Geol. Mag. **154** (3), 2017, pp. 419–440. © Cambridge University Press 2016
10.101 0016 56 16000042

, 10003
210016,
, 36 4 -5305

(Received 1 2015; accepted 2016; first published online 1 2016)

Abstract

~4 5 ~400 ε(t) (13 20) δ (+5.3 ‰)

1. Intro uct on

(et al. 200 & 200 et al. 2012 et al. 2012, 2013 et al. 2013), et al. 200 et al. 200 a). (1 et al. 2000 1 1 3 & 2003 et al. 200 2014). & (2011) (2014)

( ), (& 1 3 & 2000 et al. 2002 et al. 2004 200 a) (1). (et al. 200 a,b 2012). (1 3 et al. 2003 et al. 2003 et al. 200 a) (1).

1. ( )

( ) ( )

( )

et al. 200).

%

%

(1)

(2)

%

2. Reg.onal geology, fiel observat.ons an petrography

(

1, 2).

%

(. 3).

15 %

%

(. 2,

) %

1 5 1

%

%

> 0 %

(. 3 ,).

%

(. .

et al. 2013).

%

(40 0 %) (30 50 %)

(5 10 %)

(. 3).

%

%

( ) ( )

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

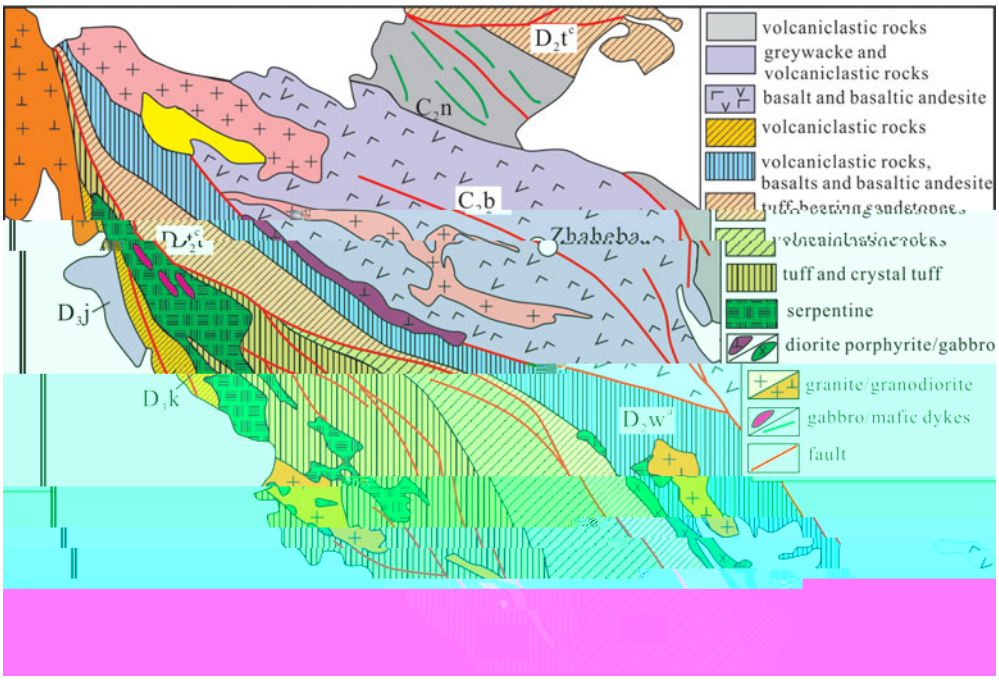
%

(. 2).

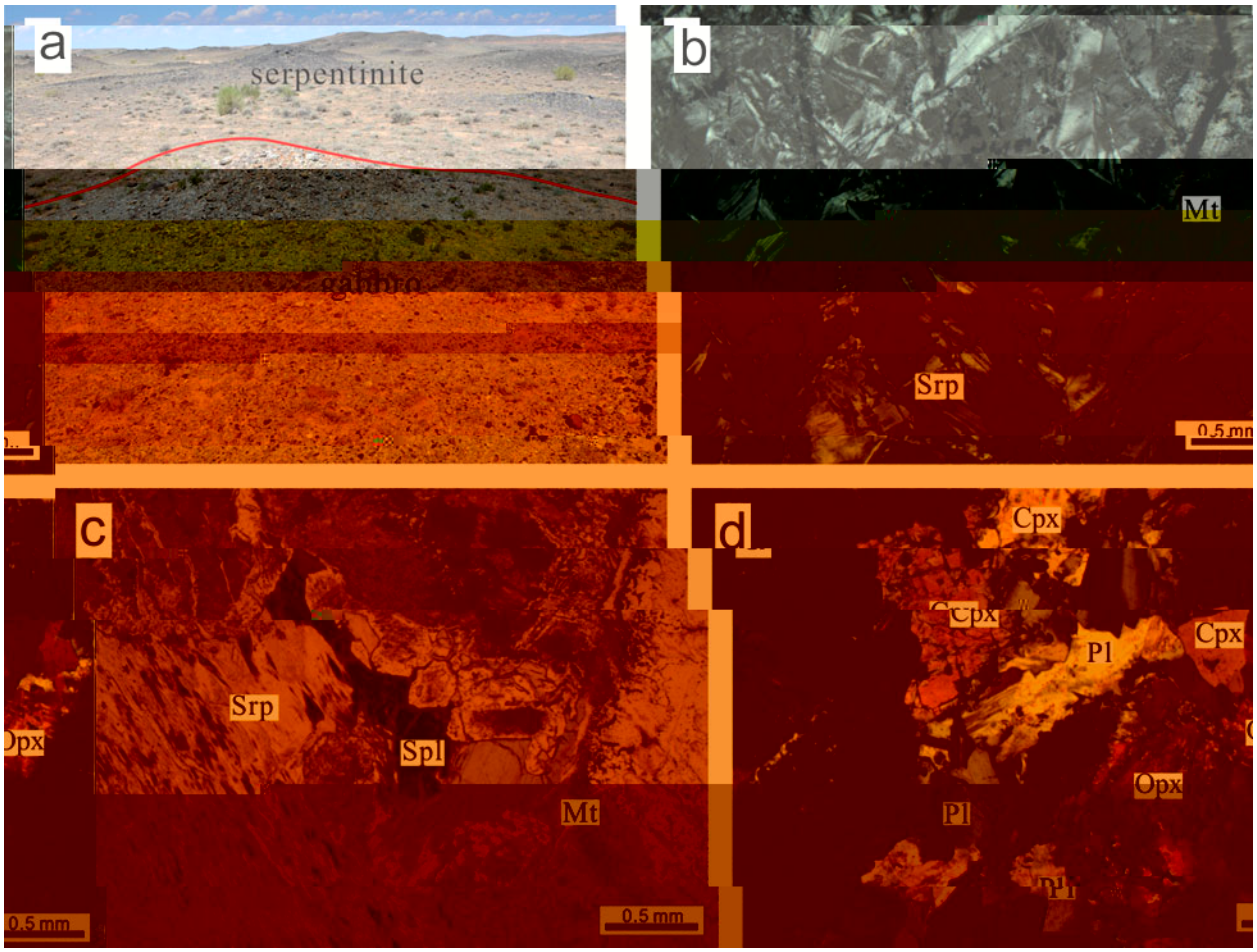
%

%

(, 1 3).



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



3. ( ) . ( ) > 0%
. ( ) %

3. Analytical procedures

3.a. Zircon U–Pb dating and Hf–O isotope analysis

(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*). / = 0.0020052), ( ) δ 5.31 ‰ (et al. 2010*b*). δ 5.44 ± 0.21 ‰ (2), 5.4 ± 0.2 ‰ (et al. 2013). 3 / .

3.b. Mineral analysis

00 15 15

20 4 5 / .

3.c. Whole-rock analysis

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

4. Analytical results

4.a. Zircon U–Pb ages

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] 3	0.61	1., 6	1.04	0.6	0., 0	0. 4	0., 0	1 .2	1, .64	1, .33
[illegible] 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	0.140,			

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
	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
[illegible]	2013 [illegible] 01 5	2013 [illegible] 01 6	2013 [illegible] 01	2013 [illegible] 01	2013 [illegible] 01	2013 [illegible] 03 2	2013 [illegible] 03 3	2013 [illegible] 03 4	2013 [illegible] 03 5	2013 [illegible] 01 3
[illegible]	[illegible]	[illegible]	[illegible] (1)	[illegible] (1)	[illegible] (1)	[illegible] (1)	[illegible] (1)	[illegible] (1)	[illegible] (1)	[illegible] (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
3	1 , ,	1, .5	16.5,	16.1,	15., 3	15.	16. 6	15.55	15.4	1, .61
3	4.52	3.34	.	.11	.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
	4. 6	.3	. 2	.3,	.00	4.52	.31	4. 0	4.0	.11
	0.13	0.11	0.3,	0.31	0.42	2.04	0.33	1.2	2.03	0.1
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
	52., 4	55.5,	-61( )-66	.1(52., 4)-56	4 3..3	13	(55 0.	(16. 6)-56	51(.0.066)-56	45. .05, 6 , (113.2)-6240. (46 25.55)-56 4. 3.2,)-56 4. ( )-636

[illegible] 1. [illegible]

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

Table 1.

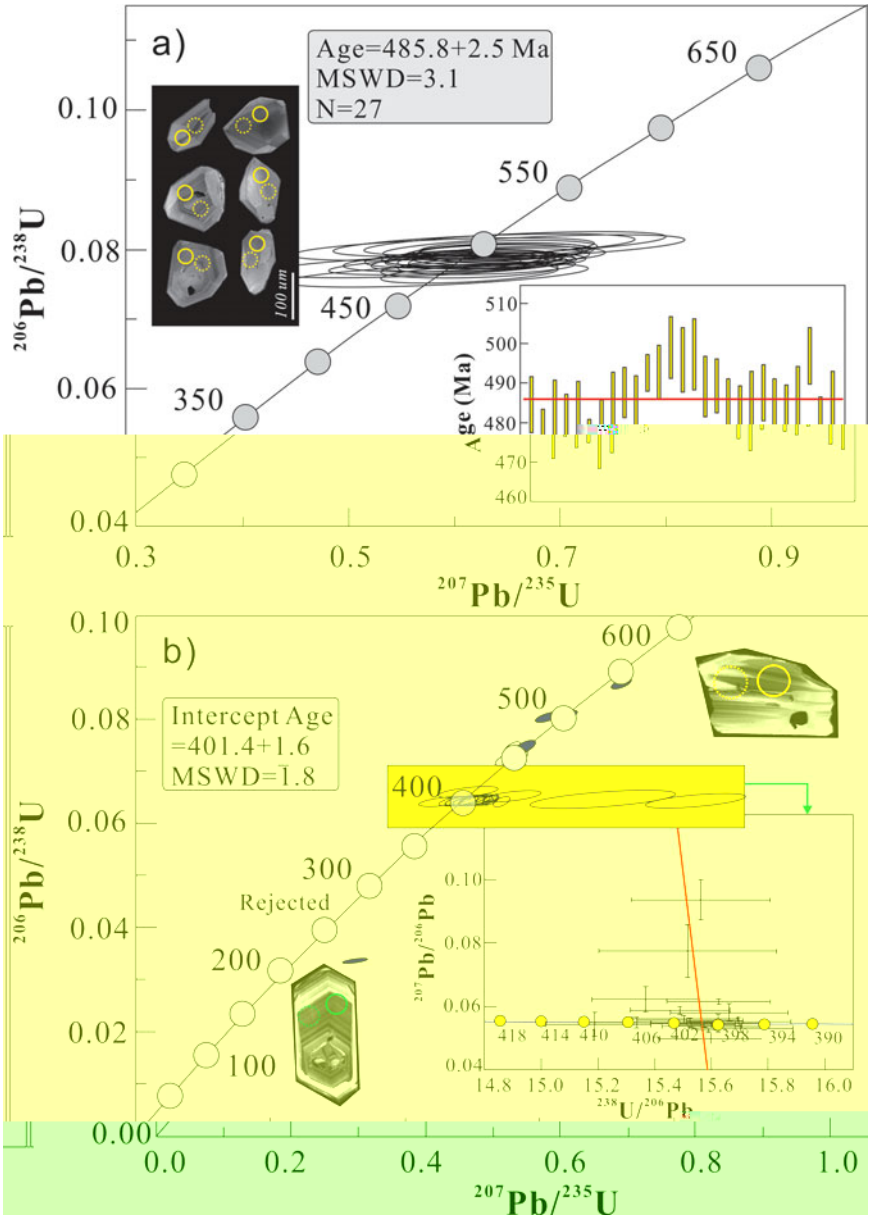
	2013 [illegible] 01_11 [illegible] (r 2)	2013 [illegible] 02_1 [illegible] (r 2)	2013 [illegible] 02_2 [illegible] (r 2)	2013 [illegible] 03_1 [illegible] (r 1)	2013 [illegible] 03_6 [illegible] (r 1)	2013 [illegible] 01_10 [illegible] (r 2)	04/06 [illegible] (r 1)	04/24 [illegible] (r 1)	04/2, [illegible] (r 1)	03/1 [illegible] (r 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] 1 / 04/06, 04/26, 04/2, [illegible] 04/1 [illegible] / [illegible] *et al.* (200, *a*).

2.

2013 01 3 (r 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 (r 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 (r 1)	3.13	2 0	0.0335	0. 06324(20)	0. 06133	4.4,	22.3	0.121	0.51253 3(4)	0.512214	1.
2013 03 2 (r 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 (r 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 (r 1)	.65	14 0	0.01 ,	0. 0422 (51)	0. 04120	4.55	24.5	0.1123	0.512 03(53)	0.51250,	.5

(t) = 10 000((/) (t)/(/) (t)−1) (t) (/), 401



4. ( ) 1σ % 2σ ( ),

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

100 200 μ

/ 1 3. - 1 (r 1) , 0 % % (r 2)

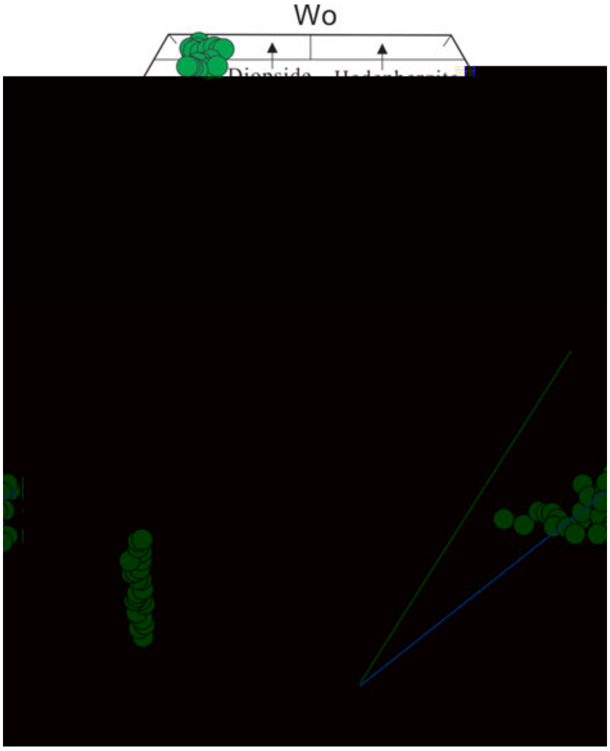


Fig. 5.

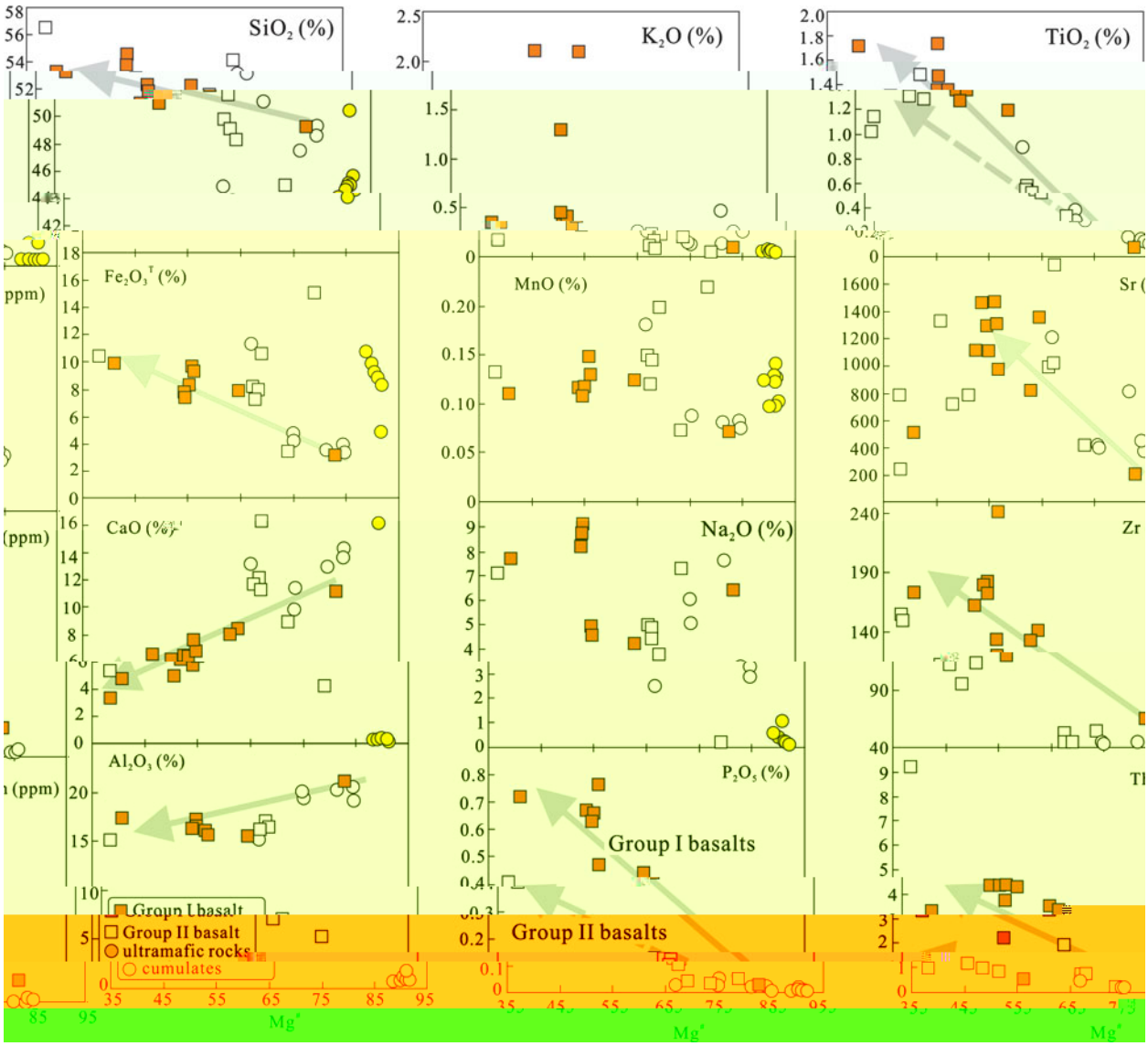
4.b. Mineral compositions

4.b.1. Spinel composition

4.b.2. Pyroxene compositions

4.c. Whole-rock elemental geochemistry

4.c.1. Serpentinites and cumulates



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

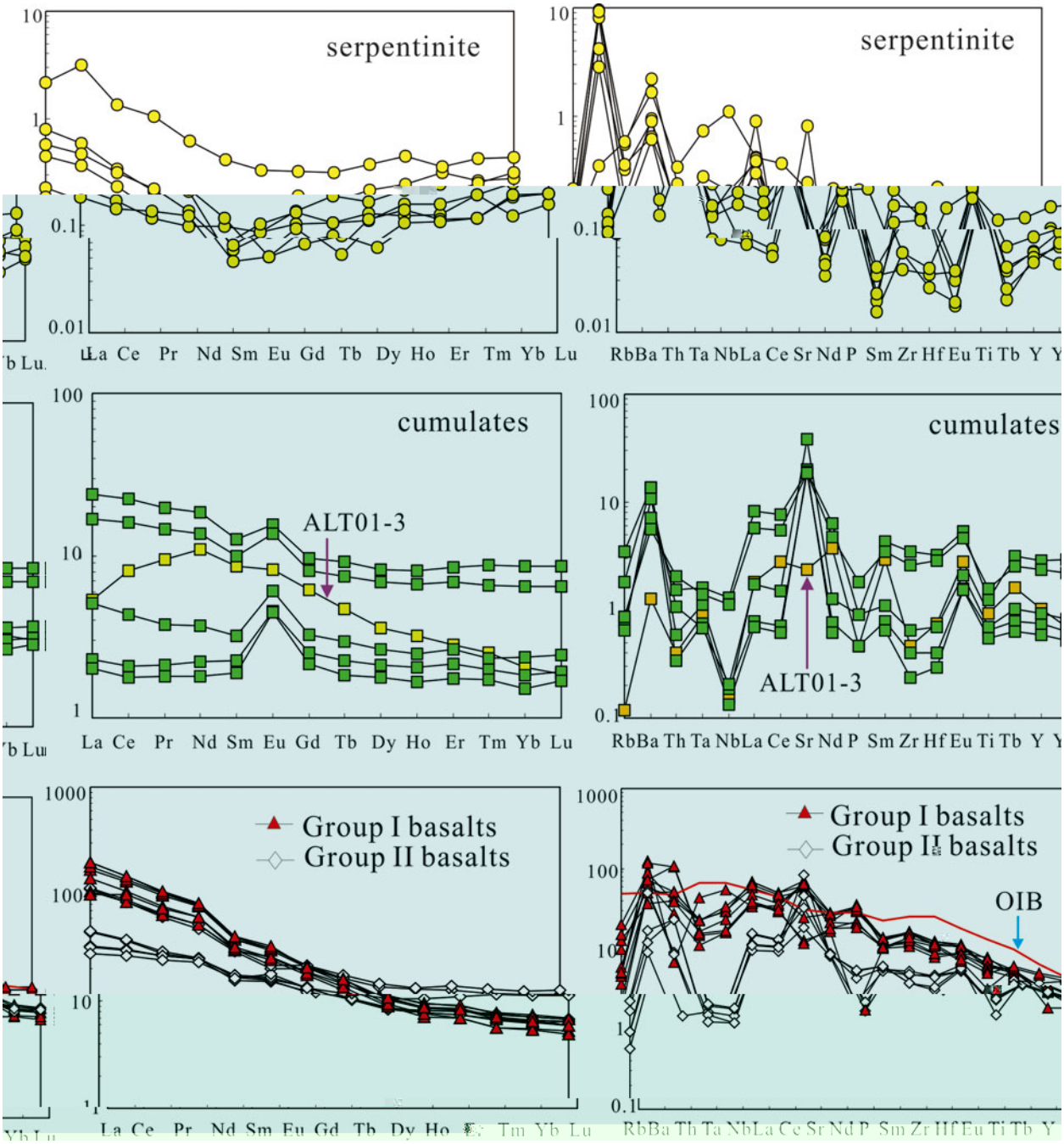
(. 6). 5 11 41 11 , ( ) ( ) = 1.3 2.) (/ = 1.1 2.2). 1 2013 . 01-3 1 , 1 % ( ) ( ), % (/ = 0.2 0.4) 1 .

4.c.2. Basalts

43.15 % 5 .65 % (% 52 %,

1) % , 1 / . / 2 , 1 1 (1) 1 2 (2). 2 1 , 1 % ( ). 1 2 ( ), 2 2 3 , 5, 2, 2 3 1 2 2, 2, 5, 2, (. 6).

1 % 124 11 205 2 50 11 60 11 . 1. (/) 10 30 (% 20)

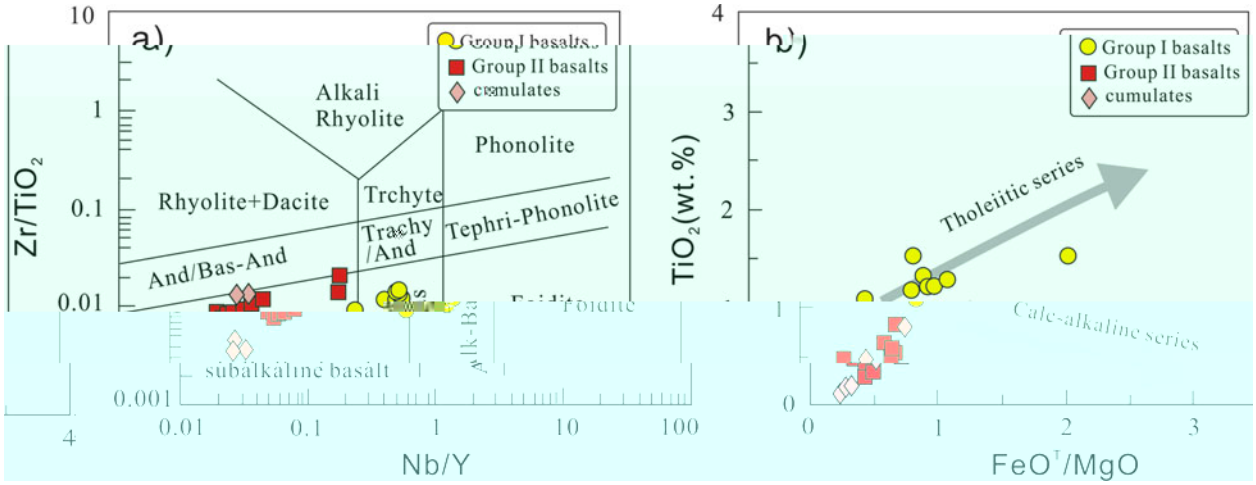


( ) & (1).

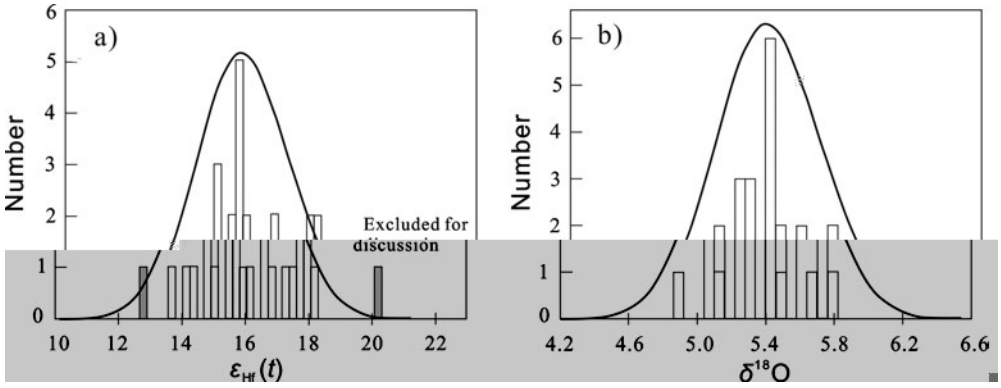
(/ = 0. 0 1.14) ( ). 2. % (/) 4 6 (/ = 1.02 1.21) ( ). 1. 0.44 0. 2. 1. % (~0.11). % ( ).

4. . Whole-rock Sr–N an z.rcon Hf–O .sotopes

% 2. 1. 2. % / (0.0024 0.0452) / (0. 04030 0. 0536), % / (0. 04015 0. 05171, 2013 03 1). % ^{14} /^{144} 0.0, 0.13, 4 ^{143} /^{144} 0.512 0 0.512 3, % $\varepsilon_{Hf}(t)$ +6.3 + .5 (2013 03 1 +1.).



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



( ) / ε (*t*) ( ), 1 1 / /

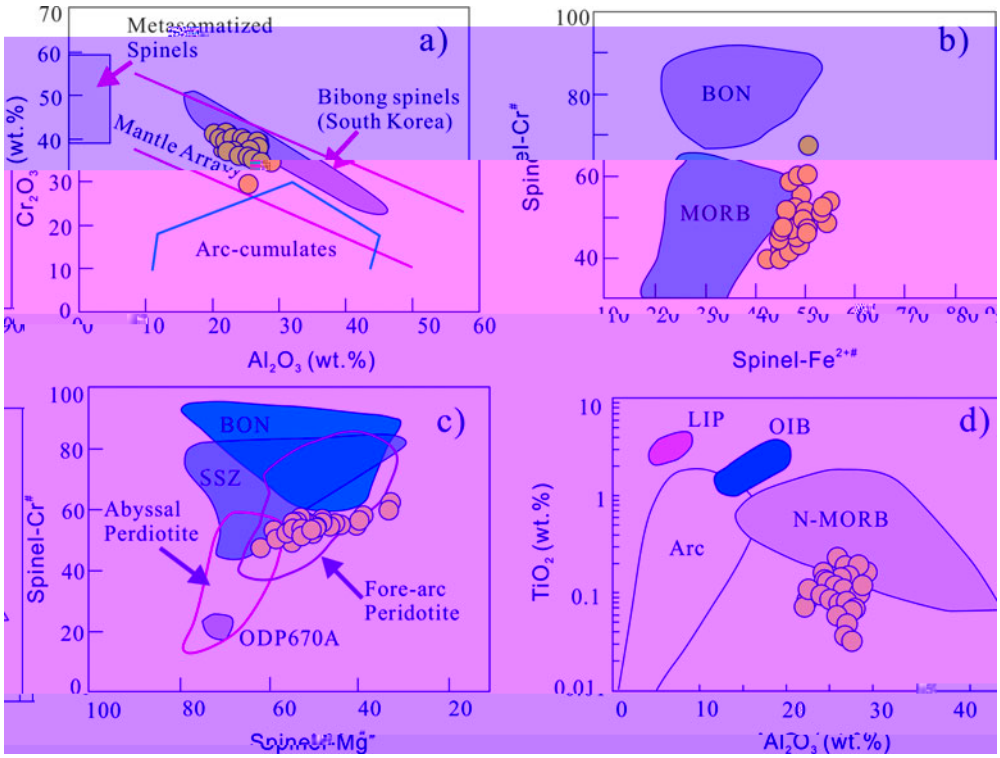
/ (2013 01) - 1 1 % 2 1 // / . /), ε (= 4 5) 13 20. — 2 5 5 . 1 % ε (*t*) (> 16) % % % ε (*t*), % % 15. - δ 4. 1 ‰ 5. 3 ‰, (. .). % 1 - δ 5.3 ± 0.23 ‰ (. .).

~400 ε (*t*) 1.4 .2 6 0 20 . d/ - (*et al.* 200).

5. Discussion

5.a. The ophiolitic members of the Zhaheba ophiolite

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

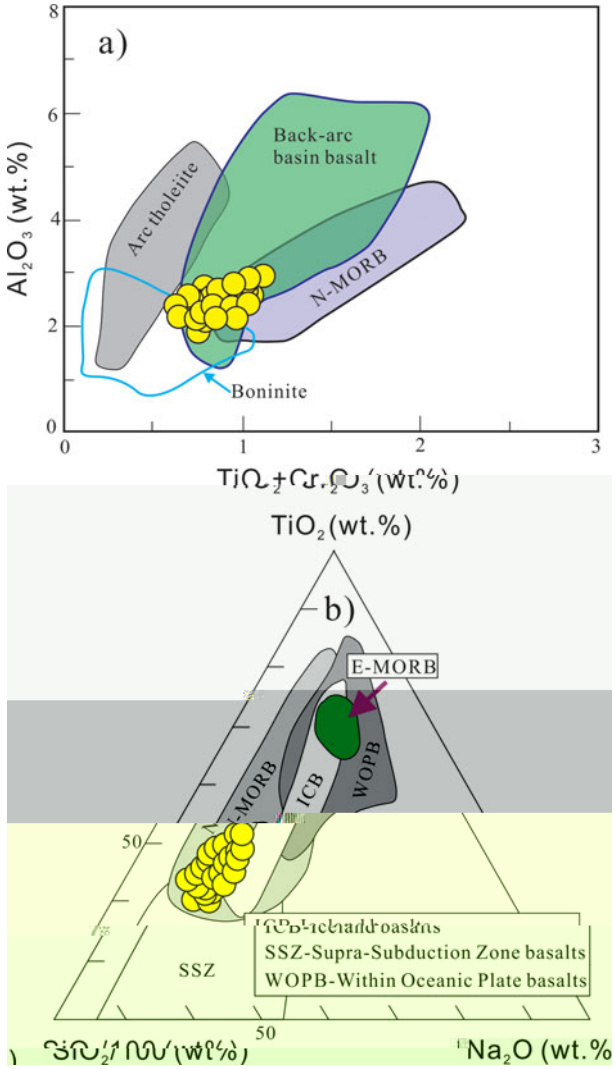


10. ( ) & , 2000). ( ) . (100 /(+)) . (100 2+/(2+ +)) (, 1, 4 & , 2001). ( ) . (100 /(+)) . (100 /(+)) (et al. 1, 5). ( ) 2 3 1 (%) (& , 2001). 4

(500 4 0) (et al. 2003 et al. 2015 %, (430 400) (et al. 200, b, 2014) 1 (3 0 350) (et al. 2003 et al. 2006).

5.b. Or,g,n of the serpent,n,te an cumulates

%, & , 2002 et al. 2010



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

( ) ( ) 5 1% 2 3 . 2 + 2 3 . 11) 2/100 2 2 (. 11) (.).

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

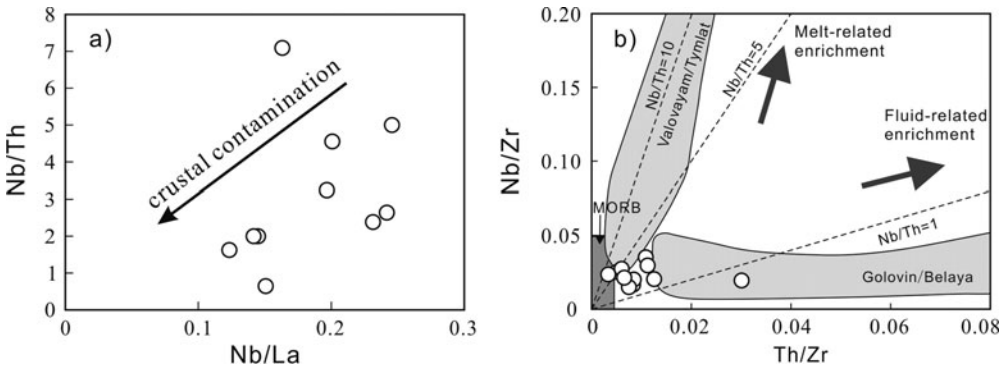
5.c. Petrogenesis of the Devonian basalts

1 2. 1 (11 24 11 15 11), 5 (0.4 0.6 %) (11 15, 60) (/) ( ) (& , 1 2 & , 2001) (. 13).

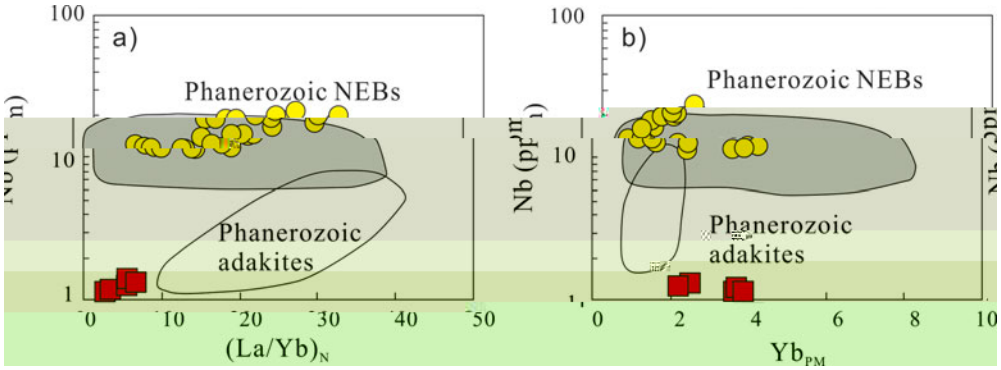
(1) (& % , 2002) (2) % (& 1 2 & , 1 3 et al. 1 6).

(%& , 200 et al. 2011) / (0. 04120 0. 06133) ε (t) (+1. + .5). % / (3.44 20.4) (1.51 2.54) (. & 1 6).

(et al. 1 6 1 6). % & 2000). %(& 1 2 et al. 1 6). et al. (200



12. ( ) / / ( ) 1 / / .

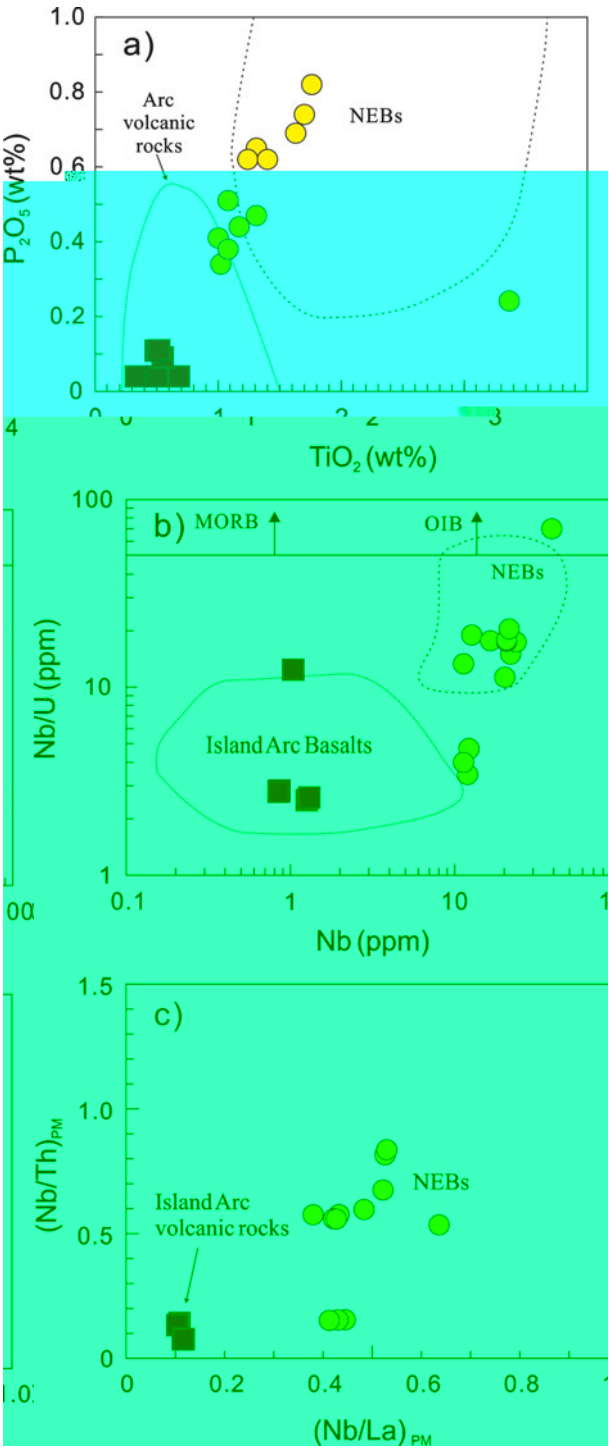


13. ( ) ( ) (/) ( ) 1 .

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

5. . Impl cat ons for the Palaeozo c accret on process n eastern Junggar

(416 *et al.* 2014 *et al.* 2015), (503 4 5 *et al.* 2003 *et al.* 2015 % % 1 (400) (. 1). % % % (*et al.* 2014), % % % % % % % 1- % (*et al.* 200 , 200, *a,b* *et al.* 200, *a*). (*et al.* 200, *b*).



14. ( ) ( ) 5 2 . ( ) ( ) ( ) ( ) ( ) & (1 2) *et al.* (1 5); 1 %

%

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). -% -% % (& 2002 *et al.* 200,). -% -% (*et al.* 2015).

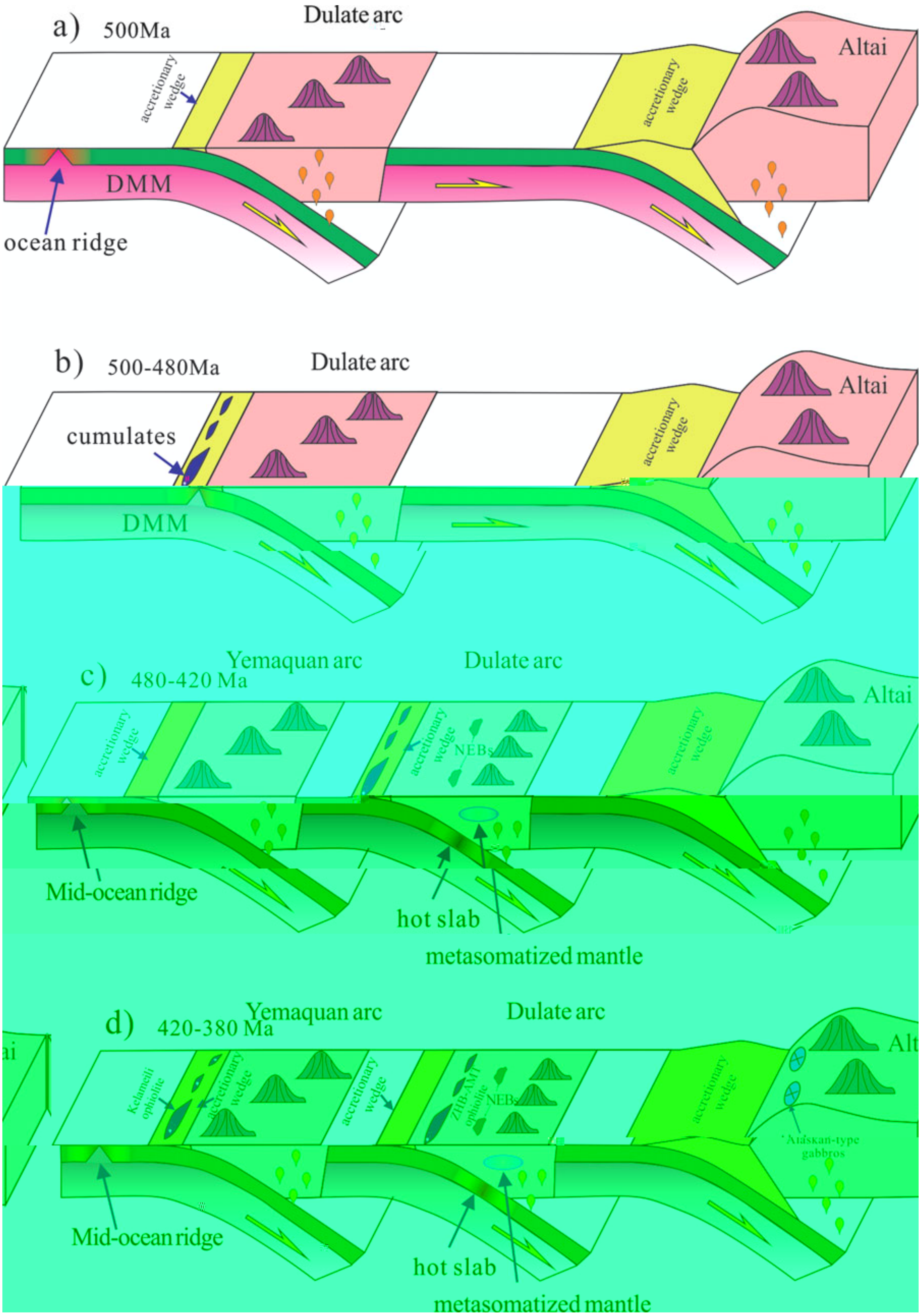
(5.), 1. % - 2 % (1 , 15). *et al.* (200 , 200, *b*) 1 - 1 % (*et al.* 200). (& , 1, , 1 % & , 200 *et al.* 2013).

(. 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
accretionary wedge
accretionary wedge
Altai
DMM
ocean ridge
b) 500-480Ma
Dulate arc
cumulates
accretionary wedge
Altai
DMM
c) 480-420 Ma
Yemaquan arc
Dulate arc
accretionary wedge
accretionary wedge
NEBs
accretionary wedge
Altai
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

15.

(4) (420 3 0) (*et al.* 2014 *et al.* 2015). 1. ( ) 2. % % % (. 15). % % (400 3 0). % % .

6. Conclus.ons

(1) ~4 5 *c.* 400 . % (2) % % (3) % % % % .

Acknowle gements. % 305 (2011 06 03-01).

Supplementary mater.al

11 % 1 //10.101 0016 56 16000042.

References

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

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

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

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

. & . 200 . % *Earth Accretionary Systems in Space and Time* (. &), 11. 1 36. . 31 .

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

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

. . 1 . *Ophiolites* , 220 11.

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

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

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

& . 2003. (2) % *Ophiolites in Earth History* (&), 11. 43 6 . % 21 .

& . 2011 1 . *Geological Society of America Bulletin* **123**, 3 411.

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

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

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

. . & . . 2011. . . *Geological Bulletin of China* **30**, 150 13).

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

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

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

. &. 1, 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 11.

. & . 2015. ( ) . *Gondwana Research*, 1 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 11.

. 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 . . *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.

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

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

. 200 . . *Lithos* **100**, 14 4 .

.2014. . *Elements* **10**, 101 .

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

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

. & . 1, 6. ( ). *Journal of Petrology* **37**, 6, 3 26.

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

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

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

. & . 1 5 . *Nature* **377**, 5, 5 600.

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

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

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

. & 200 . .

. *Science in China Series D – Earth Sciences* **52**, 1345 5 .

. & . 1, . *Magmatism in the Ocean Basin* (. . &), 11. 52 4 . . 42.

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

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

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

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

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

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

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

. & . 2002 . *Journal of Geology* **110**, 1 3, . & . 2006. . *Geology in China* **33**, 4 6 6 ( ).

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

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

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

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

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

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

3. *Regional Geology of the Xinjiang Uygur Autonomous Region*. 11. 2 145 ( ).

2015. *Journal of Asian Earth Sciences* **113**, 5 .

2012. *Gondwana Research* **21**, 246 65.

200 .

Chemical Geology **242**, 22 3, .

2006. *Acta Geologica Sinica* **80**, 254 63 ( ).

2003. *Chinese Science Bulletin* **48**, 2231 5.

2013. *Lithos* **179**, 263 4.

2012. *Journal of Asian Earth Sciences* **52**, 11 33.

200 . *Acta Petrologica Sinica* **24**, 1054 5 ( ).

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