NOTES

Zircon U/Pb ages for gniess from Qianshan, Anhui

CHEN Daogong[1], Clark Isachsen[2], ZHI Xiachen[1], ZHOU Taxi[1], CHENG Hou[1] & XIA Qunke[1]

1. Department of Earth and Space Sciences, University of Science and Technology of China, Hefei 230026, China;
2. Department of Geosciences, University of Arizona, AZ 85721, USA

Abstract Zircon U/Pb ages were measured for Qianshan gneiss at the ultrahigh pressure metamorphic (UHPM) complex in the Southern Dabie Terrain (SDT). According to morphology, Th and U contents of eight fractions of zircon and data distribution on the discordia, it is indicated that they should be treated as metamorphic overgrowth mixing zircons, in which the cores mainly are magmatic and the outers were metamorphic. The intercept ages show that the gneiss underwent UHPM. There is no direct correlation for zircon between morphological feature and genesis.

Keywords: overgrowth mixing zircon, UHPM, Dabieshan.

In recent years some new zircon U/Pb ages were obtained in the Dabie UHP terrain[1—7], in which many were intercept ages. Since the U/Pb behaviour at UHPM was not well understood, the significance of zircon ages was in dispute. In this note we will emphasize that the metamorphic overgrowth at Dabie UHPM probably is the main reason for zircon discordant age distributions, based on the data of gneissic rocks from the UHPM complex.

1 Sample and geological setting

Sample 97M30 was collected from outcrop near Shanzhushi, Yezhai, northwest of Qianshan County. In several ten square meter area, light and grey gneisses, and garnet amphibolite derived from eclogite retrogresive metamorphism occurred, their relation is not very clear. According to field occurrence, mineral paragenesis and zircon morphological feature, we believe that it is orthogneiss. A piece of 4—5 kg rock block was crushed, sieved, and gravity and magnet mineral separated, finally zircons were hand-picked under a binocular. More than 1000 grains of zircon were obtained. Most are colorless, light yellow with some large grains having light brown. Eight fractions of zircon were selected for analyses on the basis of size, color, transparence. The numbers of grain and their morphology of each fraction are shown in fig. 1.

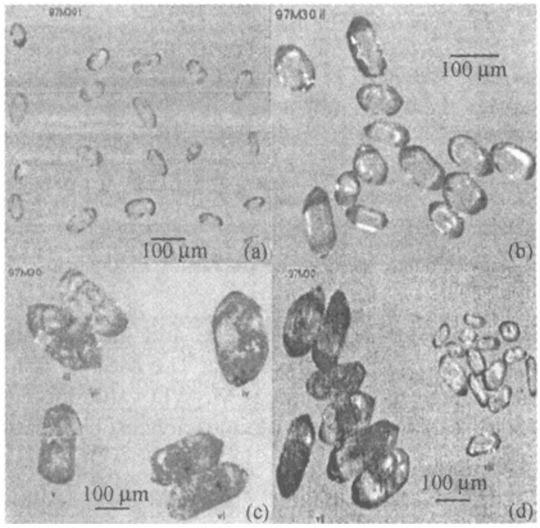

Fig. 1. Morphology and grain numbers for measured zircon fractions. (a)—(d) represent fractions i, ii, iii—vi and vii—viii respectively.

2 Analytical methods and results

Following a warm 4 N HNO_3 wash, zircons were dissolved in Teflon microbombs using the method of Parrish[8] and spiked with ^{205}Pb-^{235}U mixed tracer. Pb and U isotopic measurements were performed in a dynamic and static multicollector on VG Sector 54 solid source mass spectrometer, respectively. Mass discrimination factors were determined by 0.06%—0.03% for Pb, and U fractionation was determined. The total procedure blank ranged from 3—20 pg for Pb and 1—5 pg for U. All analytical data and results are shown in fig. 2 and table 1. Eight data all gave discordant ages with similar discordance percentage and located below the concordia. Seven of eight data

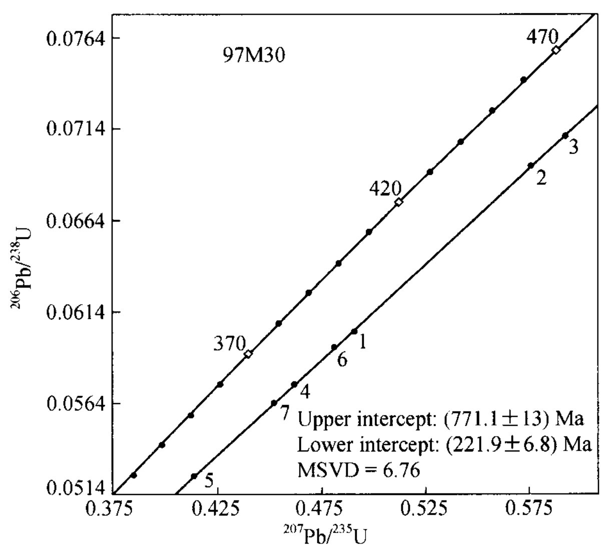

Fig. 2. Concordia diagram for 97M30 zircons.

Table 1 Isotopic dilution analyses results for 97M30 zircon

	No.	1	2	3	4	5	6	7	8
	Sample weight[a) (μg)	6.9	13.1	16.7	12.2	5.8	12.9	36.9	5.6
	Grain numbers	19	13	2	1	1	2	7	14
	U/μg • g^{-1}	1 577	1 439	867	960	1715	871	989	3890
	Pb[b) /μg • g^{-1}	1 04.9	1 14.7	62.2	63.2	93.4	60.2	63.8	318.8
	Pb[c) /pg	3.3	9.1	40.0	32.3	5.9	53.5	83.4	47.1
	Th/U[d)	0.46	0.60	0.47	0.46	0.28	0.42	0.47	0.55
	$^{206}Pb/^{204}Pb$	3 727.0	4 845.4	1 190.7	1 058.4	2 403.0	695.0	1 417.6	1 766.6
	$^{208}Pb/^{206}Pb$	0.217 4	0.268 1	0.222 1	0.220 0	0.135 9	0.198 5	0.223 2	0.246 1
Isotopic ratio	$^{206}Pb/^{238}U$	0.060 27	0.069 28	0.06254	0.057 41	0.052 46	0.059 44	0.056 41	0.070 93
	error (%)	0.19	0.13	0.17	0.20	0.25	0.19	0.20	0.20
	$^{207}Pb/^{235}U$	0.490 12	0.57613	0.51335	0.461 30	0.413 15	0.480 45	0.45162	0.592 82
	error (%)	0.21	0.14	0.20	0.24	0.26	0.22	0.22	0.21
	$^{207}Pb/^{206}Pb$	0.058 97	0.06032	0.05953	0.058 28	0.057 12	0.058 63	0.058 07	0.060 61
	error (%)	0.07	0.06	0.10	0.13	0.08	0.10	0.09	0.06
Apparent age /Ma	$^{206}Pb/^{238}U$	377.3	431.8	391.1	359.8	329.6	372.2	353.7	441.8
	2σ	0.7	0.5	0.7	0.7	0.8	0.7	0.7	0.9
	$^{207}Pb/^{235}U$	405.0	462.0	420.0	385.2	351.1	398.4	378.4	472.7
	2σ	0.8	0.6	0.8	0.9	0.9	0.9	0.8	1.0
	$^{207}Pb/^{206}Pb$	566.1	615.0	586.6	540.2	496.2	553.2	532.4	625.5
	2σ	1.6	1.2	2.1	2.9	1.9	2.3	1.9	1.4

a) Sample weight was estimated on the size and grain numbers of zircon, with 25% error. b) radiogenic Pb weight; c) common Pb contents; d) calculated Th/U ratios, assuming all ^{206}Pb in excess of common, blank and spike lead is radiogenic from ^{232}Th.

constituted a good discordia line and gave an upper intercept age of (771.1±13.0) Ma and a low intercept age of (221.9 ± 6.8) Ma. The MSWD is 6.76. If all eight data are included, the intercept ages do not change much, whereas MSWD value increased doubly. All the experiments were done at U/Pb Laboratory of Department of Geosciences, University of Arizona, the USA.

3 Discussion

Zircon U/Pb intercept ages on the concordia were usually interpreted with Wetherill's episodic thermal event model[9], in which the upper intercept age represents the time of formation of the minerals and the lower intercept age the time of thermal event. Besides, delatance, continuous diffusion, low temperature annealing and complex models also explained data distributions on the discordia. For our sample we released the so-called overgrowth- mixing model.

Recent research indicates[4] that based on U, Th contents of granitic rocks and Th , U partition coefficients between mineral zircon and granitic melt, one can estimate approximately Th/U value for zircon from granitic magma crystallization is around 1, in first order. For example, zircons from granitic mylonite, northern Dabie measured by Xue et al.[5] dropped on the concordia curve have their Th/U ratios of 0.75—0.86. Whereas in a complicated metamorphic environment, since Th^{+4} ionic radius (1.05 Å) is larger than that of U^{+4}(1.00 Å), Th^{+4} is more difficult to substitute Zr^{+4}(0.84 Å) at zircon metamorphic recrystallization. Hence metamorphic zircons generally have lower and scattered Th/U values of 0.1—0.2, even lower. Our eight zircon fractions have their Th/U ratios between 0.2—0.6. If this Th/U array depends on radiogenic Pb diffusion loss, the fraction of small grain with large ratio surface or those with high U contents, easy to suffer metamictization should have lost more radiogenic Pb. Actually, the lowest point (fraction 5) is only one large grain, and the highest point (fraction 8) has the highest U content. This observation is opposite to the Pb diffusion loss model.

When we roughly divided all eight fractions into the upper, middle and lower parts on the discordia, their Th/U ratios decreased from 0.55—0.60 to 0.42—0.47 to 0.28. We propose that the variation in Th/U ratios represents the mixing of two genetic zircon components. The data closer to lower intercept have more metamorphic zircons, whereas those closer to upper intercept have more magmatic zircons. If this kind of mixing happened within one grain, metamorphic zircon component grew or recrystallized at original magmatic zircon, the measured zircon would become a magmatic core and metamorphic ring. We call it overgrowth-mixing zircon. Rowley et al.[4] measured three zircon samples from eclogite host gneisses of the Dabieshan, all three samples defined a single discordia. The Th/U values of all points can also be divided into three groups of 0.32—0.45, 0.68—0.73 and 0.97 from the nearest lower intercept to the farthest one. This distribution is similar to our data and also belongs to overgrowth mixing zircons. Six Th/U values of eclogite zircon from Maowu measured by Rowley et al.[4] dropped in between 0.10—0.26. All those zircon data are very close to lower intercept and those zircons should be metamorphic. Our Qianshan gneiss plus two examples above shows that zircon Th/U ratios from the Dabie metamorphic terrain conform the Th/U variation in magmatic and metamorphic zircon components.

Of course, one should know that the overgrowth mixing model could not completely substitute the Pb diffusion loss model. Because of metamictization, Pb loss could occur in various degrees at different geological events, especially at chemical leaching and high T recrystallization.

Geologically, granitic gneisses from SDT, for lack of direct UHPM evidence, were treated as post-UHPM products by some researchers. There is still much debate as to whether these rocks underwent UHPM and what is correlation between gneisses and eclogites. If we treat the upper intercept age as crystallization time for Qianshan gneissic protolith and lower intercept age as its metamorphic age, we believe that Qianshan gneiss also underwent the Triassic metamorphic event coherent with eclogite UHPM. Qianshan gneiss was neither derived from partial melting of crust induced by eclogite exhumation at post-UHPM, nor combined with eclogite at middle crust at some later time. Almost the same intercept age of Qianshan gneiss as that of Wumiao gneiss determined by Rowley et al.[4] indicates that the host gneisses and eclogites in SDT as a whole coherent terrain underwent UHPM.

Our results also indicate that definite correlation between morphological feature and genesis of zircons does not always exist. When doing research on Alpine metamorphic rocks using the SHRIMP technique, Gebauer et al.[10,11] found that growth ages can be found at various zircons with quite different morphology. There is no simple correlation between them because of overgrowth.

4 Conclusion

U/Pb age distributions on discodia, and its Th and U contents for Qianshan granitic gneiss indicate that zircon metamorphic growth, not Pb loss mainly occurred for magmatic protolith zircon during UHPM. One cannot distinguish zircon genesis by their morphology alone.

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References

1. Liu, R., Fan, Q, Li H et al., Protolith characteristics of garnet peridotile-eclogite from Bixiling Dabieshan and their geochronological implication, Petrologica Sinica (in Chinese with English abstract), 1995, 11(3): 243.
2. Li, S., Li, H., Chen, Y. et al., Metamorphic geochronology of Dabieshan-Sulu UHP Terrain —II. U/Pb isotopic system of zircon, Science in China, Ser. D, 1997, 27(3): 200.
3. Ames, L., Zhou, G. Z., Xiong, B. C., Geochronology and isotopic character of ultrahigh-pressure metamorphism with implications for collision of the Sino-Korean and Yangtze cratons, Central China, Tectonics,1996, 15(2): 472.
4. Rowley, D. B., Xue, F., Tucker, R. D. et al., Ages of ultrahigh pressure metamorphism and protolith orthogneisses from the eastern Dabie Shan: U/Pb zircon geochronology. Earth Planet. Sci. Lett., 1997, 151: 191.
5. Xue, F., Rowley, D. B., Turker, R. D. et al., U-Pb Ages of Granitoid Rocks in the North Dabie Complex, Eastern Dabieshan, China, J. Geol., 1997, 105: 744.
6. Hacker, B. R., Ratshbacher, L., Webb, L. et al., U/Pb zircon ages constrain the architecture of the ultrahigh-pressure Qinling-Dabie Orogen, China, Earth Planet. Sci. Lett., 1998, 161: 215.
7. Xie, Z., Chen, J., Zhou, T. et al., U-Pb zircon ages of the rocks in Northern Dabie terrain, China, Scientia Geologica Sinica, 1998, 7(4): 501.
8. Parrish, R. P., An improved micro-capsule for zircon dissolution in U-Pb geochronology, Isotope Geoscience,1987, 66: 99.
9. Wetherill, G. W., An interpretation of Rhodesia and Witwatersrand age patterns, Geochim Cosmochim Acta, 1956, 9: 290.
10. Gebauer, D., Schertl, H. P., Brix, M. et al., 35 Ma old ultrahigh-pressure metamorphism and evidence for very rapid exhumation in the Dora Maira Massif,Wester Alps, Lithos., 1997, 41: 5.
11. Gebauer, D., A P-T-t Path for an (Ultra?-) High-Pressure Ultramafic/Mafic Rock-Association and its Felsic Country-Rocks Based on SHRIMP-Dating of Magmatic and Metamorphic Zircon Domains, Example: Alpe Arami (Central Swiss Alps), 1996, in Earth Processes: Reading the Isotopic Code, Geophysical Monograph 95,307—329.

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