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北苏鲁仰口地区变辉长岩中锆石U-Pb定年、微量元素和Hf同位素特征及其地质意义

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摘要:

北苏鲁仰口地区出露超高压的变辉长岩。锆石阴极发光图像和其内部矿物包体激光拉曼测试的联合研究表明,变辉长岩锆石具有弱发光效应的岩浆韵律环带的核和被改造的强发光效应的边。岩浆韵律环带的核部保存大量而复杂的矿物包体,包括普通辉石 (Cpx)+斜方辉石 (Opx)+斜长石 (Pl)+石英 (Qtz)+黑云母 (Bt)+钛铁矿 (Ilm)+磷灰石 (Ap); 边部保存的矿物包体则相对较少,包括普通辉石 (Cpx)+斜方辉石 (Opx)+斜长石 (Pl)+磷灰石 (Ap)。尽管岩浆韵律环带核部的稀土元素总含量比被改造的锆石边部明显偏高,但二者稀土元素配分模式具有明显的相似性,主要表现为轻稀土相对亏损,而重稀土明显富集,相应的 $(La/Yb)_N=0.00015\sim 0.00039$,并具有明显的负Eu异常 ($Eu/Eu^*=0.20\sim 0.26$)、相对明显的正Ce异常 ($Ce/Ce^*=71.5\sim 147.4$) 和较高的Th/U比值 (1.97~2.69)。上述特征表明 仰口地区变辉长岩中的锆石均为继承性的岩浆锆石,而没有新生的变质锆石。LA-(MC)-ICP-MS锆石原位U-Pb定年和Lu-Hf同位素分析结果表明,两件锆石样品Y1和Y2的年龄数据所构成的不一致线显示了十分接近的上交点和下交点年龄。其上交点年龄分别为 $785\pm 15Ma$ (2σ) 和 $784\pm 12Ma$ (2σ),应代表原岩的形成时代,表明变辉长岩的原岩与Rodinia超大陆裂解的岩浆事件存在密切的成因关系; 而下交点年龄分别为 $226\pm 24Ma$ (2σ) 和 $228\pm 26Ma$ (2σ),与苏鲁其它类型超高压岩石中含柯石英锆石微区记录的变质年龄十分吻合,应代表变辉长岩的超高压变质时代。岩浆结晶锆石的核部具有明显偏高的 $^{176}Lu/^{177}Hf$ (0.00044~0.00291) 和 $^{176}Yb/^{177}Hf$ (0.0165~0.1168) 比值,而 $^{176}Hf/^{177}Hf$ 比值变化于0.281956~0.282048之间,相应的 $\epsilon_{Hf}(t)=-8.5\sim -14.0$, $t_{DM2}=2.03\sim 2.32Ga$,表明仰口地区变辉长岩的原岩起源于古元古代时期的富集地幔或发生部分熔融的下地壳残留体。被改造的岩浆结晶锆石的边部则具有明显偏低的 $^{176}Lu/^{177}Hf$ (0.00029~0.00060) 和 $^{176}Yb/^{177}Hf$ (0.0112~0.0200) 比值,而 $^{176}Hf/^{177}Hf(t)$ 比值变化于0.281953~0.282002之间,相应的 $\epsilon_{Hf}(t)=-10.2\sim -11.9$, $t_{DM2}=2.12\sim 2.21Ga$ 。与岩浆结晶锆石核部相比,被改造的岩浆锆石边部的 $^{176}Lu/^{177}Hf$ 、 $^{176}Yb/^{177}Hf$ 、 $^{176}Hf/^{177}Hf(t)$ 比值和 $\epsilon_{Hf}(t)$ 和 t_{DM2} 值的变化范围更小,表明中-新三叠纪的超高压变质作用使岩浆结晶锆石边部的Lu-Hf同位素体系发生调整,更趋向于均一化。

英文摘要:

Meta-gabbro blocks are commonly distributed in Yangkou area, north Sulu ultrahigh-pressure (UHP) metamorphic belt. Laser Raman spectroscopy and cathodoluminescence (CL) image reveal that zircons separated from the meta-gabbro Y1 and Y2 preserve complex mineral inclusions in different domains. Obviously zoned, dark-luminescent zircon cores preserve mineral inclusions of clinopyroxene (Cpx)+orthopyroxene (Opx)+plagioclase (Pl)+quartz (Qtz)+biotite (Bt)+ilmenite (Ilm)+apatite (Ap), and weakly zoned, grey-white luminescent zircon rims contain mineral inclusions of Cpx+Opx+Pl+Ap indicative of a mafic igneous protolith. Both zircon cores and rims have similar rare earth element (REE) patterns. The chondrite-normalized REE patterns of the cores and rims are characterized by higher contents of the (heavy) HREE and particularly lower contents of the (light) LREE with $(La/Yb)_N$ of 0.00015 to 0.00039. Their strongly negative Eu anomaly (mean $Eu/Eu^*=0.21\sim -0.26$), and high Ce/Ce* ratio (mean $Ce/Ce^*=71.5\sim 147.4$) and Th/U ratio (mean $Th/U=1.97\sim 2.69$) is a common feature of magmatic zircon. Magmatic zircon core and recrystallized zircon rims from both samples Y1 and Y2 yielded $^{206}Pb/^{238}U$ ages of 809~380Ma with an upper intercept age of $785\pm 15Ma$ (2σ) and $784\pm 12Ma$ (2σ), respectively, interpreted as the age of a mafic igneous protolith, and a lower intercept age of $226\pm 24Ma$ (2σ) and $228\pm 26Ma$ (2σ), respectively, interpreted as the UHP metamorphic age. Magmatic zircon cores show higher $^{176}Lu/^{177}Hf$ ratios of 0.00044~0.00291 and $^{176}Yb/^{177}Hf$ ratios of 0.0165~0.1168. The $^{176}Hf/^{177}Hf(t)$ ratios range from 0.281956 to 0.282048, corresponding to $\epsilon_{Hf}(t)$ of -8.5 to -14.0 and t_{DM2} ages of 2.03 to 2.32Ga. In contrast, recrystallized zircon rims are characterized by lower $^{176}Lu/^{177}Hf$ (0.00029~0.00060) and $^{176}Yb/^{177}Hf$ (0.0112~0.0200) ratios. The $^{176}Hf/^{177}Hf(t)$ ratios range from 0.281953 to 0.282005, with $\epsilon_{Hf}(t)$ of -10.2 to -11.9 and t_{DM2} ages of 2.12 to 2.21Ga. The Hf contents of the studied meta-gabbro samples imply a significant input from the enriched mantle to the Sulu UHP terrane during Paleoproterozoic times. Whereas lower $^{176}Lu/^{177}Hf$ and $^{176}Yb/^{177}Hf$ ratios for the recrystallized zircon rims and similar $^{176}Hf/^{177}Hf(t)$, $\epsilon_{Hf}(t)$ and model age (t_{DM2}) to the magmatic cores indicate the Lu-Hf isotope of recrystallized rims was equilibrated with the whole-rock during the UHP metamorphism.

关键词: [岩浆锆石](#) [变辉长岩](#) [U-Pb定年](#) [Hf同位素](#) [富集地幔](#) [仰口](#) [苏鲁超高压变质带](#)

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