Supplementary Material 4

U-Pb m*ethods*

Zircons were separated with conventional methods (crushing, heavy liquids, hand picking). Zircons as free as possible from fractures and inclusions were mounted in epoxy resin, polished and characterised for the internal structure by cathodoluminescence (CL).

In-situ U-Pb geochronology of the amphibole-gabbros from the Adamello batholith was carried out with an excimer laser ablation (ELA)-ICPMS at C.N.R.-I.G.G.-UOS of Pavia. The laser ablation instrument couples an ArF excimer laser microprobe at 193 nm (Geolas200Q-Microlas) with a sector field high resolution ICPMS Element I from Thermo Finnigan. The analytical method is basically that described in Tiepolo (2003). Each analysis consist in the acquisition of 60s of background signal and 60s of ablation signal for masses 202, 204, 206, 207, 208, 232 and 238. Masses 232 and 238 were acquired in analog mode whereas the other masses in counting mode. Instrumental and laser-induced U/Pb fractionations were corrected using zircon 91500 (1064Ma; Widenbeck et al., 1995) as external standard. Unknowns were bracketed by 10 analyses of external standards divided in three different blocks. The same integration intervals and spot size were used on both the external standard and unknowns. During the analytical run reference zircon 02123 (295 Ma; Ketchum et al., 2001) was analysed together with unknowns for quality control and yield a U-Pb concordant age at 299±8 Ma (2s). In this work, the spot size was set to 20 µm, laser fluency to 12J/cm2 and repetition rate to 5Hz. No appreciable common Pb was detected in the analysed zircon having the signal of 204 always at the background level and no common Pb correction was applied. Data reduction was carried out using the “Glitter” software package (van Achterbergh et al., 2001) setting at 1% the error of the external standard. The reproducibility on the standards was propagated to all determinations according to the equation in Horstwood et al. (2003). After this operation, analyses are considered accurate within quoted errors. Concordia ages were determined and Concordia plots were constructed using the Isoplot/EX 3.0 software (Ludwig, 2000). All errors in the text are given at 2s level.

In situ U-Pb geochronology of the Bergell zircons was carried out by laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS), using an Agilent 7500a quadruple ICPMS connected with a 193 nm excimer ArF laser-ablation system (Geolas plus), at the Institute of Geology and Geophysics, Chinese Academy of Sciences (IGGCAS) in Beijing, China. The detailed analytical procedures can be found in Xie et al. (2008). Before analysis, the sample surface was cleaned with ethanol to eliminate possible contamination. Every 5 sample analyses were followed by analysing of a suit of zircon standards, i.e., Harvard zircon 91500 (Wiedenbeck et al., 1995) and zircon GJ-1 (Elhlou et al., 2006). Each spot analysis consisted approximately of 20 s background acquisition and 40 s sample data acquisition. $^{207}Pb/^{206}Pb$, $^{206}Pb/^{238}U$, $^{207}U/^{235}U$ (^{235}U = ^{238}U/137.88) ratios were corrected by using zircon 91500 as external standard. The fractionation correction and results were calculated using GLITTER 4.0 (Macquarie University) (Jackson et al., 2004). No common Pb correction was applied. During this study, the spot size and pulse rate were 44 µm and 4 Hz, respectively, and reference zircon GJ-1 yielded a weighted $^{206}Pb/^{238}U$ age of 608±9 Ma (2δ, n=13).

Hf isotopes *methods*

The Hf isotope composition of zircon was determined by laser ablation-MC-ICP-MS for the two hornblendites from the Adamello batholith previously dated by Tiepolo et al. (2011) and for the newly dated amphibole-rich mafic rocks from the Adamello batholith and Bergell pluton. The Hf isotope analyses were carried out on the same zircon domains that were analysed for U-Pb geochronology. Each initial $^{176}Hf/^{177}Hf$ ratio and initial ε_{Hf} was calculated according to the corresponding U/Pb date.

Zircon Hf isotopic measurements were carried out at the Institute of Geology and Geophysics, Chinese Academy of Sciences (IGGCAS) in Beijing, China with a Neptune MC-ICPMS coupled with a 193 nm excimer ArF laser-ablation system (GeoLas Plus). The JMC 475 standard solution with 200 ppb Hf was used for evaluating the reproducibility and accuracy of the instrument before laser ablation analyses. Details about this solution are in Wu et al. (2006). The results of $^{176}Hf/^{177}Hf$ for JMC475 Hf standard solution in a long term give an average $^{176}Hf/^{177}Hf$ ratio of

0.282158±16 (n=140, 2SD) normalized to $^{179}Hf/^{177}Hf$=0.7325 using an exponential law for mass bias correction (Wu et al., 2006). This value is identical to that recommended by Nowell et al. (1998). During laser ablation analyses, the isobaric interference of 176Lu on 176Hf is negligible due to the extremely low $^{176}Lu/^{177}Hf$ in zircon (normally <0.002). However, the interference of ^{176}Yb on ^{176}Hf must be carefully corrected since the contribution of ^{176}Yb to ^{176}Hf could profoundly affect the accuracy of the measured $^{176}Hf/^{177}Hf$ ratio. In this project, the mean $^{173}Yb/^{171}Yb$ ratio of the individual spots was used to calculate the fractionation coefficient (βYb), and then to calculate the contribution of ^{176}Yb on ^{176}Hf. It is shown that this method can provide an accurate correction of the ^{176}Yb interference on ^{176}Hf (Woodhead et al., 2004; Wu et al., 2006; Kemp et al., 2009). During analysis, an isotopic ratio of $^{176}Yb/^{172}Yb$=0.5887 was applied (Wu et al., 2006). Since the integration times of our Neptune machine are designed at 0.131, 1, 4 and 8 s, a signal collection model for one block with 200 cycles, in which one cycle has 0.131 s integration time and total time for one measurement lasts about 30 s, was the most optimal model for laser ablation analyses, since more data were obtained and less time is required. During this study the spot size was set at 44 µm and laser repetition rate at 6Hz. Standard zircon Mud Tank was used for external correction. During analytical sessions, the obtained $^{176}Hf/^{177}Hf$ value of Mud Tank was 0.282509±6 (2σ, n=24) within error with the values 0.282507±6 and 0.282504±44 obtained by the solution method and by laser ablation, respectively (Woodhead and Hergt 2005). During data acquisition, analyses of GJ-1 as an unknown yielded a weighted $^{176}Hf/^{177}Hf$ ratio of 0.282016±12 (2σ, n=24), within error with the reported value of 0.282015±19 (2s, n=25) (Elhlou et al., 2006). Analysed zircons do not show correlation between $^{176}Yb/^{177}Hf$ and $^{176}Hf/^{177}Hf$, and the observed variation on $^{176}Yb/^{177}Hf$ likely reflects the characters of zircon from the samples, as no variation was found in the standard zircons and zircons from other samples analysed during that time.

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