Zircon U-Pb chronology and geological significance of the acid volcanic rocks in Liaodong Peninsula

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1 Introduction

The Liaodong area as a part of the North China Craton is mainly composed of Proterozoic metamorphic rocks (Liaohe Group) and Paleoproterozoic granite (Liaoning Jilin granite). The Proterozoic metamorphic rocks are divided into the south and the north Liaohe Group. Although many achievements have been made in the study of Liaohe Group, the problems of the formation age and the tectonic setting of the Liaohe Group are controversial. The main reason for the above problems is the selection of the study object. Langzishan formation and Lieryu formation at the bottom of the Liaohe Group are a set of volcano-sedimentary strata. Volcanic rock occurs mainly in the Lieryu formation, the proportion is very small, but has very important geological significance. On one hand, it is the basis for the division of Liaohe Group, on the other hand, it is the direct evidence of discrimination of formation age and tectonic setting of Liaohe Group. A set of acidic volcanic rocks were found in the Lieryu formation in Liaoyang area. In view of important geological significance of acidic volcanic rocks, zircon U-Pb LA-ICP-MS geochronology had been undergone to discuss the formation age and tectonic setting of the Liaohe group combining with regional geological data.

2 Geological setting

Liao-Ji active belt is located in the middle of the Liaodong Peninsula, the south of the Longgang block and the north of Nangrim block. According to the rock combination, the Liaohe group is divided into Langzishan formation, Lieryu formation, Gaojiayu formation, Da shiqiao formation and Gaxian formation from bottom to up. The volcanic rocks composed of rhyolite and decite were mainly developed in Lieryu formation by the working of Liaoning geology team in 1970s. In addition, a set of basic...
volcanic rocks were found in the form of the interlayer in the Dashiqiao formation, which is the submarine volcanic eruption basalt (pillow lava). In this paper, the research object is the acidic volcanic rocks in Lieryu formation including rhyolite, rhyolitic breccia tuff, mylonization rhyolite, weakly silicified rhyolite and rhyolitic tuff, which is located in Huayan Temple area in the southern of Liaoyang in Liaodong peninsula.

3 Zircon U–Pb ages

3.1 Analytical methods

Zircon grains were extracted from whole–rock samples and handpicked at the Langfang Yuneng mineral separation limited company, Hebei Province, China. Cathodoluminescence (CL) images were collected at the Peking Zirconium in pilot technology limited company. The LA-ICP-MS zircon U-Pb analyses were completed at the Geologic Lab Centre, China University of Geosciences, Beijing, China and University of jilin university northeast Asia mineral resources evaluation of key laboratory of land and resources.

3.2 Analytical results

In CL images, All samples display striped absorption and fine-scale oscillatory zoning. Zircons within the samples are short to long column. Most zircons have high Th/U ratios, from 0.34 to 1.63, indicating a magmatic origin. Therefore, the LA-ICP-MS U-Pb zircon ages represent their magmatic crystallization ages.

Twenty-five analyses of zircon were obtained from sample D1442-1. On a Concordia diagram, two concordant analyses have older ages and the weighted mean 207Pb/206Pb age of 2557 ± 38 Ma (n = 2). All the other analyses define an age of 2190 ± 19 Ma (n = 23).

For the sample D1444-2, twenty-five U-Pb analyses were obtained. All but one of the analyses are concordant and yield a upper intercept age of 2192 ± 17 Ma (n = 23).

Twenty-two analyses of zircons were obtained from D14109-2. The first and the last ages are consistent with two upper intercept ages of 2181 ± 47 Ma (n = 9) and 2012 ± 17 Ma (n = 11) within error.

Twenty-two analyses of zircons were obtained from D14111-1a. Thirteen analyses fall on a discordia line with an upper intercept age of 1744 ± 7 Ma.

Twenty-two analyses of zircons were carried out on D14111-1b. Ten analyses fall on a discordia line with an upper intercept age of 2062 ± 54 Ma (n = 9).

Twenty-two analyses of zircons were obtained from D14112-1. All but three of the analyses are concordant or nearly concordant and an upper intercept age of 2013 ±31 Ma (n = 19).

Twenty-two analyses of zircons were obtained from D14114-1b. Thirteen analyses fall on a discordia line with an upper intercept age of 1942 ± 12 Ma (n = 13).

Twenty-five analyses of zircons were carried out on 14GW585. Nearly all the concordant or nearly concordant analyses yielded three 207Pb/206Pb weighted average ages of 2055 ± 20 Ma (n = 8), 2181 ± 23 Ma (n = 15), 2322 ± 40 Ma (n = 2). The youngest age should represent the crystallization age of the rhyolite. The others of two inherited zircon ages could reflect two differentia magmatic activity in this area.
4 Discussion and conclusion

4.1 The magmatic activity stage in Liaohе Group and its limitation on the formation time of Liaohе Group

Zircon U-Pb LA-ICP-MS datas of 8 acidic volcanic rocks in Lieryu formation in Liaoyang area show frequent volcanic activities in Liaohе group, and representing the age of magmatic activity has 5 stages of 2180−2190 Ma, 2055−2077 Ma, 2010−2015 Ma, 1949 + 6 Ma, 1744 + 7 Ma. The first phase of 2180−2190 Ma magmatic activity is the same as crystallization age (2198−2158 Ma) of fined-grained gneiss and metamorphic basalts in Lieryu formation (Li et al. 2014), and is the same period with volcanic clastic rocks (2174±10 Ma) in boron deposits. The second phase volcanic rocks of 2055−2077 Ma are the same magmatic activity products with the protolith of amphibolite (2059 + 22 Ma) in Mafengpo area. These two stages of magmatic activity 2010−2015 Ma and 1949 + 6 Ma are reflected in detrital zircons in metamorphic sedimentary rocks (Luo, et al., 2004, 2008; Zhao, et al., 2005; Li, et al., 2006; Wan, et al., 2006; Lu, et al., 2006). The final stage of 1744 + 7 Ma has not been reported. In addition to the direct diagenetic age, there is a display of inherited zircons of Archean and Paleoproterozoic magmatism in the period of 2538−2557 Ma, 2322 + 40 Ma, 2105 + 6 Ma. The Archean age 2538−2557 Ma represents the crystalline basement of the North China Craton. Re-Os dating results of 6 samples of arsensopyrite in Maoling gold deposit, which is 2316 + 140 Ma, shows the sedimentary age of Liaohе Group earlier than this age, and so the inherited zircon 2322 + 40 Ma is product of magmatic activity in Liaohе group. Combining with the age of metamorphic basalt (1869 + 28 Ma) in Dashiqiao formation, it is believed that there are at least 8 magmatic activities in the long process of sedimentation in Liaohе group: 2322±40 Ma, 2180−2190 Ma, 2105±6 Ma, 2055−2077 Ma, 2010−2015 Ma, 1949±6 Ma, 1869 Ma±, 1744±7 Ma.

Based on the study of the Precambrian granites in Liaodong Peninsula, the formation age of the Liaohе Group was restricted to 2.16−85 Ga, and was narrowed to 2035−1885 Ma by the study of metamorphic sedimentary rocks, and was limited to be earlier than 1857 Ma by the study of Kuangdonggou alkaline syenite complex rocks. But some scholars believe that the formation of Liaohе Group may be earlier. The age of 2229 + 3 Ma of mixed granites in Ming’an boron deposit in Liaodong represent the age of acidic volcanic rock in Liaohе group. The phenomenon of strong δC13 drift indicates that the Liaohе Group is deposited between 2.33−2.06 Ga. The age of 2322 + 40 Ma in this paper is product of the earliest volcanic activity of Liaohе Group, so the Liaohе Group formed before it.

The beginning and ending times of metamorphism of Liaohе Group are 1. 93 Ga and 1.85 Ga, and the latter represents the end of sedimentation of Liaohе Group (Luo, et al., 2004; Lu, et al., 2006; Li, et al., 2014). However, some researchers believed that the metamorphic zircon age of ~ 1.85 Ga indicates the response of the South Liaohе Group to the late thermal events (Li, & Zhao, 2007; Luo, et al., 2008) and could not represent the late depositional age of the South Liaohе Group. The 207Pb/206Pb ages (1715±62 Ma and 1787±34 Ma) of “Lianhuashan granites” in Nangrim block and Pb-Pb ages (1749 Ma and 1793 Ma) of rapakivi granites in Liaodong indicated that there were magmatic activities after the peak metamorphism of Liaohе Group. The 1744 + 7 Ma age was the product of volcanic activity after the metamor-
phism of the Liaohe Group. In summary, the times of volcanic activity can be extended to 2322–1744 Ma, which represents the formation time of Liaohe Group is very long, which lasted about 580 Ma.

4.2 Tectonic setting of Liaohe Group

A series of acidic volcanic rocks (rhyolite and rhyolitic tuff) that identified in Lieryu formation in Huayan temple and Lianguanshan in south of Liaoyang and metarhyolite (2201±5 Ma) that found in South Liaohe group were the acidic composition. Plagioclase amphibolite (2059±22 Ma) in Langzishan formation in Haicheng area, meta-basalts (2198±10 Ma, 2172±8 Ma) in Lieryu formation in South Liaohe group, basaltic pillow lava (1869±28 Ma, 1828±13 Ma) in Dashiqiao formation, gabbro in Haicheng and Guohua mafic dyke in west of Liaoning, all of these were basic composition. These evidences indicated the existence of bimodal volcanic rocks in Liaohe Group, and they could be compared in geochronology. Combining with A-type granite, it was suggested that Liaohe Group was formed in extensional environment.

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References


