1.13 石榴石 LA-ICP-MS 微区原位 U-Pb 定年和微量元素分析

石榴石 U-Pb 同位素定年和微量元素含量在武汉上谱分析科技有限责任公司利用 LA-ICP-MS 同时分析完成。详细的仪器参数和分析流程见（Chen et al., 2021）。GeolasPro 激光剥蚀系统由 COMPexPro 102 ArF 193 nm 准分子激光器和 MicroLas 光学系统组成，ICP-MS 型号为 Agilent 7900。激光剥蚀过程中采用氦气作载气、氩气为补偿气以调节灵敏度，二者在进入 ICP 之前通过一个 T 型接头混合，激光剥蚀系统配置有信号平滑装置 (Hu et al., 2015)。本次分析的激光束斑和频率分别为××μm 和××Hz。U-Pb 同位素定年和微量元素含量处理中采用与石榴石成分接近的锆石标准 91500 (Wiedenbeck et al., 1995)和玻璃标准物质 NIST610 作外标分别进行同位素和微量元素分馏校正。石榴石 Mali 以及 Willsboro 作为未知样品进行分析，同位素组成参考 (Seman et al., 2017)。每个时间分辨分析数据包括大约 20-30 s 空白信号和 50 s 样品信号。对分析数据的离线处理（包括对样品和空白信号的选择、仪器灵敏度漂移校正、元素含量及 U-Pb 同位素比值和年龄计算）采用软件 ICPMSDataCal (Liu et al., 2008; Liu et al., 2010) 完成。石榴石样品的 U-Pb 年龄谐和图绘制和年龄加权平均计算采用 Isoplot/Ex_ver3 (Ludwig, 2003) 完成。

1.13 In-situ U-Pb dating and trace element analysis of Garnet by LA-ICP-MS

U-Pb dating and trace element analysis of garnet were simultaneously conducted by LA-ICP-MS at the Wuhan SampleSolution Analytical Technology Co., Ltd., Wuhan, China. Detailed operating conditions for the laser ablation system and the ICP-MS instrument and data reduction are the same as description by (Chen et al., 2021). Laser sampling was performed using a GeolasPro laser ablation system that consists of a COMPexPro 102 ArF excimer laser (wavelength of 193 nm and maximum energy of 200 mJ) and a MicroLas optical system. An Agilent 7900 ICP-MS instrument was used to acquire ion-signal intensities. Helium was applied as a carrier gas. Argon was used as the make-up gas and mixed with the carrier gas via a T-connector before entering the ICP. A “wire” signal smoothing device is included in this laser ablation system (Hu et al., 2015). The spot size and frequency of the laser were set to ××μm and ××Hz, respectively, in this study. zircon standard 91500 (Wiedenbeck et al., 1995) （which is close to the composition of garnet）and glass NIST610 were used as external standards for U-Pb dating and trace element calibration, respectively .Garnet Mali and Willsboro were analyzed as unknown samples, with reference to isotopic composition (Seman et al., 2017). Each analysis incorporated a background acquisition of approximately 20-30 s followed by 50 s of data acquisition from the sample. An Excel-based

software ICPMSDataCal was used to perform off-line selection and integration of background and analyzed signals, time-drift correction and quantitative calibration for trace element analysis and U-Pb dating (Liu et al., 2008; Liu et al., 2010). Concordia diagrams and weighted mean calculations were made using Isoplot/Ex_ver3 (Ludwig, 2003).

References

Ying Hua Chen , et al. "Precise UPb dating of grandite garnets by LA-ICP-MS: Assessing ablation behaviors under matrix-matched and non-matrix-matched conditions and applications to various skarn deposits - ScienceDirect." Chemical Geology 572(2021).

Hu, Z.C., Zhang, W., Liu, Y.S., Gao, S., Li, M., Zong, K.Q., Chen, H.H., Hu, S.H., 2015. “Wave” signal-smoothing and mercury-removing device for laser ablation quadrupole and multiple collector ICPMS analysis: application to lead isotope analysis. Analytical Chemistry, 87(2), 1152–1157.

Wiedenbeck, M. et al., 1995. Three natural zircon standards for U-Th-Pb, Lu-Hf, trace element and REE analysis. Geostandards Newsletter, 19(1): 1-23.

Seman, S., Stockli, D.F., McLean, N.M., 2017. U-Pb geochronology of grossular-andradite garnet. Chem. Geol. 460, 106–116

Liu, Y.S., Hu, Z.C., Gao, S., Günther, D., Xu, J., Gao, C.G. and Chen, H.H., 2008. In situ analysis of major and trace elements of anhydrous minerals by LA-ICP-MS without applying an internal standard. Chemical Geology, 257(1-2): 34-43.

Liu, Y.S., Gao, S., Hu, Z.C., Gao, C.G., Zong, K.Q. and Wang, D.B., 2010. Continental and oceanic crust recycling-induced melt-peridotite interactions in the Trans-North China Orogen: U-Pb dating, Hf isotopes and trace elements in zircons of mantle xenoliths. Journal of Petrology, 51(1–2): 537–571.

Ludwig, K.R., 2003. ISOPLOT 3.00: A Geochronological Toolkit for Microsoft Excel. Berkeley Geochronology Center, California, Berkeley, 39 pp.