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SHRIMP zircon U-Pb dating for gabbro from the Tiding ophiolite in Tibet

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Ophiolite is fragments of oceanic lithosphere formed by obduction and its formation age is very important for reconstructing the formation and evolution of ancient oceanic basin and the configuration of ancient plate tectonics. The Yarlung Zangbo suture zone is the eastern part of the Tethyan suture zone between the India and Eurasian plates. Petrologic sequences of this suture zone in different sections are of some differences[1−5], and their formation ages are also different. There are only a few precise reports about them, for instance, Sm-Nd isochron age for the Luobusha ophiolite in the easthern part is 177± 31 Ma[6], but SHRIMP zircon U-Pb age for the Dgzhuka ophiolite is 126 ± 1.5Ma [7]. The dating of other ophiolitic sections mostly relies on radiolarian fossils, lacking precise and accurate geochronological study, which restricts our understanding of Tethys tectonic evolution. For this reason, we selected the gabbro from the Tiding ophiolite west to Xigaze, and dated it with the SHRIMP zircon U-Pb method. The results provide an important constraint on the tectonic evolution of the Yarlung Zangbo suture zone.

The Jiding ophiolite outcrops in the Yenong Village, Tiding Town, Sa'gya County, 55 km west to Xigaze. It belongs to the middle part of the Yarlung Zangbo suture zone. The Jiding ophiolite massif is located on the Trassic flysch deposites to the south, and Xigaze forearc basin sediments, Gangdise welded magma arc and Tertiary molase and grit rocks to the north. And it is composed of the peridotites, mafic-ultramafic cumulates, diabase sills (dikes) (Fig. 1). The cumulative complex in the Jiding ophiolite consists of the transition zone at the bottom, and the layered cumulation and the massive gabbros covered it [1]. Especially, the Jiding ophiolite is one of the few complete ophiolite profiles in the Yarlung Zangbo suture zone.

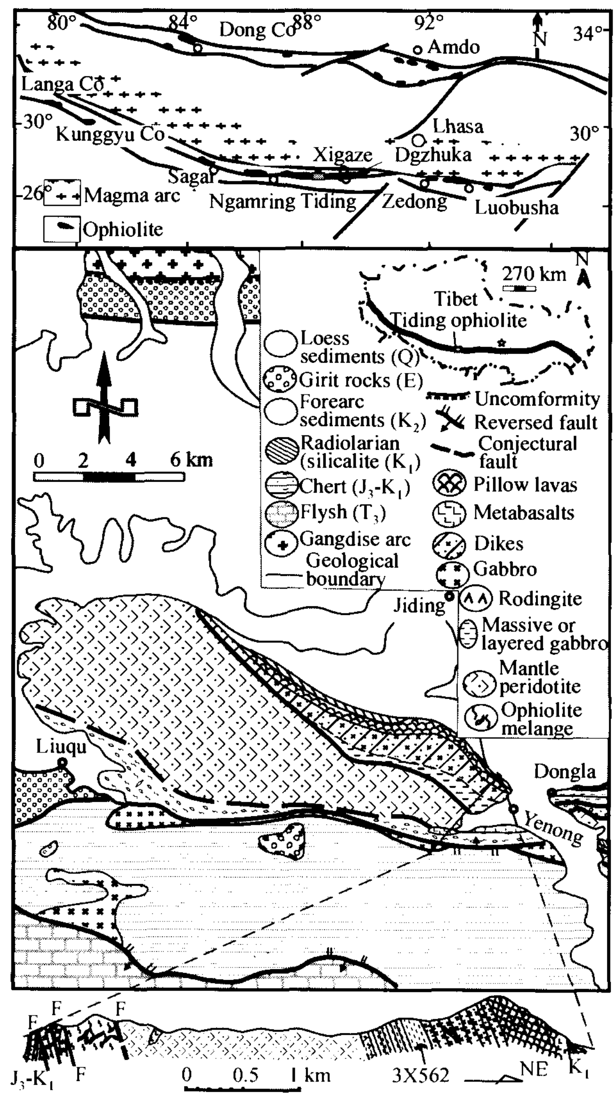

Fig. 1. Geological map of the Jiding ophiolite[1].

1 Samples and analytical methods

Samples were collected from a massive gabbro that is about 300 to 350 m thickness, which is graded into a layered gabbro unit beneath it. The sampling location was positioned by GPS with 29°07′53.0″N and

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88°23′55.2″E (Fig. 1). The optical mineralogy features of gabbros under polarizing microscope indicate that they suffer from stress, and possess medium-grained gabbroic texture. The pyroxenes are altered to uralite, while there are some fresh original crystal remained; and the plagioclases are altered to epidote and prehnite.

The major petrographic unit of the ophiolite is mafic-ultramafic rocks, in which zircon is very few, fine and difficult to separate. In order to get sufficient, appropriate-sized and well crystallized zircon, 2 km samples were manually broken into size of 1 cm^3, put into stainless steel bowls with diameter of 20 centimeters, then abraded about 3—5s in XZW100 Vibro- pulverization (1.1/0.75 KW), and then the samples powder goes into the aperture screen with diameter 0.4 mm repeatedly until all samples achieve the granularity, and then heavy minerals are panned out and enriched by aluminum pan. Non-electromagnetism minerals were gained by Isodynamic separation techniques, and then zircons were enriched by standard heavy liquid again. The final concentration was handpicked under a binocular microscope, and the devices in whole procedure are able to clean, and avoid contamination.

Zircon grains were mounted in epoxy together with the zircon standard TEM (417 Ma), and were then polished into approximately a half, and photographed by reflection and transmission method. Cathodoluminescence (CL) imaging on a Scanning Electron Microscope (SEM) was carried out prior to the analyses to aid the selection of the best target areas for the analyses. The U-Pb dating was done by SHRIMPⅡ ion probe following the standard program in Beijing SHRIMP center. The fractionations between the elements were corrected by the zircon standard TEM, and the abundance of the elements U, Th and Pb was corrected by the zircon standard SL13 (572 Ma, U = 238 ppm)[8]. Detailed testing programs and principles refer to the refs. [9, 10], and the dating analyses can refer to the refs. [11, 12]. For zircons in ophiolites are poor in U, Th and Pb, and Th and U of zircons analyzed in this paper are similar in abundances, and the common Pb was corrected by ^{207}Pb. The errors of the dating spots were all 1σ, and the ages of $^{206}Pb/^{238}U$ were adopted, and the confidence of the weighted average was 95 percent.

2 Results

The grain sizes of the zircons are between 50 mm and 200 mm. The CL imaging suggests three types of zircon: most of zircons were well crystallized, showing crystallized zones or bands texture (refer to 3.1, 7.1, 9.1, 11.1, 14.1 and 15.1 in Fig. 2); some zircons were homogeneous (refer to 6.1 and 10.1 in Fig. 2), suggesting stable crystallizing conditions; and a few zircons possess crystal nucleus (refer to 5.1 in Fig. 2), which we selected to analyze the shells that represent the crystallizing ages.

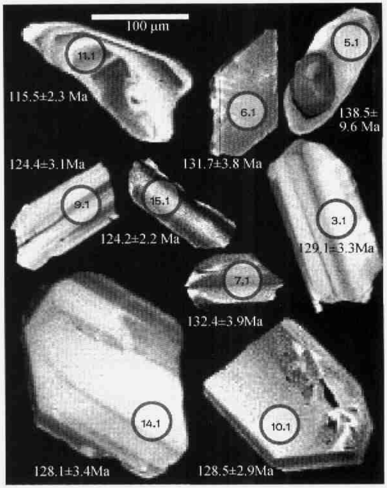

Fig. 2. Representatives of CL imaging for gabbro from the Tiding ophiolite.

The U-Pb isotope analyses show that the abundances of U, Th and Pb are low (Table 1), in the range of 14—233, 5—273, and 1.99—42.2 ppm, respectively. Th/U ratios are 0.29 to 1.21. Crystallizing ages of these three types of zircon are in coincidence, suggesting that the magmatic events are simple. The age of spot 5.1 is 138.5±9.6 Ma and the error is relatively high because of the lowest abundance of U (14 ppm), and the $^{238}U/^{206}Pb$ ratio of spot 11.1 is the highest in the all spots, so these two spots are precluded for further discussion (Fig. 3). The $^{206}Pb/^{238}U$ ages of remaining 13 spots are 124.2 to 132.4 Ma. A weighted mean yields an age of 128±2 Ma (2σ, MSWD = 0.71), which is considered as the crystallizing age of gabbro.

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Table 1 Results of SHRIMP zircon U-Pb dating of gabbro from Tiding ophiolite a)

Spot	U($\mu g \cdot g^{-1}$)	Th($\mu g \cdot g^{-1}$)	Th/U	$^{206}Pb^*$($\mu g \cdot g^{-1}$)	f_{206}(%)	$^{238}U/^{206}Pb$	Error (±1σ)	$^{207}Pb/^{206}Pb$	Error (±1σ)	$^{206}Pb/^{238}U$ age (Ma)	Error (±1σ)
3X562-1.1	233	273	1.21	4.05	3.45	49.46	4.13	0.0612	3.74	128.5	1.7
3X562-2.1	99	68	0.71	1.77	10.66	48.13	4.46	0.0791	5.13	129.1	2.8
3X562-3.1	58	40	0.71	1.06	16.55	46.95	4.63	0.0973	6.09	129.1	3.3
3X562-4.1	150	86	0.59	2.62	3.98	49.29	4.21	0.0699	4.18	127.5	2.0
3X562-5.1	14	5	0.34	0.323	42.2	37.39	7.58	0.2060	8.04	138.5	9.6
3X562-6.1	42	12	0.29	0.809	13.17	44.83	4.78	0.1170	6.40	131.7	3.8
3X562-7.1	50	31	0.63	0.958	9.49	45.03	4.80	0.1096	6.58	132.4	3.9
3X562-8.1	64	46	0.74	1.17	6.83	46.88	4.58	0.0851	6.89	131.4	3.2
3X562-9.1	61	42	0.72	1.12	8.55	47.28	2.43	0.1113	4.45	124.4	3.1
3X562-10 .1	58	39	0.69	1.08	5.95	47.00	2.12	0.0910	6.43	128.5	2.9
3X562-11.1	97	59	0.63	1.58	3.39	53.51	1.93	0.0741	4.11	115.5	2.3
3X562-12.1	76	63	0.85	1.45	5.9	46.11	2.79	0.1016	12.5	129.2	4.2
3X562-13.1	71	52	0.75	1.28	2.36	48.88	2.19	0.0738	6.26	126.4	2.8
3X562-14.1	35	19	0.55	0.653	4.44	47.33	2.49	0.0883	7.28	128.1	3.4
3X562-15.1	130	127	1.01	2.27	1.99	50.16	1.73	0.0676	6.13	124.2	2.2

a) f_{206} and Pb* indicate the common and rediogenic portions respectively; error in standard calibration is 0.38%.

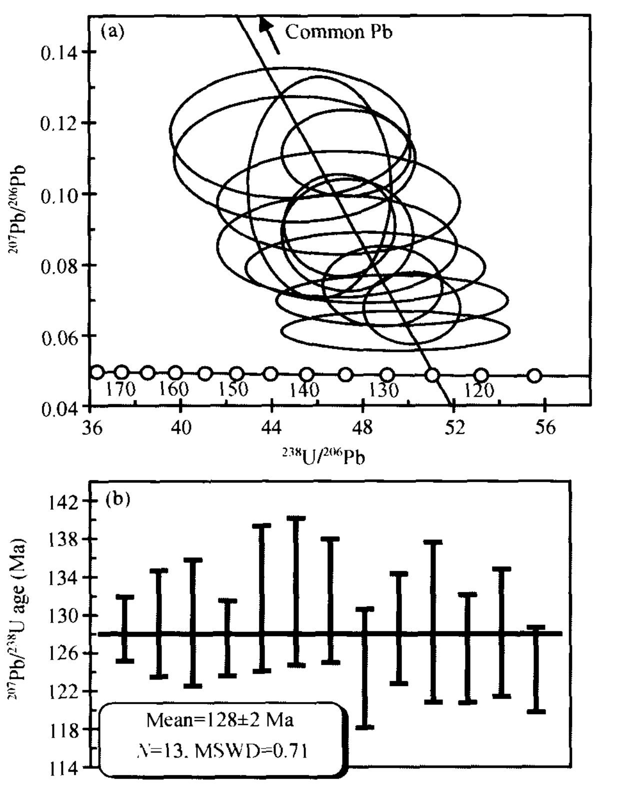

Fig. 3. Tera-Wasserburg U-Pb discordia plot (a) and age statistics (b) for gabbro from Tiding ophiolite.

3 Discussion

SHRIMP zircon U-Pb dating for gabbro from ophiolite is one of the best methods to study the formation time of ophiolites[12], and the age represents the spreading time of the ancient oceanic crusts. The gabbros in question belong to the massive gabbro unit of the Tiding ophiolite, and are graded into the layered gabbro unit beneath it. Thus these gabbros are the products of the magma chamber under the spreading axis of Tethyan crust in the studying area. And the result represents the age of the sea floor spreading of Tethys, which suggests the presence of mature oceanic basin in this region at about 128 Ma. The ophiolitic mélange south to it indicates that the Tiding ophiolite formed in a back-arc basin or an oceanic island setting[13]. This age is consistent with the formation age of 126±1.5 Ma for the Dgzhuka ophiolite as dated by the SHRIMP zircon U-Pb method for the Dgzhuka quartz diorite[7]. Meanwhile, the radiolarian fossils suggest a period between the late Barremian age and the late Aptian age[14], and the Dgzhuka ophiolite probably formed in a fore-arc basin[4,5]. It appears that the different ophiolites in Xigaze that were produced in different tectonic settings have the same ages of formation.

Furthermore, the age of amphibolite-facies metamorphic aureole at the base of the peridotite of Xigaze ophiolite is 81 Ma, which is the time of the tectonic emplacement of Xigaze ophiolite[11]. According to *Orbitolina* found in the flysch group overlying on the Xigaze ophiolites, the obduction emplacement of the Xigaze ophiolites may be in the Eocene [15]. In the eastern part of the Yarlung Zangbo suture zone, however, the Luobusha ophiolite formed in the Middle Jurassic (177 ± 31Ma[6]) and emplaced in the Early Cretaceous[16], which belongs to the SSZ-type[17]. For the Yungbwa ophiolite south of La'ang Co, Ngari, the Sm-Nd isochron age of basalts is 147 ± 25 Ma, the $^{40}Ar/^{39}Ar$

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age of magnesiohornblende in tholeiitic diabase dike is 152 ± 33 Ma, the two ages are both interpreted as the formation time of the Yungbwa ophiolite[18], which formed in a initial marginal basin[2]. It is shown by the chronological evidence mentioned above and geological structure that the ophiolite in the Yarlung Zangbo suture zone has the feature of discontinuity, the rocks suites and tectonic settings are different from each other, and the formation and emplacement ages in the different sections are also different. The formation ages of ophiolite in the eastern and western parts are earlier, while the medium is later. This suggests that the structure pattern of the east Tethys ocean may be a tectonic configuration in the continent-island and oceanic basin, controlled under the same tectonic region, just like the trench-arc-basin systems in west Pacific.

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References

1 Wang X B, Bao P S, Deng W M, et al. Ophiolites of Xizang (Tibet). Tectonic Evolution of Lithosphere in Himalaya) (in Chinese with English abstract). Beijing: Geological Publishing House, 1987
2 Xia B, Wang G Q, Zhong F T, et al. Map of Ophiolites and Tectonostratigraphic Terranes in Himalaya and Its Adjacent Areas and Instruction (in Chinese with English abstract). Lanzhou: Gansu Science and Technology Publishing House, 1993. 4—26
3 Zhang Q, Zhou G Q. Ophiolites of China (in Chinese with English abstract). Beijing: Science Press, 2001. 1—15
4 Xia B, Yu H X., Chen G W, et al. Geochemistry and tectonic environment of the Dagzhuka ophiolite in the Yarlung Zangbo suture zone, Tibet. Geochemical Journal, 2003, 37: 311—324
5 Xia B, Yu H X, Chen G W, et al. Geochemistry of basalts:Evidence for formation of Dazhu ophiolite, Tibet(China), in a supru-subduction zone environment. J Geol Soc of India, 2003, 61: 7—15
6 Zhou S, Mo X X, Mahoney J J, et al. Geochronology and Nd and Pb isotope characteristics of gabbro dikes in the Luobusha ophiolite, Tibet. Chin Sci Bull, 2002, 47(2): 143—146
7 Malpas J, Zhou M F, Robinson P T, et al. Geochemical and geochronological constraints on the origin and emplacement of the Yarlung Zangbo ophiolites, Southern Tibet. In: Dilek Y, Robinsin P T, eds. Ophiolites in Earth History. Geological Society, London, Special Publications, 2003, 218: 147—164
8 Black L P, Kamo S L, Allen C M, et al. TEMORA1: A new zircon standard for Phanerozoic U-Pb geochronology. Chemical Geology, 2003, 200(1—2): 155—170
9 Composton W, Williams I S, Meyer C. U-Pb geochronology of zircons from lunar breccia 73217 using a sensitive high mass-resolution ion microprobe. J Geophys Res, 1984, 89: B525—534
10 Song B, Zhang Y H, Liu D Y. Introducion to the naissance of SHRIMP and its contribution to isotope geology. Journal of Chinese Mass Spectrometry Society (in Chinese), 2002, 23(1): 58—62
11 Williams I S. U-Th-Pb geochronology by ion microprobe. In: Mckibben M A, Shanks W C, Ridley W I, eds. Applications of Microanalytical Techniques to Understanding Mineralizing Processes. Rev Econ Geol, 1998, 7: 1—35
12 Jian P, Liu D Y, Zhang Q, et al. SHRIMP U-Pb dating of ophiolite and leucocratic rock in ophiolite. Earth Science Frontiers (in Chinese with English abstract), 2003, 10(4): 439—456
13 Dupuisa C, Héberta R, Dubois-Côtéa V, et al. Petrology and geochemistry of mafic rocks from mélange and flysch units adjacent to the Yarlung Zangbo Suture Zone, southern Tibet. Chemical Geology, 2005, 214: 287—308
14 Zizbrev S V, Aitchison J C, Abrajevitch A V, et al. Precise radiolarian age constraints on the timing of ophiolite generation and sedimentation in the Dazhuqu terrane, Yarlung-Tsangpo suture zone, Tibet. J Geol Soc London, 2003, 160: 591—599
15 Pearce J A, Deng W M. The ophiolites of the Tibet Geotraverse, Lhasa to Golmud (1985) and Lhasa to Kathmandu (1986). In: Chang C, et al, eds. The Geological Evolution of Tibet. London: The Royal Society, 1988, 215—238
16 Wang G Q, Xia B. The Norbusa ophiolite of Xizang (Tibet) and its tectonic significance. Geotectonica et Metellogenia (in Chinese with English abstract), 1987, 11(4): 349—362
17 Zhou M F, Robinson P T, Malpas J, et al. Podiform chromitites in the Luobusa ophiolite (Southern Tibet): Implications for melt-rock interaction and chromite segregation in the upper mantle. J Petrol, 1996, 37(1): 3—21
18 Miller C, Thoni M, Frank W, et al. Geochemistry and tectonomagmatic affinity of the Yungbwa ophiolite, SW Tibet. Lithos, 2003, 66: 155—172