Neoproterozoic deglacial meltwater-rock reaction recorded by zircon in-situ oxygen isotopes in metaigneous rocks from the Sulu orogen

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To seek the unusually ^{18}O-depleted magmatism in the Neoproterozoic, zircon in-situ O and U-Pb isotopes were analyzed for granitic gneisses from the Sulu orogen in east-central China. Zircons exhibit complex core-rim structures and variable degrees of metamorphic overgrowth and recrystallization. Zircon U-Pb dating yields protolith ages of 753±15 Ma to 780±13 Ma and metamorphic ages of 209±9 to 240±30 Ma. The Neoproterozoic cores with concordant U-Pb ages exhibit a wide range of $\delta^{18}O$ values from -11.0 to 5.8‰, which is nearly the same as those for Neoproterozoic cores with discordant U-Pb ages. Oxygen isotope compositions are very homogeneous for rims of Triassic U-Pb ages in some samples, with $\delta^{18}O$ values of around -10‰. Rims of the other samples show a wider range with both negative and positive $\delta^{18}O$ values. The $\delta^{18}O$ values as negative as -11.0‰ for zircons with concordant Neoproterozoic U-Pb ages are reported for the first time, representing the primary record of Neoproterozoic negative $\delta^{18}O$ magmas. Theoritical calculations and core-rim differences both support the preservation of primary O isotopes in the cores of concordant U-Pb ages. A conservative estimate suggests that the hydrothermal fluid involved in water-rock interaction should have a $\delta^{18}O$ value lower than -9.2‰, corresponding to the meteoric water of cold paleoclimate or the meltwater of local continental glaciation in the Middle Neoproterozoic. The spatial variation in the O isotope compositions of Neoproterzoic zircons is a manifestation of the O isotope heterogeneity in the fossil magmatic system. In addition, the hydrothermal alteration on rock-forming minerals during the Neoproterozoic was incongruent, which is lately recorded by the wide range of $\delta^{18}O$ values for the Triassic metamorphic zircons. The extensive O isotope exchange between the surface water and the deep rock requires high temperature and high water-rock ratios. This is ascribed to continental rifting in response to breakup of the Rodinia supercontinent. Heat from the mantle may enhance the extent of hydrothermal alteration and subsequent partial melting of the hydrothermally altered rocks.