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Supplementary

The Late Triassic Molasse Deposits in Central Jilin Province, NE China: Constraints on the Paleo-Asian Ocean Closure

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Analytical techniques

1. Zircon U–Pb Dating and In-Situ Hf Isotope Analysis

Zircons were separated using a Frantz magnetic separator and heavy liquids at the Hebei Regional Geological Survey, China. Cathodoluminescence (CL) images were obtained using JEOL JXA-8900RL scanning electron microscope at the State Key Laboratory of Continental Dynamics, Northwest University, Xi'an, China. Samples were analyzed for geochronology on an Agilent 7500a ICP-MS equipped with a 193 nm laser ablation system GeoLas 2005, housed at the State Key Laboratory of Continental Dynamics, Northwest University, Xi'an, China. The instrument parameter and detail procedures were described by Yuan et al. (2004) [1]. The spot diameter and denudation depth are 32 μm and 20 to 40 μm, respectively. The 91500 zircon standard was used as an external standard for age calibrations. Furthermore, a standard silicate glass NIST SRM610 and a zircon GJ-1 are the standards as optimizing the analyses. Isotopic ratios and element contents were calculated by using the GLITTER 4.0 [2]. The age calculation and Concordia plots were made using Isoplot (Ver. 3.0) [3]. Concordance was calculated as ($^{206}Pb/^{238}U/^{207}Pb/^{235}U$) × 100 with concordance defined between 90% and 110%.

In-situ zircon Lu-Hf isotopic analysis was carried out on the similar internal domains of close to the original pit used for U-Pb isotopic analyses, using a Nu Plasma II MC-ICP-MS at the State Key Laboratory of Continental Dynamics, Northwest University, Xi'an, China. An ArF excimer laser ablation system of ASI RESOlution M-50 (193 nm) was used with a spot size of 44 μm. The Hf isotopic analysis was carried out at a beam density of 6 J/cm^2, with a repetition rate of 5 Hz. The standard zircons 91500 and Mudtank were used as external standards and were analyzed twice before and after every 8 analyses. The detailed procedures are described by Yuan et al. (2008) [4].

2. Whole-Rock Elemental Analysis

The major and trace element concentrations of the whole-rock samples were determined at the Supervision and Inspection Center of Mineral Resources, the Ministry of Land and Resources of

Jinan, China. The concentrations of Al_2O_3 and SiO_2 were analyzed using the xylenol orange method and the gelatin coagulation gravimetic method, respectively. The other major oxides and some trace elements, (Cr, V, Sr, and Ba) were determined by IRIS-Intrepid ICP atomic emission spectrometer (AES) using the standard analytical protocol of GB/T14506-2010 for the oxides. Detailed analytical procedures are similar to those described by Rudnick et al. (2004) [5]. Analytical uncertainties range from 1% to 3%. The other trace element concentrations were determined using an X-Series 2 ICP-MS, and the analytical procedures are similar to those described by Song et al. (2018) [6]. An internal standard solution containing the single element Rh was used to monitor signal drift during counting. The analytical precision for major elements is better than 1% and for trace elements is generally better than 5%.

3. Whole-Rock Sr-Nd Isotope Analysis

Rb-Sr and Sm-Nd isotopic analyses were performed on a Micromass Isoprobe multi-collector ICPMS (MC-ICP-MS) in static mode at the Institute of Geochemistry, Chinese Academy of Science, Guangzhou, China. The analytical procedures followed those of Li et al. (2004) [7]. During the process of test, the standards NBS 987 and Jndi-1 yielded $^{87}Sr/^{86}Sr$ ratios of 0.710234 ± 0.000010 (2σ, n = 2) and $^{143}Nd/^{144}Nd$ ratios of 0.512094 ± 0.000007 (2σ, n = 2).

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