

ANALYTICAL METHODS

Electron microprobe analysis

Mineral compositions were determined by WDS analysis using a CAMECA SX-100 electron microprobe at the Dionýz Štúr Institute of Geology in Bratislava. The analytical conditions were as follows: 15 kV accelerating voltage and 20 nA beam current, peak counting time 20 s and beam diameter of 2-10 μm . Raw counts were corrected using on-line PAP routine.

Mineral standards (Si, Ca: wollastonite, Na: albite, K: orthoclase, Fe: fayalite, Mn: rhodonite), pure element oxides (TiO_2 , Al_2O_3 , Cr_2O_3 , MgO) and metals (Ni) were used for calibration.

Lu-Hf dating

Sample LOF 3/12 was crushed in a steel mortar. A representative aliquot was powdered in an agate mill for bulk rock analysis. A second split of the sample was sieved and the minerals were separated from a 355-500 μm size fraction using a Frantz magnetic mineral separator. Further garnet separation was obtained by hand picking under a binocular microscope. The garnet separates were cleaned in an ultrasonic bath in 2.5 M HCl and rinsed with deionized water. A mixed ^{176}Lu - ^{180}Hf tracer was added to all samples before digestion. In order to avoid digestion of the refractory Hf-rich phases zircon and rutile the garnet separates and one whole rock fraction were dissolved following the “tabletop” digestion method (Lagos et al., 2007). The samples were digested with an $\text{HF-HNO}_3\text{-HClO}_4$ (4:2:1) acid mixture in Savillex® PFA beakers on a 120 °C hotplate, then dried down and re-dissolved in 6 N HCl. The digestion procedure had to be repeated at least one more time for all samples to achieve complete digestion of the target phase. A second split of whole rock powder was digested in a 1:1 HF-HNO_3 acid mixture inside steel-jacketed PARR bombs for four days at 180 °C, ensuring full sample digestion. Once again, HClO_4 was added to the sample. It was then dried down and re-dissolved in 6 N HCl.

All sample solutions were clear, indicating complete sample digestion. The single-column element separation procedure (Münker et al., 2001) was used to separate Lu and Hf from the rock matrix. In addition, the Hf cuts were processed a second time in order to remove matrix elements and especially Lu.

Lu and Hf isotopic analyses were carried out in static mode using Thermo Neptune MC-ICPMS at the Steinmann Institute in Bonn. Measured Hf isotope ratios were corrected for mass fractionation using the exponential law and a $^{179}\text{Hf}/^{177}\text{Hf} = 0.7325$. All measured $^{176}\text{Hf}/^{177}\text{Hf}$ ratios are reported relative to $^{176}\text{Hf}/^{177}\text{Hf} = 0.282160$ for the Münster Ames Hf standard, which is isotopically identical to the JMC-475 standard. In order to correct the interference of ^{176}Hf and ^{180}Hf , the ^{173}Yb , ^{175}Lu , ^{181}Ta and ^{182}W signals were monitored. The external reproducibilities were estimated by the empirical relationship 2σ external reproducibility $\approx 4\sigma_m$ (σ_m = standard error of a single analysis). Isochron regressions were calculated using the Isoplot v. 2.49 program (Ludwig, 2001) and a decay constant of $\lambda^{176}\text{Lu} = 1.867 \times 10^{-11} \text{ yr}^{-1}$. Procedural blanks were <31 pg for Hf and <14 pg for Lu and, thus, negligible. The depleted-mantle Hf model age (TDM Hf) was calculated using $^{176}\text{Lu}/^{177}\text{Hf} = 0.0384$ and $^{176}\text{Hf}/^{177}\text{Hf} = 0.28325$ as the present-day parameters of the depleted mantle (Chauvel and Blichert-Toft, 2001).

LA-ICPMS analysis

The distribution of Lu in garnet from the sample LOF 3/12 was measured in situ by laser ablation mass spectrometry along a line profile. The data were collected using a Resonetics M50-E ATL Excimer 193 nm laser system coupled to a Thermo X-series 2 quadrupole ICP-MS at the Steinmann Institute in Bonn. Spot sizes were set at 73 μm . Laser fluency at the sample surface was measured at 7.4 J/cm^{-2} . The laser repetition rate was set to 15 Hz. Count rates were normalized using ^{29}Si as an internal standard and NIST-612 glass as an external standard. The isotopes ^{43}Ca , ^{55}Mn , ^{89}Y and ^{175}Lu were monitored. Data reduction and evaluation were carried out following standard procedures (Longerich et al., 1996).

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Table DR 1. Representative compositions of garnet, omphacite, and phengite from sample RV-6 used for P-T calculations.

Mineral	Grt	Omp	Ph
SiO ₂	39.84	56.26	53.00
TiO ₂	0.12	0.04	0.02
Al ₂ O ₃	21.86	11.13	27.41
Cr ₂ O ₃	0.02	0.01	0.02
FeO _t	21.67	3.35	4.50
MnO	0.42	0.02	0.02
MgO	7.87	8.95	3.03
CaO	8.69	13.76	0.35
Na ₂ O		6.73	0.05
K ₂ O			8.20
Total	100.49	100.25	96.60
Si	3.025	1.986	3.434
Ti	0.007	0.001	0.001
Al	1.956	0.463	2.093
Cr	0.001	0.000	0.001
Fe ³⁺		0.023	0.171
Fe ²⁺	1.376	0.076	0.073
Mn	0.027	0.001	0.001
Mg	0.891	0.471	0.293
Ca	0.707	0.518	0.024
Na		0.461	0.006
K			0.678
X _{Alm}	0.46		
X _{Sps}	0.01		
X _{Prp}	0.30		
X _{Grs}	0.24		
X _{Jd}		0.45	

Table DR 2. Lu-Hf data from Lofoten kyanite eclogite

Sample	Lu (ppm)	Hf (ppm)	$^{176}\text{Lu}/^{177}\text{Hf}$	2σ	$^{176}\text{Hf}/^{177}\text{Hf}$	2σ
<i>LOF 3/12</i>						
WR tt	0.0694	0.187	0.05269	1	0.282238	47
WR bmb	0.0731	0.799	0.01298	26	0.281857	104
Grt 1	0.195	0.0916	0.303	8	0.284110	32
Grt 2	0.192	0.113	0.243	5	0.283732	275
Grt 3	0.204	0.107	0.271	5	0.283931	405
Grt 4	0.195	0.0824	0.337	5	0.284531	286
Omp 1	0.0295	0.168	0.0249	50	0.282047	65

Uncertainties on the $^{176}\text{Lu}/^{177}\text{Hf}$ and $^{176}\text{Hf}/^{177}\text{Hf}$ ratios are the estimated 2σ external reproducibilities, as described in text. *WR tt*: whole rock tabletop digestion; *WR bmb*: whole rock PARR bomb digestion.

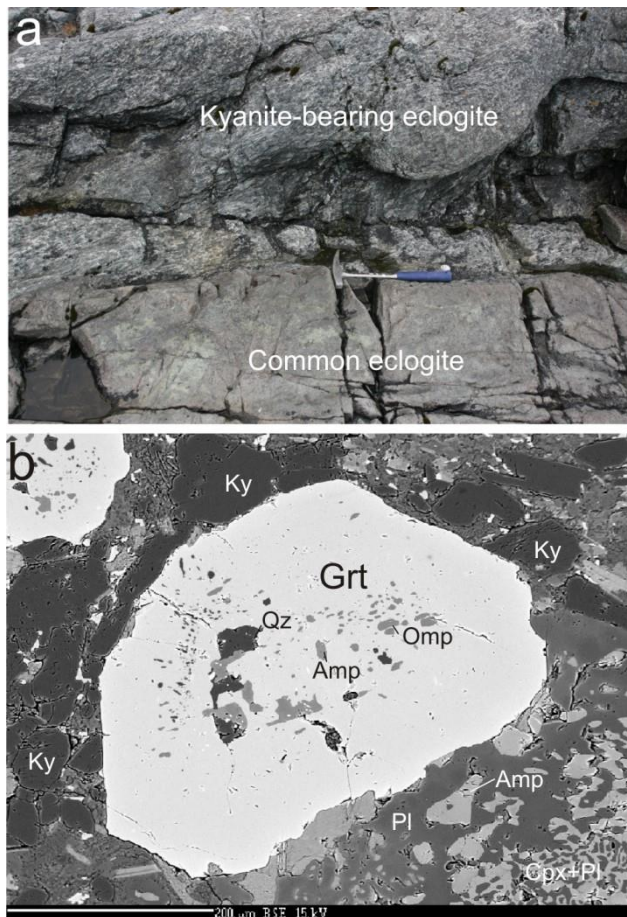


Figure DR1. Kyanite eclogite from Lofoten. (a) Outcrop of kyanite-bearing and common eclogite in a strongly deformed gabbro-anorthosite at the sample locality near Flakstad (b) BSE image of kyanite eclogite RV-6 showing garnet porphyroblast with inclusions of omphacite (Omp), amphibole (Amp) and quartz (Qz), and kyanite (Ky) as dark grains next to garnet. Symplectite of clinopyroxene (Cpx) + plagioclase (Pl) and retrograde amphibole (Amp) in the matrix are also shown.

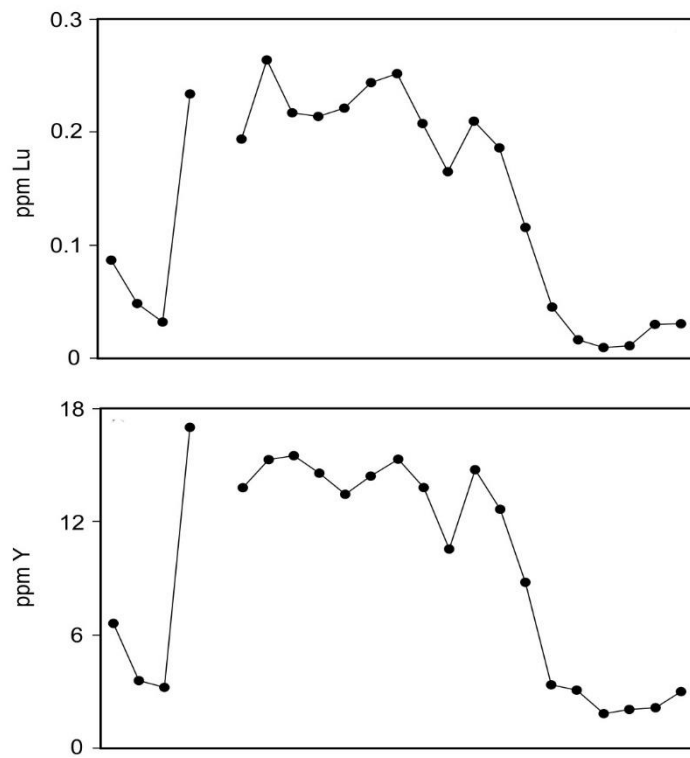


Figure DR2. Lu and Y concentration profiles of a large garnet grain in the dated sample LOF 3/12. The profile is interrupted where a measurement hit an inclusion. Profile length is 2,74 mm.