

*

叶海敏 叶现韬 张传林

YE HaiMin, YE XianTao and ZHANG ChuanLin

210016

210016

2013 05 10 2013 08 22

Ye HM Ye XT and Zhang CL. 2013. Geochemistry and geodynamic implications of Nileke Permian volcanic rocks in Western Tianshan NW China. *Acta Petrologica Sinica* 29 10 3389 – 3401

Abstract The terrestrial Nileke Permian volcanic rocks outcrop at the most western section of the Awulale Late Paleozoic volcanic belt. In this contribution we reported petrography elemental and Sr-Nd isotope compositions of the Nileke Permian basaltic rocks in aiming to have a better understanding its geodynamic implications. The Nileke volcanic strata could be divided into two series i. e. the Wulang series lower and the Hamisite seires upper and the diverse rock types include basalts andesites trachytes and rhyolites. In geochemistry the upper Hamisite seires exhibit shoshonitic signatures such as having high K_2O 2.81% ~ 3.91% Sr $> 1000 \times 10^{-6}$ total REE $> 200 \times 10^{-6}$ contents high La/Yb_N 9.7 ~ 11.7 but low Nb/La ratios most < 0.2 and shows. The lower Wulang series could be divided into two sub-groups sub-group one contains the lowest SiO_2 low Sr $< 500 \times 10^{-6}$ total REE $50 \times 10^{-6} < \Sigma REE < 80 \times 10^{-6}$ and low La/Yb_N 1.6 ~ 2.2 but the highest MgO and relatively higher Nb/La ratios > 0.35 . These features are comparable with those of E-MORB suggesting that they could be derived from high-degree partial melting in a decompressing process. Sub-group two has a wide range of geochemical compositions straddling between the Hamisite seires and the sub-group one. The Nileke Permian volcanic rocks have intensive depleted Sr-Nd isotopic compositions similar with those of MORB indicating that they were derived from the time-integrated depleted mantle sources. However their significant depletion in Nb-Ta intensive differentiation and enrichment in LILE argue that the Permian basaltic rocks in Nileke area were derived from a recently metasomatized depleted lithospheric mantle sources. Additionally our study reveals that their chemical signatures were constrained by partial melting degree and crystal fractionation process. In combination with regional geology and previous studies the Nileke Permian volcanic rocks could be genetically related to the Permian Tarim mantle plume.

Key words Nileke Western Tianshan Permian volcanic rocks Geochemistry Tectonic implications

Sr-Nd

 K_2O

2.81% ~ 3.91%	Sr $> 1000 \times 10^{-6}$	$\Sigma REE > 200 \times 10^{-6}$	La/Yb _N 9.7 ~ 11.7	Nb/La	$<$
0.2	低	SiO_2 MgO	Sr $< 500 \times 10^{-6}$	$50 \times 10^{-6} < \Sigma REE < 80 \times 10^{-6}$	
La/Yb _N 1.6 ~ 2.2		Nb/La > 0.35		E-MORB	

Sr-Nd

MORB

Nb-Ta

*

973 2011CB808903

1973

E-mail yhaimin@sina.com

P588. 14

290Ma 275Ma

1

A

2

Zhou 2006 1994 2005

Han 1997 Jahn 2004

" "

A

1

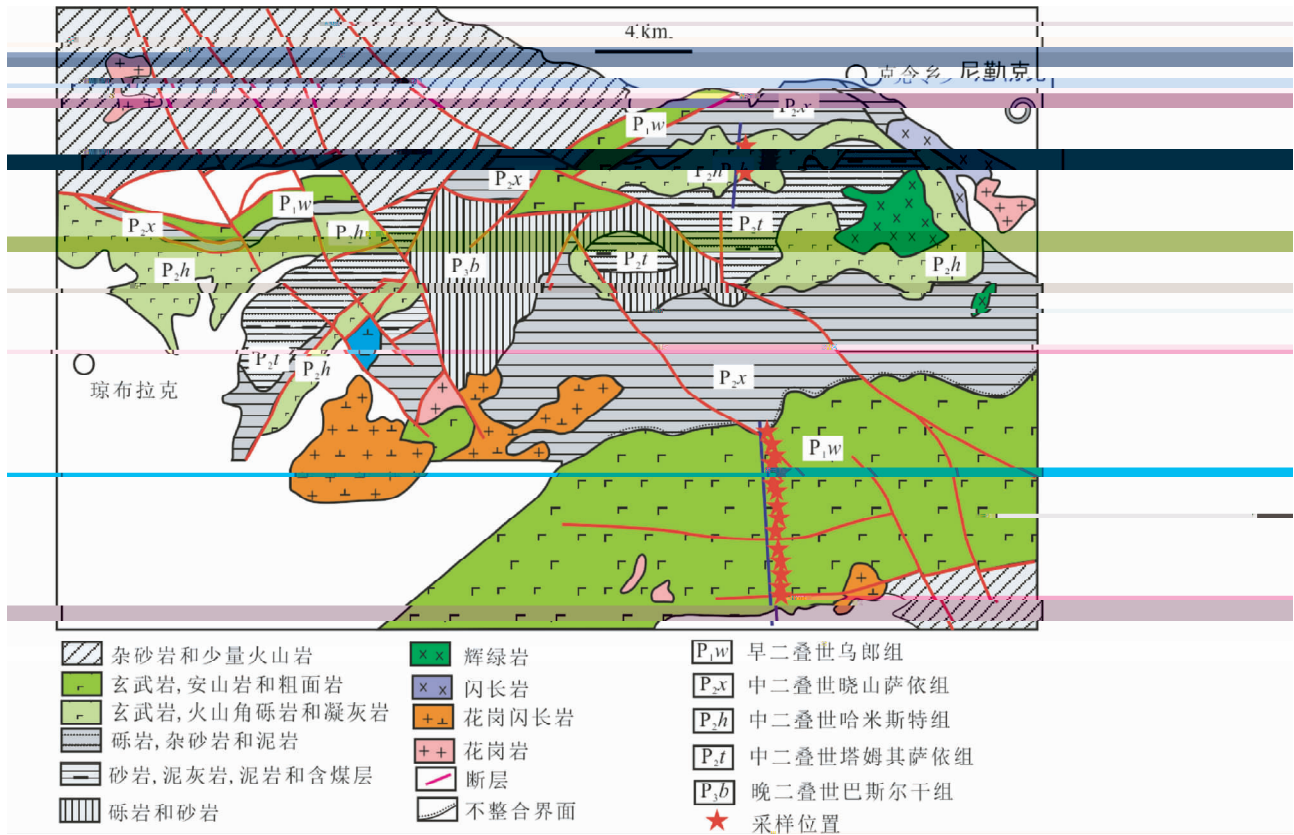
Zhou

2004 2009 Zhang 2008 2010a b Zhang and Zou

2013a b Pirajno 2008 2009 Borisenko 2006

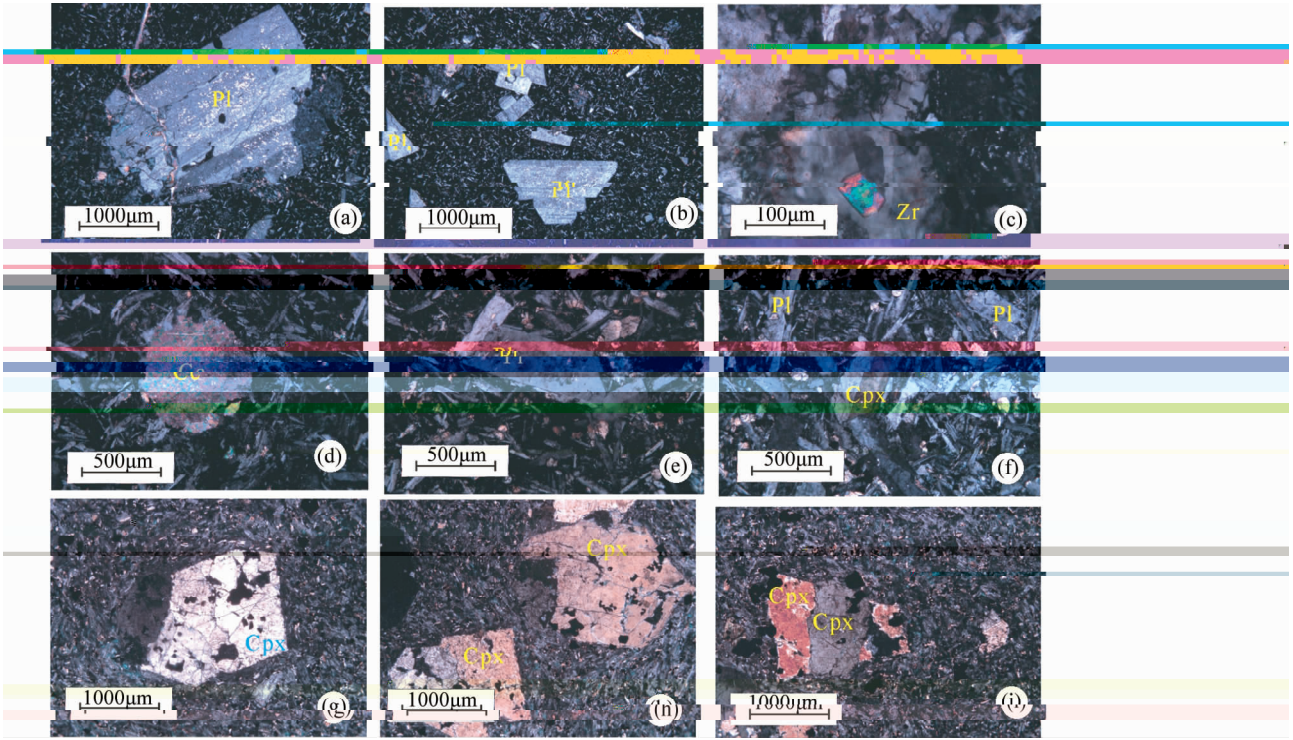
Mao 2008 Polyakov 2008 Tian 2010

50



1

Fig.1 Geological map of Nileke Xinjiang



2
 a b e - Pl c - Zr d - Cc f -
 Cpx g-i -

Fig. 2 Microphotographs showing petrologic characteristics of the Nileke Permian volcanic rocks
 a b e -tabular plagioclase phenocrysts of basalt c -zircon of basalt d -blowhole filled with calcites of basalt f -clinopyroxenes together with
 plagiocalses of basalt g-i -euhedral/semi-euhedral clinopyroxene phenocrysts of basalt

264km²
 2600m

200m

2

1

60% 2 ~

2

12mm
 3%

16%

3

1 Table 1	Major element	wt% and trace element compositions of the Permian Nileke volcanic rocks								
		WT03-1	WT03-2	WT03-3	WT03-4	WT03-5	WT03-6	WT03-7	WT04-2	WT04-5
		$\times 10^{-6}$								
SiO ₂	47.72	51.58	51.71	49.87	51.36	51.56	51.79	62.91	51.11	51.18
TiO ₂	1.48	1.50	1.56	1.51	1.55	1.55	1.55	0.77	1.57	1.53
Al ₂ O ₃	15.56	15.20	15.85	15.63	15.76	15.95	15.72	16.87	15.81	15.66
Fe ₂ O ₃	9.71	10.49	10.41	10.21	10.62	10.75	10.58	5.45	10.70	10.35
MnO	0.21	0.12	0.23	0.22	0.19	0.18	0.15	0.02	0.14	0.14
CaO	9.30	6.89	7.77	8.23	7.61	8.05	7.18	5.25	6.99	7.95
MgO	3.97	4.23	4.05	3.99	4.17	3.88	4.11	1.94	3.91	3.92
K ₂ O	3.21	3.91	3.10	3.11	2.94	2.81	3.39	1.41	3.73	3.48
Na ₂ O	2.97	3.20	3.36	3.49	3.60	3.45	3.45	4.24	3.35	3.22
P ₂ O ₅	0.53	0.60	0.66	0.63	0.65	0.64	0.64	0.33	0.65	0.65
LOI	5.47	2.18	1.15	3.02	1.38	1.02	1.30	0.69	1.88	1.78
Total	100.12	99.90	99.84	99.92	99.83	99.84	99.85	99.87	99.85	99.84
Mg [#]	57	57	56	56	56	54	56	54	55	55
La	30.92	33.71	40.09	39.88	41.09	40.44	40.66	12.97	41.80	40.90
Ce	73.21	80.18	97.81	97.21	99.83	99.24	98.68	31.20	101.2	99.66
Pr	9.93	11.03	13.61	13.53	13.90	13.71	13.75	4.40	14.50	14.24
Nd	41.94	46.49	58.26	57.42	59.07	58.48	58.30	20.06	61.81	61.09
Sm	7.85	8.62	10.57	10.36	10.66	10.58	10.49	4.95	10.92	10.70
Eu	2.35	2.48	3.00	2.87	2.93	2.95	2.95	1.55	3.01	2.95
Gd	6.56	7.09	8.33	8.07	8.45	8.35	8.44	5.08	8.60	8.44
Tb	0.91	0.93	1.13	1.10	1.13	1.11	1.13	0.89	1.13	1.11
Dy	4.75	4.62	5.78	5.44	5.60	5.49	5.60	5.75	5.69	5.47
Ho	0.91	0.85	1.09	1.02	1.04	1.03	1.06	1.25	1.08	1.04
Er	2.50	2.29	3.00	2.81	2.82	2.81	2.90	3.56	2.91	2.80
Tm	0.37	0.34	0.45	0.42	0.43	0.42	0.44	0.53	0.42	0.40
Yb	2.28	2.06	2.79	2.56	2.59	2.56	2.64	3.39	2.69	2.59
Lu	0.34	0.31	0.42	0.38	0.40	0.40	0.39	0.54	0.40	0.39
Rb	116.5	170.6	81.14	58.96	63.49	61.55	89.53	50.35	85.79	79.55
Ga	20.43	20.89	20.72	19.52	20.70	20.12	19.90	17.84	20.27	21.26
V	227.5	230.1	227.0	222.7	222.6	219.1	219.9	28.52	225.9	223.5
Cr	116.2	127.0	78.84	77.63	75.56	62.97	67.76	28.86	69.99	71.20
Ni	66.32	58.77	38.96	33.88	35.99	35.80	37.09	2.62	37.25	36.84
Sc	23.14	22.56	23.06	21.99	22.52	21.69	22.17	17.54	22.15	21.94
Sr	1157	1627	1915	1992	1979	1904	1892	472	2330	1974
Ba	1153	937	1037	1077	977	1010	1115	286	1166	1099
Th	3.29	3.41	4.18	3.96	4.14	3.95	3.99	2.13	4.17	4.19
U	0.76	0.79	0.94	1.01	0.93	0.89	0.93	0.84	0.97	1.08
Ta	0.33	0.31	0.31	0.30	0.30	0.29	0.30	0.27	0.30	0.31
Nb	5.86	5.60	5.32	5.21	5.35	5.18	5.27	3.71	5.40	5.46
Zr	149.4	151.4	183.2	180.2	186.5	177.4	178.7	99.79	184.2	184.1
Hf	3.77	3.87	4.66	4.60	4.77	4.49	4.59	2.94	4.68	4.70
Y	23.73	23.61	29.52	27.46	27.96	27.41	28.07	31.71	27.64	26.58
	WT04-21	WT09-1	WT09-2	WT09-3	WT09-5	WT09-6	WT09-7	WT010-1	WT010-2	WT010-3
	郎									
SiO ₂	51.04	50.89	50.91	49.73	52.48	50.95	53.16	48.09	47.79	48.84
TiO ₂	1.53	1.31	1.29	1.40	1.35	1.25	1.25	1.24	1.27	1.62
Al ₂ O ₃	15.83	16.22	15.95	16.92	15.65	16.53	15.64	17.59	17.99	14.60
Fe ₂ O ₃	10.50	10.38	10.30	12.22	9.97	9.99	10.87	10.21	10.34	10.29
MnO	0.23	0.42	0.39	0.66	0.16	0.16	0.18	0.32	0.50	0.51
CaO	7.40	5.03	5.43	2.83	5.92	9.05	4.62	8.40	6.03	6.60
MgO	4.30	5.70	5.62	5.01	4.88	5.65	4.49	6.63	6.89	4.68
K ₂ O	3.59	1.92	1.70	1.47	0.90	1.26	0.89	1.59	2.43	1.49

1

Continued Table 1

	WT04-21	WT09-1	WT09-2	WT09-3	WT09-5	WT09-6	WT09-7	WT010-1	WT010-2	WT010-3
郎										
Na ₂ O	3.14	4.42	4.66	5.43	5.44	2.60	5.90	2.67	3.00	3.39
P ₂ O ₅	0.65	0.56	0.56	0.60	0.60	0.22	0.54	0.21	0.22	0.64
LOI	1.63	3.09	3.11	3.66	2.57	2.21	2.34	2.96	3.48	7.72
Total	99.85	99.92	99.92	99.94	99.90	99.88	99.88	99.91	99.93	100.38
Mg [#]	57	64	64	57	62	65	58	68	69	60
La	41.59	29.80	27.71	27.88	30.58	14.51	31.90	6.94	5.51	32.45
Ce	101.5	65.12	63.25	65.56	69.31	33.35	68.31	17.75	14.24	71.23
Pr	14.48	8.51	8.31	8.65	9.04	4.76	8.77	2.70	2.26	9.45
Nd	61.81	34.04	34.00	35.01	37.26	21.04	34.38	12.94	11.38	38.52
Sm	10.86	6.55	6.52	6.92	7.47	4.98	6.41	3.52	3.36	7.26
Eu	3.02	1.73	1.78	1.72	2.11	1.70	1.78	1.24	1.25	1.99
Gd	8.42	5.94	5.89	6.18	6.74	5.05	5.84	3.66	3.60	6.60
Tb	1.13	0.88	0.88	0.92	0.97	0.88	0.88	0.68	0.68	0.99
Dy	5.65	5.02	4.92	5.25	5.51	5.53	4.94	4.31	4.38	5.54
Ho	1.05	0.99	0.99	1.05	1.10	1.19	0.99	0.91	0.92	1.13
Er	2.86	2.78	2.70	2.86	3.00	3.27	2.74	2.44	2.55	3.06
Tm	0.42	0.40	0.40	0.42	0.44	0.50	0.39	0.38	0.39	0.43
Yb	2.69	2.52	2.47	2.62	2.78	3.17	2.52	2.31	2.42	2.82
Lu	0.39	0.40	0.38	0.40	0.43	0.49	0.37	0.36	0.37	0.42
Rb	75.06	70.66	62.85	53.85	30.22	40.00	28.35	86.44	197.1	72.51
Ga	20.86	18.08	19.20	28.40	18.65	17.53	18.40	17.32	17.11	17.67
V	213.4	221.9	217.5	225.9	228.1	201.3	209.3	253.9	249.2	219.6
Cr	68.33	96.69	91.10	104.3	68.20	110.5	54.85	164.1	169.6	70.99
Ni	34.40	42.38	38.80	43.13	26.22	86.40	31.79	71.56	70.06	18.66
Sc	21.64	27.73	27.23	28.32	27.93	29.30	25.53	34.32	34.30	26.14
Sr	2131	451.7	351.8	252.1	311.3	292.6	232.7	394.4	462.1	96.50
Ba	1173	492.6	496.8	507.9	297.9	271.4	183.1	388.8	599.5	184.7
Th	4.22	2.63	2.57	2.77	3.25	2.75	2.93	0.70	0.70	3.70
U	0.93	0.81	0.78	0.92	1.03	0.85	1.00	0.24	0.27	0.99
Ta	0.31	0.56	0.54	0.59	0.60	0.34	0.55	0.19	0.19	0.58
Nb	5.34	9.40	9.24	10.00	10.13	4.58	9.15	2.44	2.51	9.44
Zr	181.8	211.6	209.2	225.7	231.9	198.2	204.7	96.71	98.82	220.4
Hf	4.65	4.78	4.63	5.05	5.17	4.54	4.52	2.47	2.51	5.15
Y	27.19	25.32	25.01	26.43	28.32	28.90	25.27	23.42	23.87	28.18
郎										
	WT010-6	WT010-7	WT011-1	WT011-2	WT011-3	ZK03	WT012-1	WT012-2-1	WT012-2-2	
SiO ₂	67.42	67.92	54.93	57.67	50.74	54.91	47.45	54.14	56.47	
TiO ₂	0.44	0.43	1.06	1.16	1.18	1.06	1.98	1.20	2.04	
Al ₂ O ₃	15.77	15.55	14.43	14.58	15.83	15.28	18.15	16.63	14.66	
Fe ₂ O ₃	3.75	3.86	10.74	9.87	10.99	9.79	12.17	9.81	8.89	
MnO	0.11	0.09	0.54	0.30	0.63	0.48	1.32	0.70	0.35	
CaO	2.84	1.58	3.63	5.34	4.79	5.32	2.75	3.08	5.89	
MgO	1.02	1.06	4.74	2.81	5.34	3.44	5.97	2.45	3.04	
K ₂ O	3.37	3.45	3.75	3.63	3.57	3.93	0.32	4.93	3.27	
Na ₂ O	3.91	4.67	2.93	2.69	3.25	2.51	5.20	3.57	2.54	
P ₂ O ₅	0.18	0.18	0.37	0.48	0.42	0.37	0.31	0.50	0.92	
LOI	1.08	1.09	2.79	1.33	3.15	2.85	4.32	2.90	1.82	
Total	99.88	99.88	99.91	99.86	99.91	99.95	99.94	99.90	99.89	
Mg [#]	47	47	59	48	62	54	62	45	53	
La	24.72	17.64	12.17	20.79	15.57	16.21	6.96	18.72	21.60	
Ce	49.61	37.15	30.21	49.02	37.79	36.77	20.67	44.21	52.62	
Pr	5.98	4.78	4.31	6.65	5.27	5.01	3.48	5.91	7.67	

1

Continued Table 1

	WT010-6	WT010-7	WT011-1	WT011-2	WT011-3	ZK03	WT012-1	WT012-2-1	WT012-2-2
	郎								
Nd	22.66	19.03	19.26	28.94	23.60	21.73	17.22	25.41	35.25
Sm	4.08	3.85	4.82	6.78	5.77	5.10	5.05	6.11	8.27
Eu	1.17	1.01	1.02	1.55	1.25	1.24	1.33	1.24	4.91
Gd	3.81	3.56	4.83	6.58	5.67	5.01	5.19	6.12	8.31
Tb	0.57	0.56	0.85	1.13	0.98	0.86	1.00	1.10	1.36
Dy	3.30	3.41	5.43	7.07	6.23	5.25	6.39	6.99	8.17
Ho	0.71	0.74	1.17	1.48	1.32	1.12	1.35	1.52	1.72
Er	2.08	2.14	3.35	4.15	3.70	3.09	3.62	4.22	4.65
Tm	0.33	0.34	0.51	0.65	0.59	0.48	0.52	0.67	0.67
Yb	2.25	2.33	3.28	4.07	3.68	3.01	3.22	4.13	4.21
Lu	0.38	0.37	0.50	0.61	0.56	0.47	0.49	0.62	0.64
Rb	103.4	108.4	188.2	188.7	191.4	186.0	13.70	232.8	85.68
Ga	15.24	14.54	14.51	16.68	16.34	16.18	25.28	19.53	17.45
V	42.48	45.59	244.0	203.9	268.1	267.2	234.5	214.8	99.53
Cr	28.37	36.90	74.77	48.06	81.26	86.08	315.70	51.42	24.52
Ni	2.25	2.59	22.00	13.64	25.22	21.60	211.7	12.65	5.09
Sc	10.34	9.97	30.77	29.55	32.97	32.54	36.02	30.07	27.71
Sr	302.6	147.5	234.9	289.4	310.4	285.1	337.7	294.7	365.8
Ba	513.9	498.6	500.8	428.8	499.8	506.8	143.6	1177	1831
Th	6.35	4.74	8.47	11.00	9.66	8.45	0.47	11.51	5.91
U	1.18	1.21	2.47	3.30	3.08	2.66	0.34	3.36	1.80
Ta	0.45	0.42	0.44	0.57	0.49	0.45	0.33	0.60	0.52
Nb	5.35	5.22	6.16	8.06	6.94	6.26	4.32	8.28	6.55
Zr	128.1	127.9	176.0	229.9	200.3	177.4	149.1	242.4	207.5
Hf	3.47	3.48	4.84	6.28	5.41	4.82	3.49	6.47	5.21
Y	19.14	20.05	31.82	39.12	35.30	29.94	36.48	42.73	41.72

2

Sm-Nd

Table 2 Sm-Nd isotopic compositions of the Permian Nileke volcanic rocks

	Rb $\times 10^{-6}$	Sr $\times 10^{-6}$	$\frac{87\text{Rb}}{86\text{Sr}}$	$\frac{87\text{Sr}}{86\text{Sr}}$ 2	$\left(\frac{87\text{Sr}}{86\text{Sr}}\right)_i$	Sm $\times 10^{-6}$	Nd $\times 10^{-6}$	$\frac{147\text{Sm}}{144\text{Nd}}$	$\frac{143\text{Nd}}{144\text{Nd}}$ 2	$\left(\frac{143\text{Nd}}{144\text{Nd}}\right)_i$	Nd		
wt03-2	170.6	1627	0.3033	0.70560	5	0.70439	8.62	46.49	0.112097	0.512692	9	0.512487	4.08
wt09-6	40	292.6	0.3954	0.70543	3	0.70385	4.98	21.04	0.142965	0.512846	3	0.512584	5.98
wt10-1	86.44	394.4	0.6341	0.70680	4	0.70427	3.52	12.94	0.164465	0.512893	4	0.512592	6.13
wt10-2	197.1	462.1	1.2343	0.70944	2	0.70452	3.36	11.38	0.17851	0.512888	4	0.512561	5.53
wt10-3	72.51	96.5	2.1751	0.71307	5	0.70440	7.26	38.52	0.113945	0.512681	9	0.512472	3.80
wt10-6	103.4	302.6	0.9887	0.70794	8	0.70400	4.08	22.66	0.108855	0.512725	8	0.512525	4.84
wt11-2	188.7	289.4	1.8873	0.71184	6	0.70432	6.78	28.94	0.141641	0.512805	4	0.512545	5.23
wt11-3	191.4	310.4	1.7834	0.70429	5	0.69718	5.77	23.60	0.147816	0.512813	6	0.512542	5.17
wt12-1	13.7	337.7	0.1173	0.70524	8	0.70477	5.05	17.22	0.177308	0.512951	5	0.512626	6.80

Note Isotopic results normalized to $^{86}\text{Sr}/^{86}\text{Sr} = 0.1194$ and $^{146}\text{Nd}/^{144}\text{Nd} = 0.7219$. NBS 987 average Sr standard = 0.71025 ± 1 and Jndi-1 Nd standard = 0.51212 ± 1.1 in this study. Initial isotope ratios and epsilon values calculated at 280Ma using present day bulk Earth-CHUR values of $^{87}\text{Rb}/^{86}\text{Sr} = 0.07809$ $^{87}\text{Sr}/^{86}\text{Sr} = 0.7045$ $^{147}\text{Sm}/^{144}\text{Nd} = 0.19667$ and $^{143}\text{Nd}/^{144}\text{Nd} = 0.512638$

		Perkin-Elmer Sciex Elan 6000							
		1 ~ 5mm		ICP-MS		40mg		bomb	
5%		5%		HNO_3 HF				Rh	
		200		USGS		W-2 G-2		GSR-I	
				GSR-2 GSR-3					
Rigaku 100e X		XRF		2% ~ 5%		1996			
1% ~ 5%		Li		2009					

MC-ICPMS Sr NBS987
 Sr-GIG $^{87}\text{Sr}/^{86}\text{Sr}$ $^{86}\text{Sr}/^{88}\text{Sr} = 0.1194$
 2002 Nd
 JNdi-1 Nd-GIG $^{143}\text{Nd}/^{144}\text{Nd}$
 $^{146}\text{Nd}/^{144}\text{Nd} = 0.7219$ 2003
 Sr Nd 0.002%

4
 4.1
 11 18
 1 Sm-Nd

2
 -SiO₂ TAS 3a
 WT04-2
 TAS K Na
 Ti Zr Y Nb
 Zr/TiO₂-Nb/Y 3b

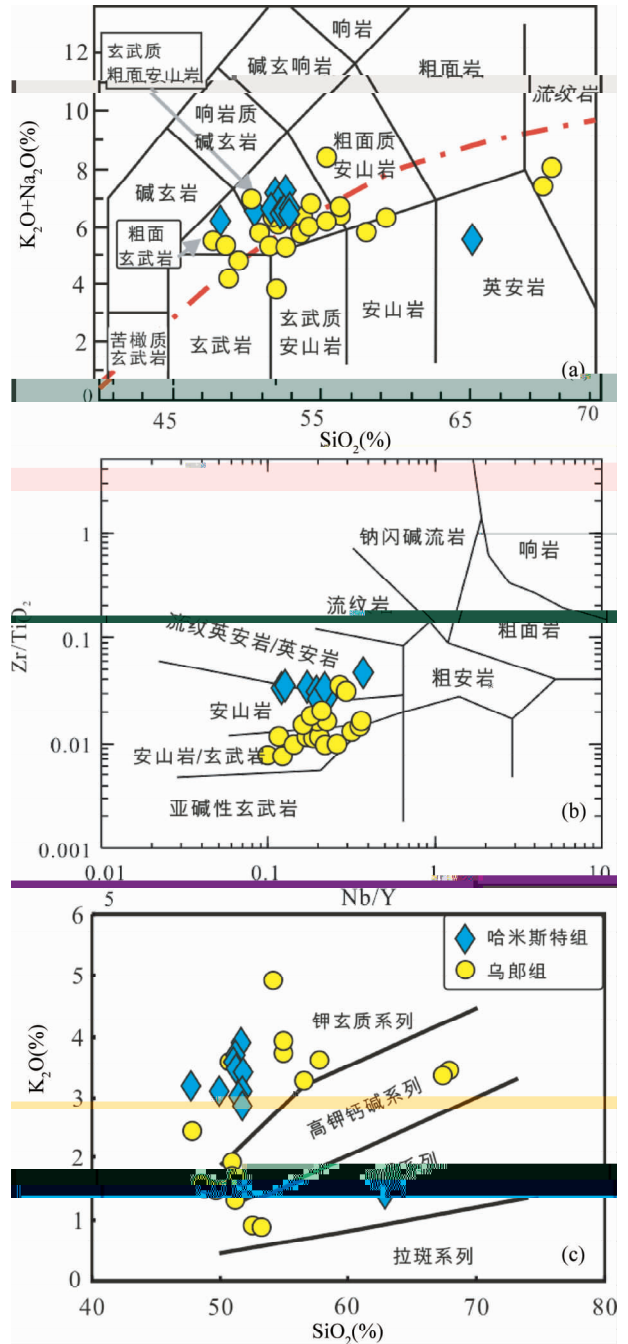
SiO₂ 47.72% ~
 51.71% TiO₂ 1.48% ~ 1.57% K₂O 2.81% ~
 3.91% K₂O/Na₂O 0.81 ~ 1.22 Al₂O₃ 15.20% ~
 15.95% 3a 4 1 K₂O-SiO₂

3c
 WT04-2
 4 WT04-2
 SiO₂ CaO
 郎
 3a 4 K₂O-SiO₂

SiO₂ MgO TiO₂
 CaO Al₂O₃ FeO MnO P₂O₅

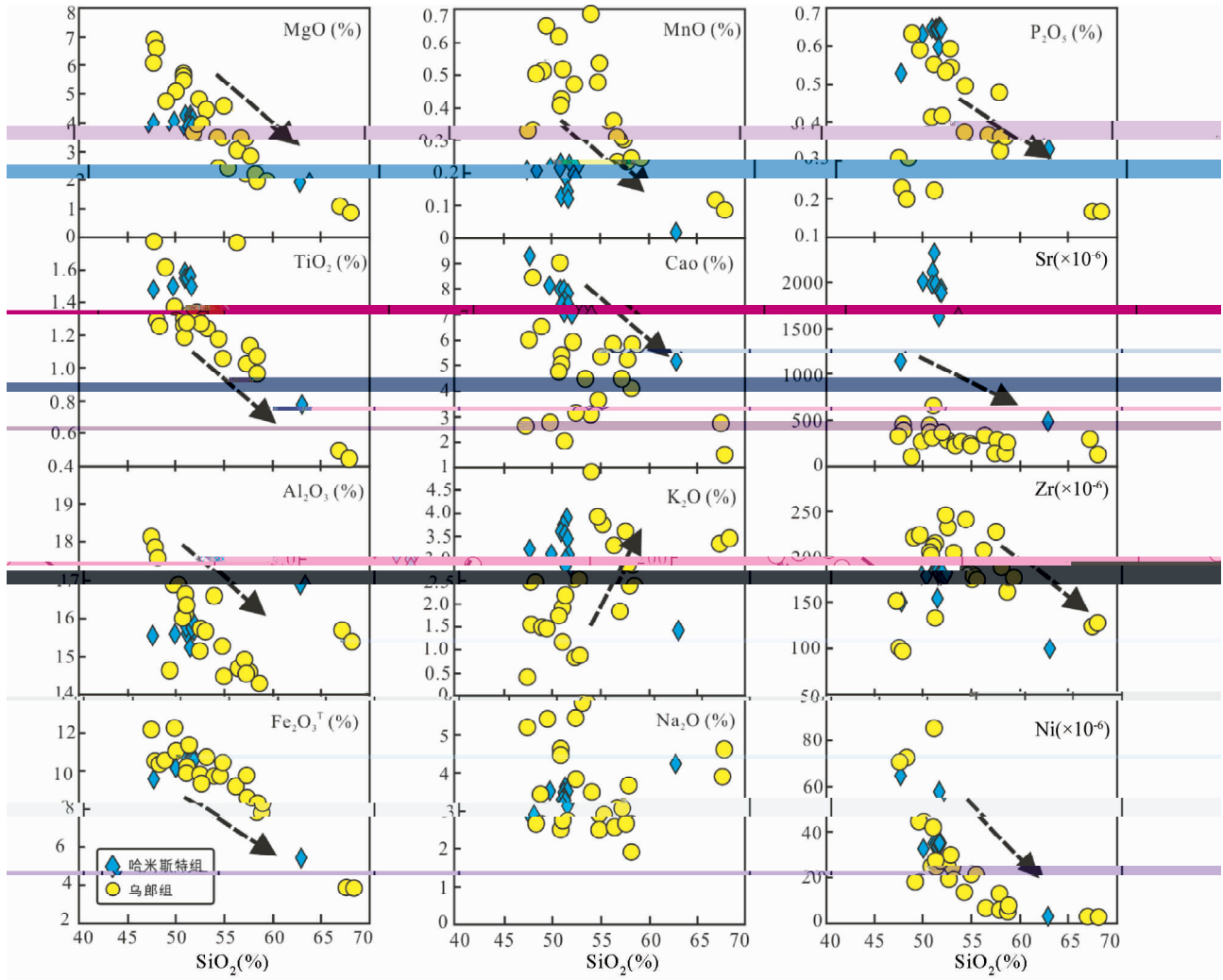
>10% SiO₂ 3a
 Al₂O₃ K₂O Na₂O Sr SiO₂ 5a b

4
 4.2



3
 Fig. 3 Classification of types and series of the Nileke Permian volcanic rocks

$184.8 \times 10^{-6} \sim 256.2 \times 10^{-6}$ La/Yb_N
 $= 9.7 \sim 11.7$ WT04-2
 96.1×10^{-6} La/Yb_N 2.7 5a Eu
 $\text{Eu}/\text{Eu}^* = 0.91 \sim 0.97$ $\Sigma\text{REE} = 53.1 \times 10^{-6} \sim$
 181.9×10^{-6} La/Yb_{N} = 1.6 \sim 9.1 Eu Eu}



4

Fig. 4 Harker diagram of the Nileke Permian volcanic rocks

$Eu/Eu^* = 0.61 \sim 1.79$

5a 5b

WT010-1 WT010-2

4.3 Sr-Nd

WT012-1

Sr-Nd

6

5b

$\Sigma REE = 53.3 \times 10^{-6} \sim$

郎

76.5×10^{-6} La/Yb_N = 1.6 ~ 2.2 Eu/Eu* = 0.79 ~

Sr-Nd

Nd

1.09

E-MORB

Sr

Nd

= 3.8 ~ 6.8

$^{87}Sr/^{86}Sr_i = 0.69718 \sim$

5c d

0.70477

OIB

Rb Ba Th K Sr 1157 ×

MORB

Sr-Nd

$10^{-6} \sim 2330 \times 10^{-6}$ WT04-2 = 472×10^{-6} Nb

Ta Zr Hf Ti

Nb-Ta

La

Nb/La = 0.13 ~ 0.19 WT04-2 = 0.28

郎

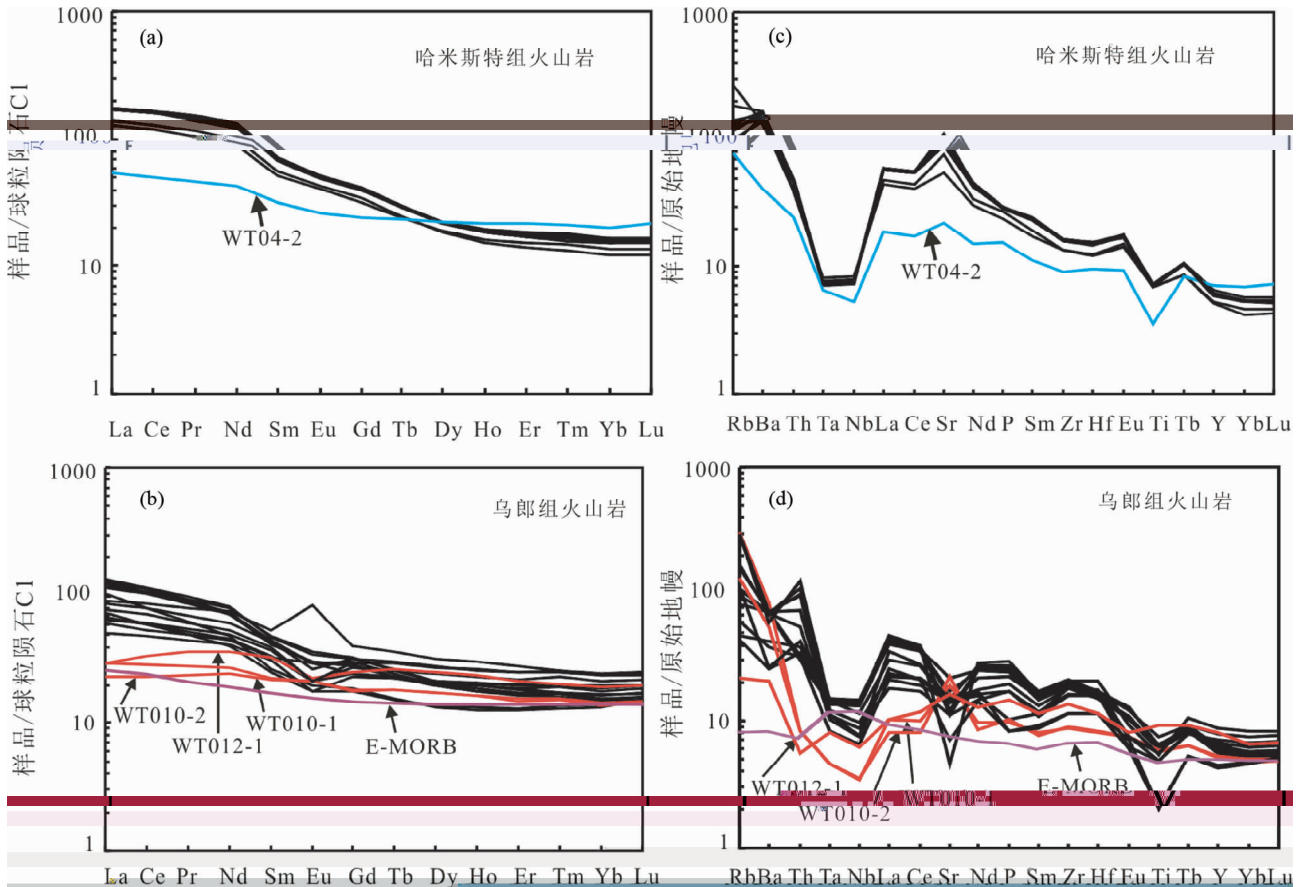
5

Sr $96 \times 10^{-6} \sim 462 \times 10^{-6}$ 5.1

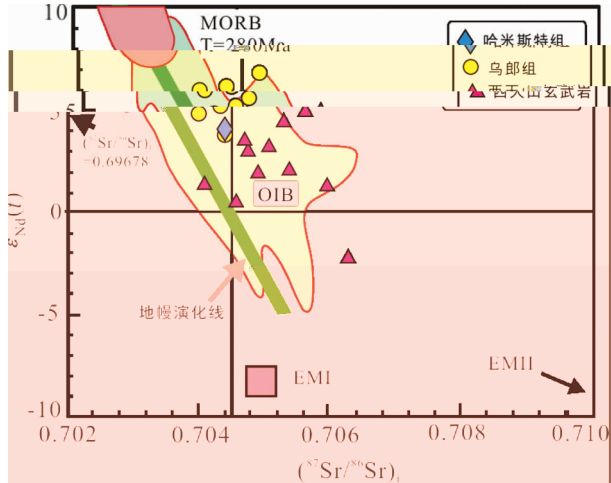
Nb-Ta

Nb/La = 0.22 ~ 0.62

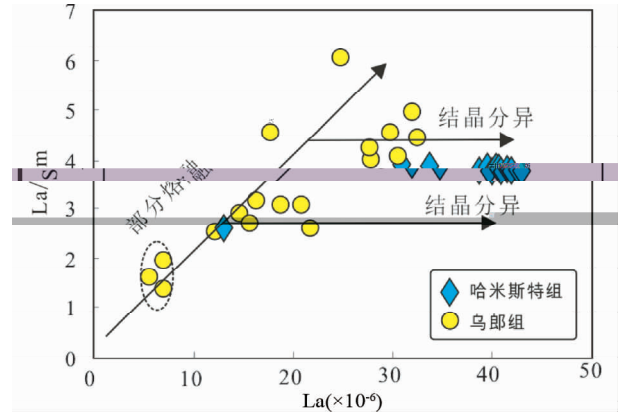
郎



5
Fig. 5 REE distribution patterns and trace element spider diagrams of the Nileke Permian volcanic rocks

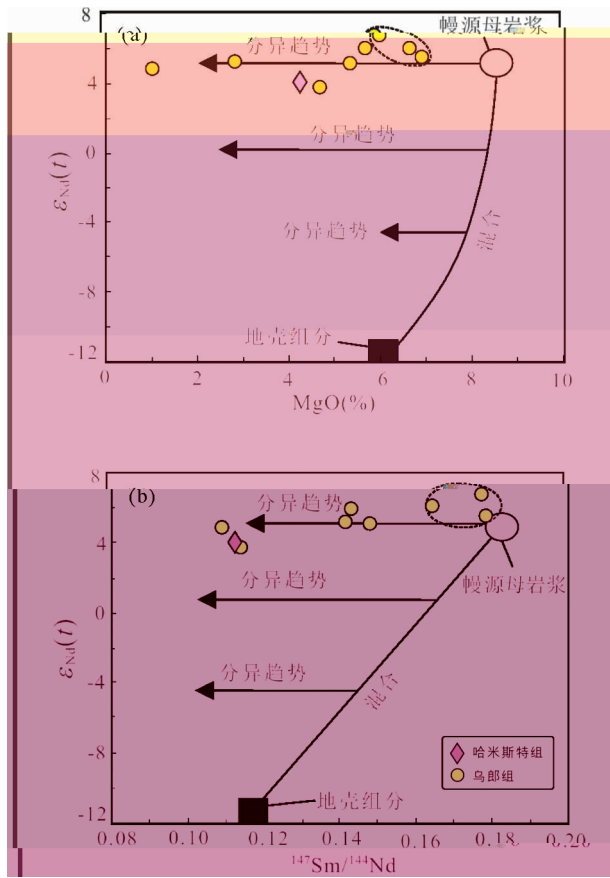


6
Sr-Nd MORB
OIB EMI EMII
Zindler and Hart 1986
Fig. 6 Sr-Nd isotopic composition diagram of the Nileke Permian volcanic rocks after Zindler and Hart 1986



7
La La/Sm
E-MORB WT010-1 WT010-2
WT012-1
Fig. 7 La vs. La/Sm of the Nileke Permian volcanic rocks

3a b Eu 5a La/Sm
La 7 OIB Sr-Nd
WT010-1 WT010-2

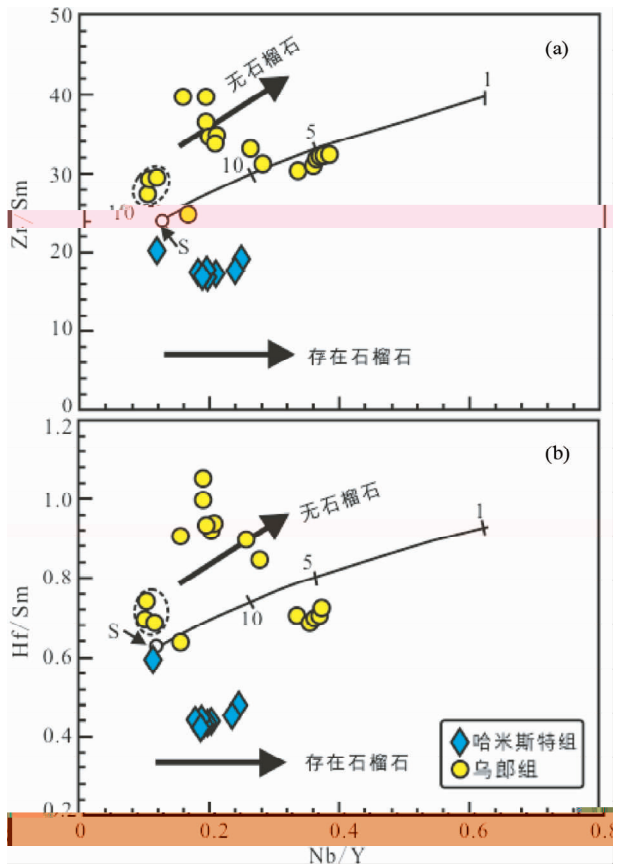


8 MgO $^{147}\text{Sm}/^{144}\text{Nd}$
 Nd
 E-MORB WT010-1 WT010-2
 WT012-1
 Fig. 8 MgO and $^{147}\text{Sm}/^{144}\text{Nd}$ vs. Nd diagram of the Nileke Permian volcanic rocks

WT012-1 SiO_2 47.5% ~ 48.1%
 MgO 5.97% ~ 6.89%
 $50 \times 10^{-6} < \sum\text{REE} < 80 \times 10^{-6}$
 1.6 ~ 2.2 Nb/La > 0.35
 E-MORB Cr
 Ni $164.1 \times 10^{-6} \sim 315.7 \times 10^{-6}$ 70.1×10^{-6}
 $\sim 211.7 \times 10^{-6}$ $^{147}\text{Sm}/^{144}\text{Nd}$ Eu
 Eu/Eu* = 0.79 ~ 1.09
 8

K_2O 2.81% ~ 3.91% Sr > 1000 ×
 10^{-6} $\sum\text{REE} > 200 \times 10^{-6}$ La/Yb_N 9.7 ~ 11.7
 9 Arth 1976
 Zr/Sm Hf/Sm Nb/

Y Nu9607
 1% 5% 10% Zr/Sm
 Hf/Sm Nb/Y
 E-MORB # × 3.2601
 > 10%
 E-MORB
 Dy/Yb
 Dy/Yb > 2.5
 Dy/Yb < 1.5 Jiang
 2009 Dy/Yb 2.07 ~
 2.24 WT04-2 = 1.7 1.46 ~
 2.0
 Nb-Ta 郎
 Nb/La 0.22 ~ 0.62 Nb/
 La < 0.2 Nb-Ta
 MgO $^{147}\text{Sm}/^{144}\text{Nd}$



9 Nb/Y-Zr/Sm a Nb/Y-
Hf/Sm b

Arth 1976

Nu9607

S

Nb/La > 0.35

E-MORB

3
MORB

Sr-Nd

Nb-Ta

References

- Arth JG. 1976. Behavior of trace elements during magmatic processes: A summary of theoretical models and their applications. *Journal of Research of the US Geological Survey* 4 (1): 41–47.
- Borisenko AS, Sotnikov VI, Izokh AE, Polyakov GV and Obolensky AA. 2006. Permo-Triassic mineralization in Asia and its relation to plume magmatism. *Russian Geology and Geophysics* 47: 166–182.
- Gao J, Long LL, Klemm R, Qian Q, Liu DY, Xiong XM, Su W, Liu W, Wang YT and Yang FQ. 2009. Tectonic

e

- igneous province southwestern China Evidence for crustal growth by magmatic underplating or intraplating. In Foulger G and Jurdy D eds. . The Origins of Melting Anomalies. Plates Plumes and Planetary Processes. Geological Society of America Special Publication 430 841 – 858
- Xu YG Luo ZY Huang XL He B Xiao L Xie LW and Shi YR. 2008. Zircon U-Pb and Hf isotope constraints on crustal melting associated with the Emeishan mantle plume. *Geochimica et Cosmochimica Acta* 72 13 3084 – 3104
- Zhang CL Li XH Li ZX Ye HM and Li CN. 2008. A Permian layered intrusive complex in the western Tarim Block northwestern China Product of a ca. 275Ma mantle plume *Journal of Geology* 116 3 269 – 287
- Zhang CL Li ZX Li XH Xu YG Zhou G and Ye HM. 2010a. A Permian large igneous province in Tarim and Central Asian orogenic belt NW China Results of a ca. 275Ma mantle plume *GSA Bulletin* 122 2020 – 2040
- Zhang CL Xu YG Li ZX Wang HY and Ye HM. 2010b. Diverse Permian magmatism in the Tarim Block NW China Genetically linked to the Permian Tarim mantle plume *Lithos* 119 3 – 4 537 – 552
- Zhang CL Zhou G Wang HY Dong YG and Ding RF. 2010. A review on two types of mantle domains of the Permian large igneous province in Tarim and the western section of Central Asian orogenic belt. *Geological Bulletin of China* 29 6 779 – 794 in Chinese with English abstract
- Zhang CL and Zou HB. 2013a. Comparison between the Permian mafic dykes in Tarim and the western part of Central Asian Orogenic Belt CAOB NW China Implications for two mantle domains of the Permian Tarim Large Igneous Province. *Lithos* 174 15 – 27
- Zhang CL and Zou HB. 2013b. Permian A-type granites in Tarim and western part of Central Asian Orogenic Belt CAOB Genetically related to a common Permian mantle plume *Lithos* 172 – 173 47 – 60
- Zhang LF Ai YL Li XP Rubatto D Song B Williams S Song SG Ellis D and Liou JG. 2007. Triassic collision of western Tianshan orogenic belt China Evidence from SHRIMP U-Pb dating of zircon from HP/UHP eclogitic rocks. *Lithos* 96 1 – 2 266 – 280
- Zhou DW Liu YQ Xin XJ Hao JR Dong YP and Ouyang ZJ. 2006. Tracing and reconstruction of the Palaeo tectonic background of the Permian basalts in Tuha and Sangtanghu Basins NW China. *Science in China Series D* 26 143 – 153
- Zhou MF Leshner CM Yang ZX Li JW and Sun M. 2004. Geochemistry and petrogenesis of 270Ma Ni-Cu- PGE sulfide-bearing mafic intrusions in the Huangshan district Eastern Xinjiang Northwest China Implications for the tectonic evolution of the Central Asian orogenic belt. *Chemical Geology* 209 3 – 4 233 – 257
- Zhou MF Zhao JH Jiang CY Gao JF Wang W and Yang SH. 2009. OIB-like heterogeneous mantle sources of Permian basaltic magmatism in the western Tarim Basin NW China Implications for a possible Permian large igneous province. *Lithos* 113 3 – 4 583 – 594
- Zindler A and Hart SR. 1986. *Chemical Geodynamics. Annual Review of Earth and Planetary Sciences* 14 1 493 – 571
- . 2006. . 27 5 424 – 446
- . 2003. MC-ICPMS ¹⁴³Nd/¹⁴⁴Nd Sm/Nd . 32 1 91 – 96
- . 1996. ICP-MS 40
- . 25 6 552 – 558
- . 2005. 23 4
- 334 – 338
- . 1994. 28 4 373
- 382
- . 2002. LP MC-ICPMS Sr . 31 3 295
- 299
- . 2005. . 79 4 489 – 502
- . 2005. 38 1
- 1 – 14
- Windley BF . 2006. SHRIMP 80 1 32 – 37
- . 2010. 29 6
- 779 – 794