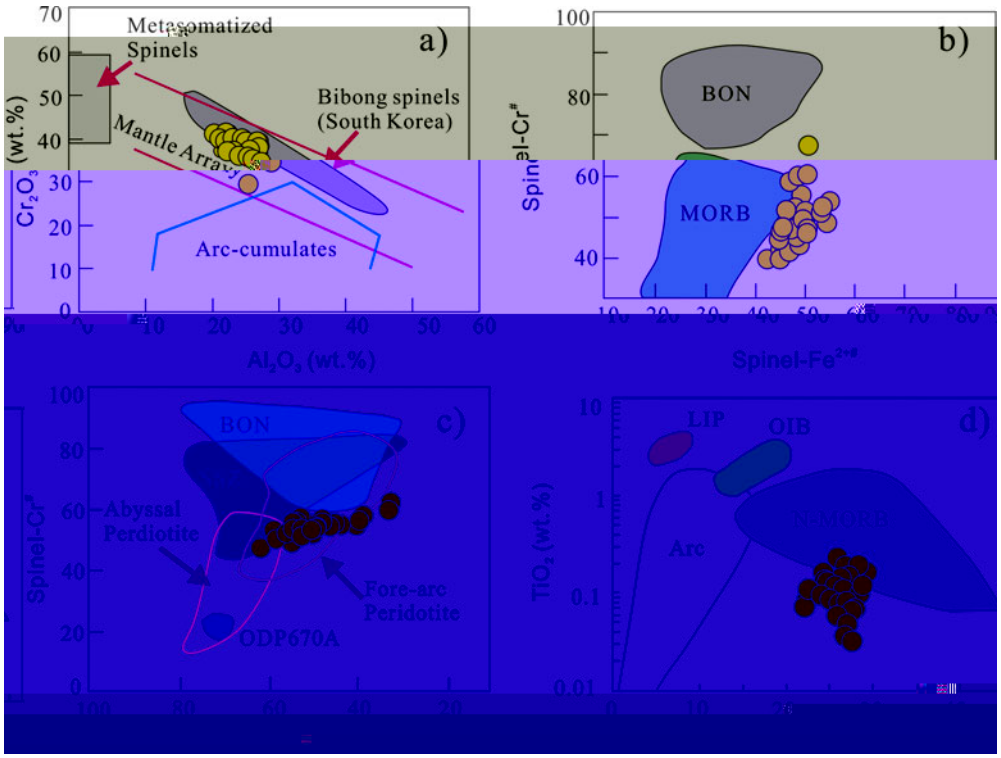
( ) ε (t) ( )

(2013 01) 2), ε (= 4 5) 13 20. 2 5 5 ε (t) (> 16) ε (t), 15. δ1 4. 1 ‰ 5. 3 ‰,). δ1 5.3 ± 0.23 ‰ ( ). ~400 ε (t) 1.4 .2 6 0 20 (et al. 200).

5. [redacted]

5.a. T a [redacted] Z a ba

c. 4 6 401 (503 ±) (416 ± 3) (et al. 2012 et al. 200 b, 1). (401) (4 6) (1 3). (1),

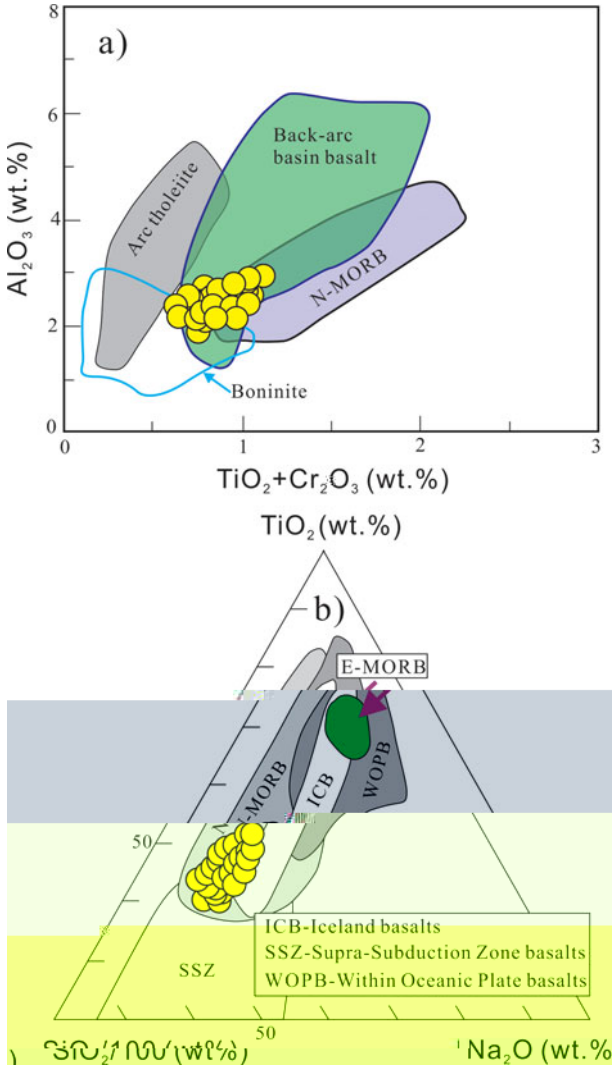


10. ( ) & / , 2000). ( ) . (100 /( )) . (100 2+/(2+)) (1 , 4 & , 2001). ( ) . (100 /( )) . (100 /( )) (et al. 1 , 5). ( ) 2 3 2 3 (%) (J , & , 2001).

(500 4 0) (et al. 2003 , et al. 2015), J (430 400) (et al. 200 b, 2014) J (3 0 350) (et al. 2003 / et al. 2006).

5.b. O a c a

(& , 2002 et al. 2010



11. ( ) ( ) 2 3 . 2 + 2 3 ( ) 2 2/100 2

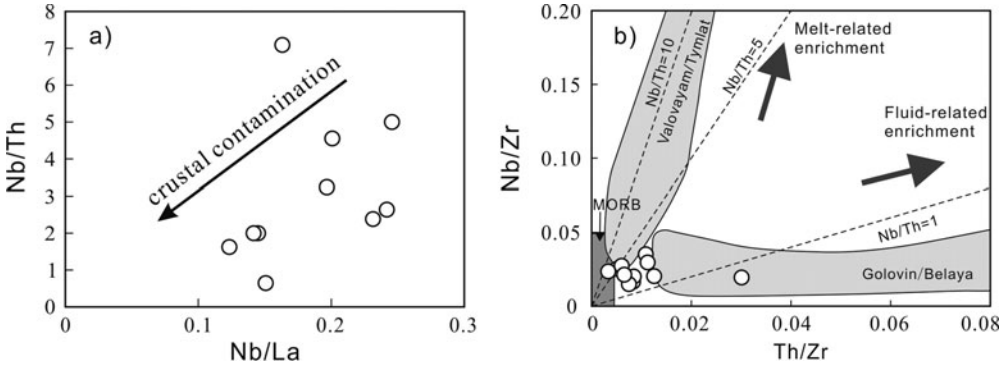
( ).

5 2 3 . 2 + 2 3 (. 11). 2/100 2 2 (. 11). (.).

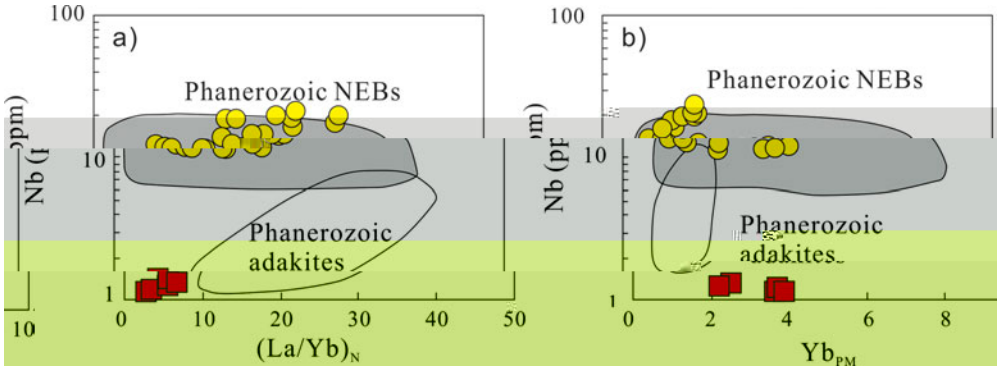
(. 12), (. 12). *et al.* (2002) ( ).

5.c. P D a

2. 1 (11 24 15). 2 5 (0.4 0.6 %) (11 15, 60) (/) ( ) (, I & , 1 2 & J , 2001) (. 13). (1) I (. , & , 2002) (2) & , 1 2 & , 1 3 *et al.* 1 6). 1 (& , I , 200 *et al.* 2011). , 1 (0. 04120 0. 06133) ε (*t*) (+1. + .5). / (3.44 20.4) / (1.51 2.54) I (. & , 1 6). I 1 (*et al.* 1 6 J , 1 6). (&J , 2000). (, I & , 1 2 *et al.* 1 6). *et al.* (200)



12. ( ) ( )



13. ( ) ( ) ( ) ( ).

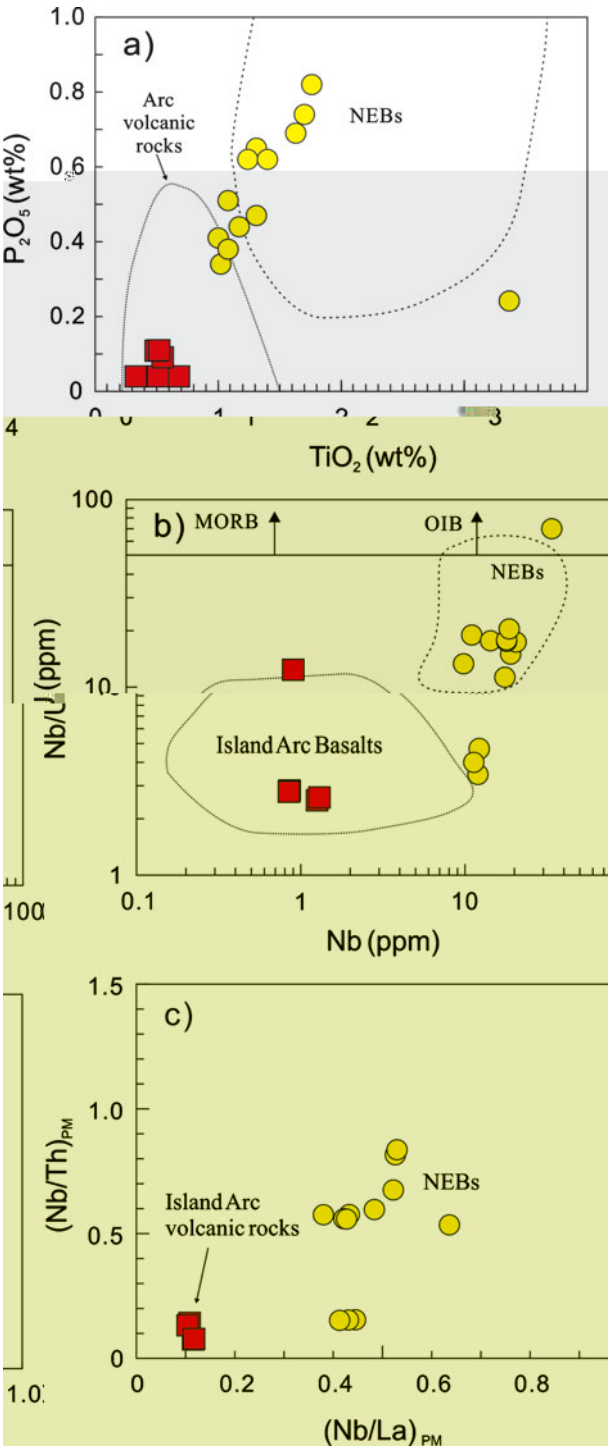
I . 1 ε (*t*) (1. .5) (/), (0. 04120 0. 06133) (. 2). ε (*t*) (/). 1 2 2 (< 0.3), / / (.), & , 1. 1 , 2002). 2 (/) (0. 1.0), ( ) (0.1 0.2) (0.6 1.0). 2 (& , 1. 6). 1 2 ( ) (1 . 14).

(. 14). 2 I . 2

5. . I ca Pa a z c acc J a

J (416 *et al.* 2014 *et al.* 2015), (503 4 5 I *et al.* 2003 *et al.* 2015) (400) (. 1). J (*et al.* 2014),

I (*et al.* 200 , 200 *a*,*b* *et al.* 200 *a*). (*et al.* 200 *b*).



14. ( ) ( ) ^{2} ^{5} ^{2} . ( ) . ( ) ( ) ( ) ( ) ( ) I & (1 2) *et al.* (1 5);

, *et al.* (2015) 400 3 0

460 3 5 *c.* 400 (/ *et al.* 2006, 200 *et al.* 200 *et al.* 200 *et al.* 200 , 200 *et al.* 2012 *et al.* 2015).

(& I , 2002 / *et al.* 200).

(*et al.* 2015).

(5.), 2

(1 , 15). *et al.* (200 , 200 *b*)

(*et al.* 200).

& , 1 , 1 & , 200 *et al.* 2013).

(. 15).

(1) (*c.* 500), (. 15).

(2) (500 4 0), (. 15).

(3) (4 0 420), (45 *et al.* 2015) (440 *et al.* 2014) (. 15).

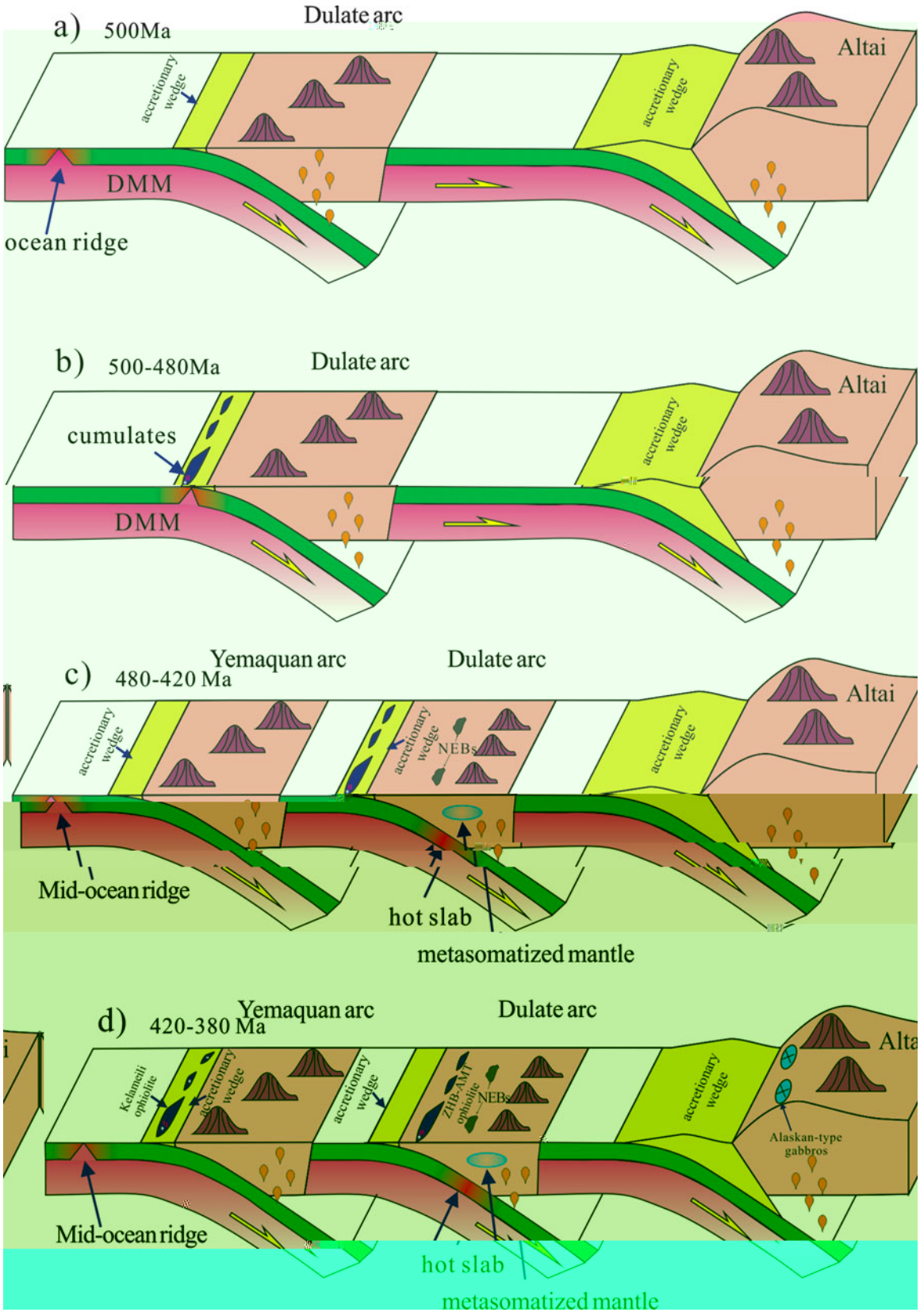

a) 500Ma
Dulate arc
Altai
accretionary wedge
accretionary wedge
DMM
ocean ridge
b) 500-480Ma
Dulate arc
Altai
cumulates
accretionary wedge
DMM
c) 480-420 Ma
Yemaquan arc
Dulate arc
Altai
accretionary wedge
accretionary wedge
NEBs
accretionary wedge
Mid-ocean ridge
hot slab
metasomatized mantle
d) 420-380 Ma
Yemaquan arc
Dulate arc
Kelameili ophiolite
accretionary wedge
accretionary wedge
ZHB-AMT ophiolite
NEBs
accretionary wedge
Alaskan-type gabbros
Mid-ocean ridge
hot slab
metasomatized mantle

Fig. 15. (

(4) J (420 3 0) (*et al.* 2014 *et al.* 2015).

1 ( ) 2 (. 15).

(400 3 0).

6. C

(1) ~4 5 *c.* 400 .

(2)

(3) J

Ac . J 305 (2011 06 03-01).

S a a a

/10.101 / 0016 56 16000042.

R c

. 1 4. . *Chemical Geology* **113**, 1 1 204.

. J. & . 2001. *Journal of Petrology* **42**, 22 302.

. J. & . 200 . *Lithos* **97**, 2 1 .

& 2002. . *Geology* **30**, 0 10.

. J . . & / . 200 . *Earth Accretionary Systems in Space and Time* (. & . J), . 1 36. . 31

. & . 2002. . *Geological Magazine* **139**, 1 13.

. 1 3. *Geological Society of America Bulletin* **105**, 15 3 . . 1 . *Ophiolites.* , 220 .

. J. & . 1 3. . *Geology* **21**, 54 50.

. J., J . & . 1 2. . *Journal of Geological Society, London* **149**, 56

. J. . & . 1 4. . *Contributions to Mineralogy and Petrology* **86**, 54 6.

J . & . J. 2003 (2) *Ophiolites in Earth History* (. & .), . 43 6 . 21

J . & . 2011. . *Geological Society of America Bulletin* **123**, 3 411.

. . & . J. . 2015. J . *Chinese Journal of Geology* **50**, 140 54 ( ).

. & / . 2000. ( ) . *Contributions to Mineralogy and Petrology* **140**, 2 3 5.

. & . J. 1 1. . *Lithos* **27**, 25 .

. 2011. *Geological Bulletin of China* **30**, 150 15).

. 2011. *Geochimica et Cosmochimica Acta* **75**, 504 2.

. 2001. *Nature* **410**, 6 1.

. 2002.) *Chemical Geology* **182**, 22 35.

. 6. *Journal of Geophysical Research: Solid Earth (1978–2012)* **101**, 11 31 .

. 2000. 2. *Contributions to Mineralogy and Petrology* **139**, 20 26.

. 2012. *Geological Bulletin of China* **31**, 126).

. 2014.). *Chinese Science Bulletin (Chinese Version)* **59**, 2213 22.

. 2000. *Transactions of the Royal Society of Edinburgh: Earth Sciences* **91**, 1 1 3.

. 1 0. *Journal of Petrology* **31**, 6 1.

. 2003. *Earth Science Frontier* **10**, 43 56).

. 2001. *Journal of Petrology* **42**, 655 1.

. 1 6. *Nature* **380**, 23 40.

. 2000. *Tectonophysics* **326**, 255 6 .

. 2010*a*. 50 *Lithos* **114**, 1 15.

. 2004. *Geological Magazine* **141**, 225 31.

. 2010*b*. *Geostandards and Geoanalytical Research* **34**, 11 34.

. 2013. *Chinese Science Bulletin* **58**, 464 54.

. 200 . *Lithos* **113**, 2 4 1.

. 2010. *Chinese Science Bulletin* **55**, 1535 46.

. 2003. *User's Manual for Isoplot 3.00: A Geochronological Toolkit for Microsoft Excel*. 4, 3 .

. 2015. ( ) *Gondwana Research*, 6 2015. 10.1016/ . .2015.04.004.

. 1 4. *American Journal of Science* **274**, 32 355.

. 1 5. ( ). *Geology* **23**, 51 4.

. 1 . *Structure of Ophiolites and Dynamics of Oceanic Lithosphere*. 36 .

. 1 . *Journal of Petrology* **38**, 104 4.

. 200 *a*. *Acta Petrologica Sinica* **25**, 16 24).

. 200 *b*. *Acta Petrologica Sinica* **25**, 14 4 1).

. 200 . 40 /3 *Acta Petrologica Sinica* **23**, 162 34).

. 2002. 1 6 *Proceedings of the Ocean Drilling Program, Scientific Results, vol. 176* (. . . .), 1 60.

. & . 200 . . *Chinese Science Bulletin* **14**, 21 6 1.

. . I., . I., I. I. & . I. . 2010. . *Lithos* **117**, 1 20 .

. & . 200 . . *Journal of Asian Earth Sciences* **30**, 666 5.

. I. . 200 . . *Lithos* **100**, 14 4 . . I. .2014. . *Elements* **10**, 101 .

. & J . 2001. 2. . *Contribution to Mineralogy and Petrology* **141**, 36 52.

. J . & . 2013. ( ) . *Gondwana Research* **24**, 3 2 411.

. I. & . 6. ( ). *Journal of Petrology* **37**, 6 3 26.

. & . J . 2013. . *Precambrian Research* **231**, 301 24.

. . J. & . 2012. . *Precambrian Research* **192–195**, 1 0 20 .

. I. & . I. 1 1 . *Philosophical Transactions of the Royal Society of London* **335**, 3 2.

. J . & . 5. . *Nature* **377**, 5 5 600.

. & . . 1 3. . *Nature* **364**, 2 30 .

. 2014. (~440) ( ) . *Lithos* **206–207**, 234 51.

. I. 2002. . *Reviews of Geophysics* **40**, 3-1 3-3 .

. J . . I. & . 200 . . *Science in China Series D – Earth Sciences* **52**, 1345 5 .

. . & . 1 . *Magmatism in the Ocean Basin* (. & . I.), . 52 4 . 42.

. &J . 200 . . *Chemical Geology* **247**, 352 3.

. . I., . I., . & . 200 . *Acta Petrologica Sinica* **23**, 1 33 44 ( ).

. I. & . I. 1 . *Contributions to Mineralogy and Petrology* **133**, 1 11.

. & . 2006. . *Journal of Geology* **114**, 35 51.

. J . & . 200 . . *Lithos* **110**, 35 2.

. & . 2012. . *Earth-Science Reviews* **113**, 303 41.

. I. & . 1 . *Chemical Geology* **20**, 325 43.

. J . I., I., . & . 2002. . *Journal of Geology* **110**, 1 3 .

. I. & . 2006. . *Geology in China* **33**, 4 6 6 ( ).

. I., . I., . & . I. 2014. ( ) *Geoscience Frontiers* **5**, 525 36.

. I., . & . 200 . . *Journal of Asian Earth Sciences* **32**, 102 1 .

. I., . & . 2013. *Gondwana Research* **23**, 1316 41.

. I., I. . J . & . 2004. . *Journal of Geological Society, London* **161**, 33 42.

[illegible] 200[illegible] *a*. [illegible] *International Journal of Earth Sciences* **98**, 11[illegible]21[illegible].

[illegible] 200[illegible] *b*. [illegible] *American Journal of Sciences* **309**, 221[illegible]0.

[illegible] 3. *Regional Geology of the Xinjiang Uygur Autonomous Region*. [illegible] 2[illegible]145 ([illegible]).

[illegible] & [illegible] 2015. [illegible] *Journal of Asian Earth Sciences* **113**, 5[illegible].

[illegible] J[illegible] & [illegible] 2012. [illegible] *Gondwana Research* **21**, 246[illegible]65.

[illegible] & [illegible] 200[illegible] *Chemical Geology* **242**, 22[illegible]3[illegible].

[illegible] & [illegible] 2006. [illegible] *Acta Geologica Sinica* **80**, 254[illegible]63 ([illegible]).

[illegible] & [illegible] 2003. [illegible] *Chinese Science Bulletin* **48**, 2231[illegible]5.

[illegible] J[illegible] & [illegible] 2013. [illegible] *Lithos* **179**, 263[illegible]4.

[illegible] & [illegible] 2012. [illegible] *Journal of Asian Earth Sciences* **52**, 11[illegible]33.

[illegible] & [illegible] 200[illegible]. [illegible] *Acta Petrologica Sinica* **24**, 1054[illegible]5[illegible] ([illegible]).

[illegible] & [illegible] 1[illegible]6. [illegible] *Annual Review of Earth and Planetary Sciences* **14**, 4[illegible]3[illegible]5[illegible]1.