

errors of all W_{ij}^{kl} , and the standard error of each W_{ij}^{kl} is computed by using standard errors of X_{ij} or \dot{S}_{ij} based on the transmit rule of error. In tables 1 and 2, M1 means the results by using the method described in section 2(i), and M2 the results by using the method described in section 2(ii).

Table 2 Detecting results in the south half of the Earth (mm/a)

Tech.	Method	AFRC-AUST	AUST-PCFC	PCFC-SOAM	SGAM-AFRC	W1	W2
GPS	M1	5.1±1.7	-0.8±0.9	18.9±1.6	-7.8±1.7	15.4±3.0	11.9±3.0
	M2	0.7±1.0	2.8±0.4	6.7±1.0	4.5±0.8	14.7±1.7	13.1±1.7
VLBI	M1	-0.2±1.9		15.4±3.6	-9.7±2.5	5.5±4.7	4.0±4.8
	M2	1.6±1.1		4.6±2.2	2.6±1.5	8.8±2.9	7.8±2.9
Inte.	M1	3.5±1.8	1.2±1.1	19.4±2.3	-7.9±3.0	16.2±4.3	12.7±4.3
	M2	1.1±1.0	3.1±0.5	6.6±1.4	4.1±1.6	14.9±2.4	13.4±2.5

From tables 1 and 2 we can see, whether using data from different techniques or using different methods, all give consistent detecting results. Within the mid-latitude belt on the north half of the Earth, the closed differences (W) derived by two methods are all negative; within the mid-latitude belt on the south half of the Earth, the closed differences (W) are all positive. If the detecting methods have no problems, this result would show that the reverse global tectonic change in the north and south half of the Earth probably exists. The size of the change could be determined by VLBI and GPS detecting results due to their higher precision measurements, larger number and better distribution of stations. The compressing change in the Northern Hemisphere of the Earth is about 8—10 mm/a, the swelling change in the south half of the Earth is about 12—14 mm/a, the latter result may have larger error due to less number and poor distribution of stations in the south half of the Earth.

References

1. Ma, Z., Chen, Q., Global seismotectonic system and asymmetry of the Earth, *Science in China, Ser. B* (in Chinese), 1988 (10): 1092.
2. Ma, Z., Gao, X., Ren, J., The features of contemporary global tectonics and its dynamic explanation, *Quaternary Science* (in Chinese), 1992(4): 293.
3. DeMets, C., Gordon, R. G., Argus, D. F. et al., Current plate motions, *Geophys. J. Int.*, 1990(101): 425.
4. DeMets, C., Gordon, R. G., Argus, D. F. et al., Effect of recent revisions to the geomagnetic reversal time scale on estimates of current plate motions, *Geophys. Res. Lett.*, 1994(21): 2191.
5. Argus, D. F., Post-glacial rebound from VLBI geodesy: on establishing vertical reference, *Geophys. Res. Lett.*, 1996(23): 973.

(Received June 3, 1999)

Trace element characteristics and origin of intergranular components in mantle peridotites

XU Yigang

Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China

Abstract Leaching experiment has been carried out on mantle xenoliths with different petrographic features in order to directly characterize the nature of intergranular components. ICP-MS analyses of leachates show that they are characterized by high LREE concentrations with strong depletion of Ta. The total REE contents and whether the negative Rb, Ba and Nb anomalies are present or not in intergranular components are largely dependent upon the nature of mantle metasomatism experienced by its host rock. It is proposed that intergranular components may represent residues of small volume metasomatic melts.

Keywords: peridotite xenoliths, intergranular components, trace elements, upper mantle.

Trace element geochemical studies show that large ion lithophile elements (LILE) mainly reside in intergranular components in peridotites, rather than in crystal structures of rock-forming minerals^[1-3]. Available information about the trace element characteristics of intergranular components was inferred

NOTES

using indirect methods and considerable debates persist with regard to their origin^[1,2]. In order to directly characterize the nature of intergranular components, acid leaching experiments have been conducted on mantle xenoliths which display different petrographic and geochemical features. It is found that the trace element compositions of intergranular components are largely dependent upon the metasomatic history of the peridotites. It is possible that intergranular components represent residues of metasomatic fluids.

1 Samples, acid leaching experiment and analytical methods

The samples which were collected from Nushan in Anhui Province include anhydrous spinel lherzolites, amphibole-bearing and phlogopite-bearing lherzolites. They are believed to come from different depths of the upper mantle^[4], and display different trace element geochemical characteristics (table 1).

Table 1 Trace element composition of clinopyroxenes in Nushan peridotite xenoliths and its leaching products (10⁻⁶)

Sample No.	N-35		XON-4		N-6		N-13		XON-25	
	spinel lherzolite		spinel lherzolite		phlogopite lherzolite		amphibole lherzolite		amphibole lherzolite	
Eq. temperature	1140°C		1100°C		1147°C		930°C		900°C	
Geochem. feature	LREE-enriched		LREE-depleted		LREE-depleted		LREE-enriched		LREE-enriched	
	leachate	Cpx	leachate	Cpx	leachate	Cpx	leachate	Cpx	leachate	Cpx
Rb	9.09	0.02	1.55	0.01	3.87	0.01	1.28	0.04	1.70	0.03
Sr	68.16	99.51	41.11	71.86	49.91	82.80	483.83	217.27	107.42	115.89
Y	1.81	14.58	2.38	16.25	1.19	16.93	11.04	16.19	4.12	17.62
Zr	15.62	51.28	11.73	38.73	7.51	44.38	9.47	59.94	17.54	41.47
Ba	54.84	0.18	82.17	0.13	19.49	0.23	51.37	0.88	117.22	0.19
La	3.486	2.862	3.873	0.970	0.967	1.426	73.457	11.012	4.615	5.129
Ce	6.972	9.178	0.941	3.670	1.859	4.740	93.867	28.564	6.461	11.925
Pr	0.685	1.502	0.443	0.700	0.223	0.831	8.973	3.647	0.852	1.511
Nd	2.926	7.976	1.881	4.330	0.967	4.934	30.467	15.498	3.337	6.989
Sm	0.560	2.185	0.332	1.620	0.223	1.774	4.043	3.202	0.710	1.963
Eu	0.187	0.864	0.111	0.700	0.074	0.768	1.183	1.144	0.284	0.793
Gd	0.498	3.027	0.443	2.690	0.223	2.920	3.155	3.263	0.710	2.758
Tb	0.062	0.491	0.055	0.490	0.000	0.518	0.394	0.532	0.142	0.499
Dy	0.436	3.38	0.387	3.560	0.223	3.750	2.268	3.626	0.852	3.690
Ho	0.062	0.659	0.055	0.730	0.074	0.761	0.394	0.698	0.142	0.759
Er	0.187	1.769	0.221	2.020	0.149	2.110	1.085	1.957	0.426	2.166
Tm	0.000	0.245	0.000	0.290	0.000	0.303	0.099	0.277	0.071	0.318
Yb	0.125	1.452	0.166	1.820	0.149	1.847	0.690	1.727	0.426	1.969
Lu	0.000	0.22	0.000	0.280	0.000	0.289	0.099	0.273	0.071	0.315
Hf	0.311	1.137	0.221	1.010	0.149	1.149	0.099	0.913	0.284	1.144
Pb	2.801	0.083	3.375	0.050	2.901	0.056	5.029	0.427	3.266	0.334
Th	0.623	0.206	0.111	0.020	0.149	0.056	11.832	1.299	1.420	1.449
U	0.249	0.04	0.055	0.010	0.149	0.016	4.437	0.359	0.497	0.389
Nb	5.727	1.691	2.656	0.322	2.008	0.525	2.859	0.786	0.284	0.132
Ta	0.002	0.202		0.021	0.004	0.037	0.001	0.043		0.013

Samples were crushed to about 20—40 mesh after the envelopes of xenoliths have been cut off. The cpx separates with relatively large grain size and undestroyed crystal facets were hand picked under a binocular microscope. Precisely weighted clinopyroxenes (Cpx) were leached with hot (about

100 °C) 6N HCl for 45 min and then washed with MILLIQ pure water for 6 times before acid digestion. The leachates have been collected for purpose of estimation of the trace element compositions in grain boundary components. The leached samples were weighted again and the difference between the weights before and after leaching is taken as the weight of the intergranular components. The whole rocks, Cpx and their leachates were then analyzed for 24 trace elements (REE, Rb, Ba, U, Th, Nb, Ta, Hf, Zr, Sr and Y) abundances using inductively coupled plasma-mass spectrometry (ICP-MS) at Montpellier, France. The analytical procedure follows that described by Ionov et al.^[3]. The blank varies between $0.n \times 10^{-9}$ – $n \times 10^{-9}$ and detection limits are $0.n \times 10^{-9}$ – $10 \times n \times 10^{-9}$. The precision is estimated to be 15% for U, Th, Nb, Ta, and better than 8% for other elements.

2 Evidence for the existence of intergranular components in peridotites

Petrographic observation shows that there is commonly a thin film on the surface of minerals in peridotites. Tiny minerals such as rutile and phlogopite have been identified in peridotite grain boundaries^[1,2]. Fig. 1 illustrates the measured and reconstructed bulk rock trace element compositions of a spinel lherzolite (XON-50). The reconstruction is made using modal proportions and trace element compositions in minerals. The similarity between the trace element distribution patterns of Cpx and reconstructed bulk rock suggests that in dry peridotites, Cpx is an important host for trace elements, whereas the contribution of other silicates (orthopyroxene and olivine) to the bulk rock budget is negligible^[3]. The reconstructed whole rock HREE and MREE compositions fit well with the measured values (fig. 1). However, there is a marked difference between the reconstructed and measured concentrations for LILE. Cpx and calculated whole rock are depleted in LILE. In contrast, the measured bulk rock LILE concentrations form an enrichment pattern. In particular, the measured whole rock concentrations of Rb, Ba, Th, U, Nb and Ta are significantly higher than the reconstructed ones, and even higher than those in Cpx. This suggests that the residence of highly incompatible elements in the agents other than the silicate minerals. Fluid inclusion is frequently suggested as a possible candidate^[1–3]. However, the trace element compositions of minerals as well as whole rocks obtained by the ICP-MS solution method include those from minerals themselves and those from fluid inclusions. That fact that the calculated values are always lower than the measured values (fig. 1) suggests that the fluid inclusion only plays a minor role in the whole rock budget of most trace elements. It is believed that most LILE appear to be concentrated in intergranular components. This is confirmed by the analyses of leachates which indeed show large amounts of LILE in them (see next section).

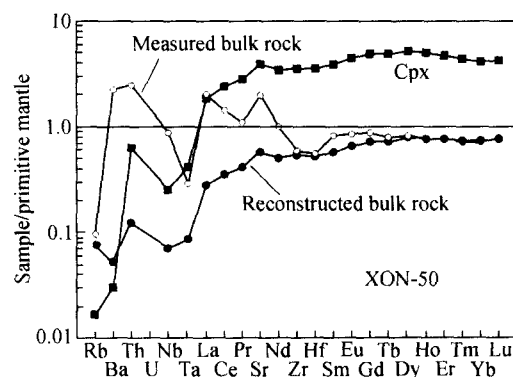


Fig. 1. Comparison between the measured and calculated bulk rock trace element compositions of a spinel lherzolite (XON-50). The primitive mantle data is after ref. [6].

3 Trace element characteristics of leachates of clinopyroxenes

The analytical results are listed in table 1 and illustrated in fig. 2. The following points are noteworthy. (i) All acid leachates are enriched in LREE with strong negative Ta anomaly. (ii) Trace element concentrations in the leachates of LREE-depleted samples (XON-4, N-6) are lower than those for the LREE-enriched samples. (iii) Trace element concentrations in the leachates of the LREE-enriched "dry" peridotite (N-35) are lower than those for the amphibole-bearing samples (N-13, N-25). The Cpx in the latter and their leachates show remarkably similar trace element distribution patterns with negative HFSE and Rb (Ba) anomalies. This contrasts sharply with the absence of such anomalies in the leachates of Cpx in N-35. (iv) The leachate of Cpx in XON-4 shows a negative Ce anomaly.

NOTES

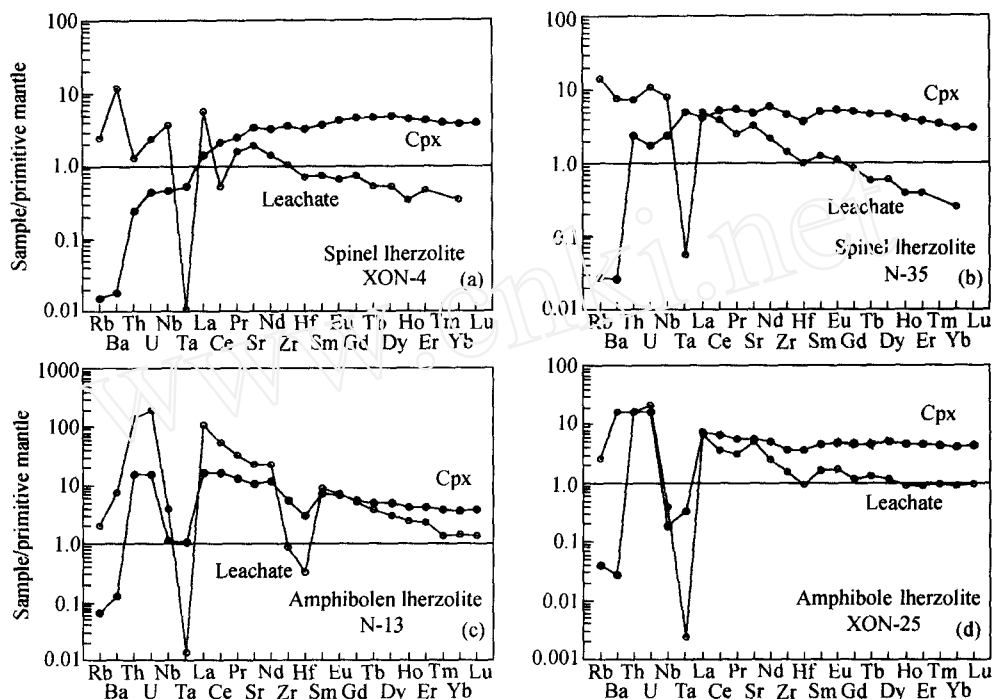


Fig. 2. Primitive mantle-normalized distribution patterns of trace elements in clinopyroxenes and their leachates. (a) XON-4; (b) N-35; (c) N-13; (d) XON-25.

4 Does the composition of Cpx leachates represent that of intergranular components?

Peridotitic minerals contain certain LILE-rich fluid inclusions. If these inclusions were broken during the sample crushing, tiny materials coating at the surface of inclusions would be dissolved in acids. If so, the composition of leachates does not necessarily represent that of intergranular components. In order to avoid this problem, only Cpx with relatively large grain size and undistorted crystal facets were hand picked. This certainly would lower the frequency at which inclusions are exposed to the surface. On the other hand, even if there are broken inclusions on the mineral facets, it will not significantly affect the compositions of intergranular components, because LILE contents in minerals and fluid inclusion are much lower than those in intergranular components^[2, 3] (cf. fig. 1). Moreover, since the leaching experiment concerns only the surface of minerals, it is thus reasonable to infer that the influence of inclusions on the composition of leachates is rather limited.

Bodinier et al.^[2] showed that the leachates of Opx, Ol and Cpx of the same sample have extremely similar trace element distribution pattern except for slight difference in absolute concentration. Given the fact that the weight of intergranular components cannot be precisely estimated, there is no sense to discuss the absolute elemental concentrations. Hence, although only Cpx is dealt with in this study, it can be concluded with confidence that the composition of leachates of Cpx can effectively represent that of intergranular components in peridotites.

5 Origin of intergranular components

Intergranular components may be formed through: (i) infiltration of host basalts in peridotite xenoliths; (ii) percolation of surface water and precipitation of crustal minerals in grain boundaries; (iii) partial melting and/or partial dissolution of Cpx, and (iv) mantle metasomatism. Below, the possibility of these mechanisms will be evaluated in detail.

The first mechanism cannot be possible, because the host basalts and leachates display considerably different trace element distribution patterns^[7]. For instance, the negative HFSE anomalies

in acid leachates are not seen in the host basalts^[7].

Mantle xenoliths were probably altered by surface processes after their transport by volcanic rocks to the surface. Zindler and Jagoutz^[1] have conducted a detailed mineral and isotopic analyses as well as leaching experiments. They proposed that most intergranular components in peridotites are genetically related to surface alteration. However, such an interpretation is not consistent with the analytical results presented in this study. There is a negative Ce anomaly in the leachate of Cpx in XON-4. If the formation of negative Ce anomaly is related to surface alteration, it requires that the surface water is able to preferentially leach Ce from intergranular components but leaving other elements unaffected, or itself has a negative Ce anomaly. However, available data suggest that there is no negative Ce anomaly in ground water such as river water and near-shore seawater^[8]. Negative Ce anomaly is only found in deep seawater^[9]. The eruption age of Nushan volcanics is 0.63 Ma. Such then there was no record of deep sea sedimentation. The REE concentrations in surface water are extremely low ($10^5 \times 10^6$). Moreover, crust-originated minerals are not observed in grain boundaries. All these suggest that intergranular components which have high REE concentrations cannot be formed through surface alteration.

However, because of their mobility under surface conditions, concentrations of Rb, Ba and Sr may be affected to a larger extent than those of REE. This is particularly true for some of the Nushan samples in which olivines are partially oxidized. Positive Sr anomaly in some rocks is probably related to surface alterations. Nevertheless, fig. 2 shows that some leachates are still depleted in these elements. This, together with the relationship between trace element characteristics of leachates and petrologic features of peridotites, leads us to think that there is no significant influence of surface processes on the intergranular components in the peridotites studied in this note.

Incongruent melting of Cpx may happen during the rapid transportation of xenoliths from the deep to the surface. This raises the question as to whether the formation of intergranular components is related to the partial melting of Cpx. In addition, is it possible that the similarity of trace element distribution pattern between leachates of Cpx and leached Cpx (cf. fig. 2(c), (d)) is due to the partial dissolution of Cpx? Both mechanisms are not possible. First, the above mentioned processes cannot account for the marked negative Ta anomaly in leachates. Secondly, since the difference between the weights before and after leaching is only 1%—2% of the weight of Cpx, thus even if such a difference resulted from partial dissolution of Cpx by acids, it is impossible to produce higher LILE concentrations in solution than in residual Cpx (table 1). The presence of negative Ce anomaly in leachates of XON-4 also indicates that there is no direct genetic relationship between intergranular components and Cpx.

Intergranular components are more likely mantle-derived. Ce is the only trivalent REE element that can be oxidized in nature to a tetravalent state. Therefore, the geochemical behavior of Ce is largely controlled by its oxidation and reduction state. In ocean, the oxidation of the soluble Ce^{3+} to the insoluble Ce^{4+} is responsible for the negative anomaly in seawater. The removal of Ce^{4+} from the seawater is facilitated by incorporation into Fe-Mn nodules. Negative Ce anomalies are also common in the rocks on the ocean floor, such as altered basaltic pillow glasses and pelagic sediments^[8]. Ce^{4+} is unlikely to occur in magmatic system due to the reaction $Ce^{4+} + Fe^{2+} = Ce^{3+} + Fe^{3+}$ as well as to the excess Fe^{2+} relative to Ce in basaltic magmas. Therefore, the negative Ce anomaly in island arc lavas is widely considered to be inherent in the source region rather than to be related to magmatic processes. The recycling of pelagic sediments and seawater altered basalts into the mantle is the main mechanism to produce the negative Ce anomaly in the deep source. It is therefore possible that the negative Ce anomaly in the leachates of XON-4 is related to the mantle metasomatism of subduction-related fluids^[10]. Such an interpretation needs further confirmation because basalts from this area do not show geochemical evidence for subduction^[6]. The strong negative Ce anomaly is the common feature of the leachates of peridotitic minerals analyzed so far^[2]. There are two possible explanations for this. (i) Ta is strongly partitioning into the rutile which is generally coated on the surface of spinel^[2]. These rutiles are not dissolved in leachates because spinel was not dealt with in this study, and even if rutile is also associated with other minerals, the dissolving capability of the adapted leaching procedure is rather limited. (ii) Negative HFSE anomalies can be produced in small volume melts after interaction

NOTES

between melt and rock^[11]. It is possible that intergranular components represent the residues of such small melt fractions.

The upper mantle beneath Nushan has been subjected to multiple stages of metasomatism¹⁾. The enrichment in the anhydrous peridotites with high equilibrium temperatures (> 1 000°C) is a local phenomena, with a mechanism similar to the metasomatic aureole. It involves diffusion-percolation reaction of vein melts with wall rocks. The metasomatic agent is basaltic in nature. In contrast, the mechanism of metasomatism associated with the amphibole-bearing peridotites of low equilibrium temperature (850—930°C) is a pervasive percolation of a small volume melt which is similar to carbonate in nature. It is noteworthy that the leachates of Cpx in these two petrologically different peridotite suites also display distinct trace element characteristics. If Ta or Ce negative anomalies are ignored, the trace element characteristics of the leachates of the anhydrous peridotites resemble that of basalts, whereas the leachates of the amphibole-bearing peridotites have negative anomalies of Rb, Ba and HFSE, a feature typical of carbonatite^[12]. Since only rough estimation can be made for the weight of the intergranular components, the emphasis is thus placed on the comparison of trace element distribution pattern rather than on absolute concentrations. These observations lead us to propose that intergranular components may represent the residues of mantle metasomatic fluids. Probably influenced by surface tension, a very small amount of metasomatic fluid can be left along grain boundaries during the metasomatism, resulting in the formation of intergranular components. Using a geophysical approach, McKenzie^[13] speculated that highly incompatible elements in the upper mantle are preferentially partitioning into small volume melts which may be kimberlitic or carbonatitic in nature. The results of this study imply that the intergranular component may represent one sort of occurrence of such small volume melts.

6 Conclusions and implications

Intergranular component in peridotite xenoliths is enriched in LREE and other highly incompatible elements. Although its formation is inevitably related to the surface alteration processes, it is demonstrated that the intergranular components in the peridotites investigated in this study are mantle-derived and likely represent the residues of mantle metasomatic fluids. If this interpretation is correct, the geochemical characteristics of intergranular components can be used as a criterion to identify the nature of mantle metasomatism. Because the intergranular component plays an important role in the bulk rock budget of trace elements, it is therefore not appropriate to use bulk rock LILE composition to study mantle processes, especially when the nature and origin of grain boundary components are not clear.

Acknowledgments This study was supported by the National Natural Science Foundation of China (Grant No. 49704023) and represents a part of results of an international co-operation project between CAS (China) and CNRS (France).

References

1. Zindler, A., Jagoutz, E., Mantle cryptology, *Geochim. Cosmochim. Acta*, 1988, 52: 319.
2. Bodinier, J. L., Merlet, C., Bedini, R. M. et al., The distribution of niobium, tantalum, and other highly incompatible trace elements in the lithospheric mantle: the spinel paradox, *Geochim. Cosmochim. Acta*, 1996, 60: 545.
3. Xu, Y.G., Distribution of trace elements in spinel and garnet peridotites, *Science in China, Ser. D*, to appear.
4. Xu, Y. G., Mercier, J. C., Lin, C. Y., Amphibole-bearing peridotite xenoliths from Nushan, Anhui Province: Evidence for melt percolation process in the upper mantle and lithospheric uplift, *Chinese J. Geochem.*, 1997, 16: 213.
5. Ionov, D. A., Savoyant, L., Dupuy, C., Application of the ICP-MS technique to trace element analysis of peridotites and their minerals, *Geostandard Newsletters*, 1992, 16: 311.
6. Sun, S. S., McDonough, W. F., Chemical and isotopic systematic of oceanic basalt: Implication for mantle composition and process, *Magmatism in the Ocean Basin*, Oxford: Geol. Soc. Spec. Publ., Blackwell Sci. Publ., 1989, 313—346.
7. Liu, C. Q., Masuda, A., Xie, G. H., Major- and trace-element compositions of Cenozoic basalts in eastern China: petrogenesis and mantle source, *Chem. Geol.*, 1994, 114: 19.
8. Humphris, S. E., The mobility of the rare earth elements in the crust, *Rare Earth Element Geochemistry*, Amsterdam: Elsevier, 1984, 317—342.
9. Fleet, A. J., Aqueous and sedimentary geochemistry of the rare earth elements, *Rare Earth Element Geochemistry*, Amsterdam: Elsevier, 1984, 343—374.

1) Xu, Y. G., Bodinier, J. L., Multiple thermal evolution and contrasted LILE-enrichments in the lithospheric mantle beneath Nushan, eastern China, *Contrib. Mineral. Petrol.*

10. Neal, C. R., Taylor, L. A., A negative Ce anomaly in a peridotite xenolith: evidence for crustal recycling into the mantle or mantle metasomatism? *Geochim. Cosmochim. Acta*, 1989, 53: 1035.
11. Bedini, R. M., Bodinier, J. L., Dautria, J. M. et al., Evolution of LILE-enriched small melt fractions in the lithospheric mantle: a case study from the East African Rift, *Earth Planet. Sci. Lett.*, 1997, 153: 67.
12. Ionov, D. A., Dupuy, C., O'Reilly, S. Y. et al., Carbonated peridotite xenoliths from Spitsbergen: implications for trace element signature of mantle carbonate metasomatism. *Earth Planet. Sci. Lett.*, 1993, 119: 283.
13. McKenzie, D. P., Some remarks on the movement of small melt fractions in the mantle, *Earth Planet. Sci. Lett.*, 1989, 95: 53.

(Received March 6, 1999)

Zircon U-Pb age of granitic gneiss on Duku highway in western Tianshan of China and its geological implications

CHEN Yibing, HU Aiqin, ZHANG Guoxin & ZHANG Qianfeng

Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China

Abstract Granitic gneiss on Duku highway in western Tianshan has been dated by the U-Pb zircon method. When plotted on the concordia diagram, the results give linear data array and the upper intercept age of (882 ± 33) Ma, and the age was considered as the crystallization age of the protolith. Granitic gneiss has high ASI value (1.09), high LILE and LREE contents, significantly negative Eu depletion, distinctly negative Ba, Sr, P, Ti and Nb anomalies and indicate continental crust parentage, which is consistent with high initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios value (0.7170) and very negative $\epsilon_{\text{Nd}}(t) = -14.1$. The protolith magma is interpreted as a product of partial melting of the basement rocks of older basement crust.

Keywords: zircon U-Pb age, granitic gneiss, Duku highway, western Tianshan.

Tianshan orogen is a part of East-Central Asian Orogenic Belt (ECAOB), which is one of the most important sites of juvenile crustal growth on the Earth in the Phanerozoic. It was realized that Nd isotopic composition of Paleozoic granites indicates variable contributions of old basement rocks of Tianshan orogen in their petrogeneses^[1]. Thus, the study on the basement of Tianshan provides important insights into the dynamics of Paleozoic crustal growth and the tectonic evolution of Central Asia Orogen, and it is one of the focuses of IGCP-420^[1]. The basement rocks of continental crust in the Tianshan Orogen were formed at 1.8–2.0 Ga based on Nd-Sr isotope characteristics^[2], but the tectonic evolution of eastern Tianshan Orogen is different from that of western Tianshan Orogen according to many researchers^[3–5]. In the past few years, the existence of the Paleoproterozoic-Mesoproterozoic Block has gained increasing acceptance due largely to the enormous amount of radiometric work in eastern Tianshan. The ages of 1.4 and 1.8 Ga for the metamorphic rocks of Xingxingxia Group in eastern Tianshan have been obtained by U-Pb dating of zircons, whole rock Rb-Sr isochron age and whole rock Sm-Nd isochron age^[6–8]. However, the debate on the timing of the western Tianshan basement formation and its evolution, which is largely attributed to the complicated geology of the region, is still continued. The dating for metamorphic rocks of the Narat Group in the south segment of Duku highway was done^[9,2], but no good result has been gotten yet. Moreover, the lack of precise radiometric age data for the key rock units has confused the debate. In such a complicated region, modern U-Pb geochronological techniques and Nd-Sr isotopes may supply particularly valuable information on the evolution of the Precambrian basement crust.

1 Geological background

The basement rocks of western Tianshan are Proterozoic in age and exposed only in a scattered manner in the Narat range and the northern slope of Haerke Mountain. Paleoproterozoic Narat Group

1) Jahn, B.M., Introduction to IGCP-420: What, Why and How? Continental Growth in the Phanerozoic: Evidence from the East-Central Asian Orogenic Belt (ECAOB). IGCP-420 First Workshop Schedule and Abstracts, 1998.

2) Hu, A.Q., Zhang, G.X., Zhang, Q.F. et al., Study on feature of Precambrian basement from orogens and implication for its mineralization in northern Xinjiang, Office of the National Key Project "305" in Uygur Autonomous Region of Xinjiang, China (in Chinese), 1995.