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Dawn A. Kellett, John M. Cottle, and Matthijs Smit, Eocene deep crust at Ama Drime, Tibet: Early evolution of the Himalayan orogen: Lithosphere, doi: 10.1130/L350.1.

SUPPLEMENTARY DATA

Sample characterization methods

Whole rock

Whole rock major and minor elements were measured by inductively-coupled plasma mass spectrometry (ICPMS) (Cs, Ta, U and REE) or X-ray fluorescence (XRF) (remaining elements) of powders at the Washington State University (WSU) GeoAnalytical Laboratory. Data reduction followed Knaack et al. (1994) and Johnson et al., (1999) for ICPMS and XRF, respectively. Major and minor element data are shown in Tables 2 and 3, respectively.

Garnet

Major element mapping and standard 10 element quantitative transects of garnets in polished thin sections were conducted using the Cameca SX100 electron probe microanalyzer (EMPA) housed at the University of California, Santa Barbara (UCSB). Garnet compositions were calculated using the garnet calculation spreadsheet of Locock (2008) and are plotted relative to rim in Fig 5. The complete analytical dataset is shown in Table A1. Quantitative trace element data were measured in the same garnet grains along similar transects by laser ablation single collection inductively-coupled plasma mass spectrometry (LA-SC-ICPMS) using a Nu Instruments AttoM SC-ICPMS coupled to a Photon Machines 193 nm ArF Excimer laser at UCSB. A laser spot diameter of 53 μm was used. Mass calibration of the AttoM was done using a trace element tuning solution in Linked Scan mode, and trace element data was collected in Servo mode. Data was normalized to primary standard NIST glass 612. An internal lab standard, Norwegian garnet 8815B, was used as a secondary reference material. Primary and secondary reference materials bracketed every 4-5 unknowns. Data reduction of trace element data was performed using Iolite v. 2.0 software (www.iolite.org.au) run within the Igor Pro host environment. Reproducibility of the secondary reference material was within 2σ of the accepted values. Lu and Hf concentration data are plotted relative to garnet rims in Figure 4, and the data are shown in Table A2.

Zircon

Zircon were identified in thin section and imaged under both back-scattered electrons (BSE) and cathodoluminescence using an FEI Quanta 400F field emission source scanning electron microscope housed at UCSB.

Lu-Hf geochronology methods

Sample preparation

Garnets were separated from samples AD43A and AD43B by Selfrag electrical pulse fragmentation at Queen's University, Canada, while AD43D was crushed using a conventional jaw crusher and disc mill. The resulting separated material was sieved and isodynamically separated using a Frantz magnetic separator. Aliquots of garnet were hand-picked from the 710-355 μm size fractions and the coarser, unsieved fractions, and included both aliquots of relatively inclusion-free garnet and aliquots containing obvious inclusions. Whole rock powders were prepared to trace element analysis standards at WSU.

Chemistry

100-200 mg (garnet grains) or 20 mg (whole rock powder) were weighed out into 15 mL Savillex beakers previously cleaned by cycling HCl and HF/HNO_3 solutions in the capped beakers on a hot plate (garnet) or in Teflon® bombs at 180 ºC. The grains were washed in DI H_2O, bathed in cold 1M HCl, mixed with a ^{175}Lu-^{180}Hf tracer solution, and digested in Savillex© beakers on a hotplate using concentrated HF-HNO_3-$HClO_4$ and HCl. Whole-rock powders were digested in steel-jacketed Parr© vessels using concentrated HF-HNO_3 for 5 days. Digestion of garnets and whole rock powders followed Smit et al. (2010), excluding the first hot plate digestion step for whole rock powders.

The digested samples were loaded onto Bio-Rad columns containing Eichrom® Ln-Spec resin. Column chemistry to separate Lu and Hf from matrix elements followed Münker et al. (2001), with the addition of a secondary column chemistry clean up routine, used to remove Fe, as described in Sprung et al. (2010).

Analysis of solutions

Exponentional-law mass bias corrections were done assuming 0.7325 for ^{179}Hf/^{177}Hf, whereas ^{176}Yb interference on ^{176}Lu was corrected for using the method of Blichert-Toft et al. (2002). All ratios are reported relative to 0.282163 for the Hf standard used in this study (JMC-475). The external reproducibility of ^{176}Hf/^{177}Hf, which was calculated from the results of repeated analyses of the standard at concentrations that bracket those of samples (Bizzarro et al., 2003), was estimated to be 0.3 ε_{Hf}. The Lu and Hf cuts were analyzed using the Nu Plasma high resolution MC-ICPMS at UCSB. Isochron ages and uncertainties (2 s.d.) were calculated using Isoplot version 3.27 (Ludwig, 2003), applying decay constants of 1.867×10^{-11} yr^{-1} for ^{176}Lu (Scherer et al., 2001; Scherer et al., 2003; Söderlund et al., 2004).

U-Pb geochronology methods

U-Pb geochronology of zircon *in situ* in polished thin sections was conducted using a Photon Machines (San Diego, USA) 193 nm ArF Excimer laser ablation system equipped with a two-volume “HeleX” ablation cell (Eggins et al., 1998; Eggins, 2005) that facilitates rapid transfer to the mass spectrometer. The ablation cell was connected to the Nu Plasma MC-ICPMS at UCSB. The collector arrangement of the Nu Plasma at UCSB allows for simultaneous measurement of ^{232}Th and ^{238}U on high-mass side Faraday cups equipped with 10^{11} ohm resistors and ^{208}Pb, ^{207}Pb, ^{206}Pb and ^{204}Pb on four low-mass side ETP discrete dynode electron multipliers. Each analysis began with two cleaning shots and a clean-up period of 15 s followed by 30 s ablation of a 19.3 μm diameter spot at a frequency of 4 Hz and 3.12 J/cm^2 fluence. BSE images guided spot selection. Primary in house standard “SL1” zircon (563.5 ± 3.2 Ma ^{206}Pb/^{238}U age) (Gehrels, 2000) was used to monitor and correct for mass bias and Pb/U fractionation. Two secondary reference standards, “GJ1” zircon (608.4 ± 0.4 Ma ^{207}Pb/^{206}Pb isotope dilution thermal ionization mass spectrometry (ID-TIMS) age; 601.7 Ma ^{206}Pb/^{238}U ID-TIMS age) (Jackson et al., 2004; Condon, unpublished data) and “91500” zircon (1062.4 ± 0.4 Ma ^{206}Pb/^{238}U ID-TIMS age) (Wiedenbeck et al., 1995) were analyzed concurrently to monitor data accuracy. SL1 and GJ1 standards were measured between every 4 unknowns, while 91500 was measured between every 12 unknowns, to measure data accuracy. During the analytical session, GJ1 yielded a weighted mean ^{207}corrected ^{206}Pb/^{238}U age of 601.8 ± 1.6 Ma (MSWD = 1.5, n = 29), while 91500 yielded 1064 ± 14 Ma (MSWD = 2.1, n = 10). All quoted uncertainties include contributions from the external reproducibility of the standard for ^{206}Pb/^{238}U ratio. Data reduction of age and trace element data, including corrections for baseline, instrumental drift, mass bias, down-hole fractionation and uncorrected age calculations were carried out using Iolite version 2.1.2 (www.iolite.org.au). Full details of the data reduction methodology can be found in Paton et al., (2011). Age data were plotted using Isoplot v. 3.7 (Ludwig, 2001; 2003).

Mass balance estimation

To perform mass balance calculations, relative apparent Lu concentrations and the estimated volumes of garnet eclogitic cores vs. granulitic rims were compared. Input and calculated values are listed in Table A3. Note that this exercise provides only a gross estimation, with relatively large errors on the input values, particularly core and rim Lu concentrations, mean garnet volume, and rim volume, and thus is not proposed to produce precise ages, but merely to explore what the relative influence of two garnet populations of distinct age might have on the bulk Lu-Hf age of the garnet in these samples. Thus the proportions of eclogitic and granulitic garnet calculated in Table A3 are broad estimates only, and are best used to demonstrate that the garnet Lu-Hf age is dominated by garnet cores and likely closely approximates the measured bulk Lu-Hf ages.

A particularly poorly constrained value is the garnet rim width of sample AD43D. Garnet composition in Fig. 5c illustrates a broad, diffusive boundary between garnet core and rim for this sample. The garnet rim is thus not well defined. For calculation purposes, a rim width of 0.1 mm has been chosen, based on the drop in Lu concentration at the rim on the left side of the grain illustrated in Fig. 5c, but it is poorly defined. The rim on the right side of the same grain was not considered representative of garnet rim width because that rim has an irregular shape perhaps reflecting a fracture surface along which there was exchange with the bulk rock.

The following equations were used to calculate values in Table A3:

Garnet volume and garnet core volume:

$$V = 4/3\pi r^3 \qquad \text{Eq. 1}$$

where V (mm^3) is volume and r (mm) is estimated radius.

Garnet core radius:

$$r_C = r_T\text{-estimated\_rim\_width} \qquad \text{Eq. 2}$$

where r_C is garnet core radius (mm) and r_T is garnet radius (mm) and estimated_rim_width values (mm) are estimated from Fig. 5 garnet compositions.

% Lu in core:

$$\%\ Lu_C = ([Lu]_C \times V_C) / ([Lu]_C \times V_C + [Lu]_R \times V_R) \times 100 \qquad \text{Eq. 3}$$

where [Lu] is the estimated concentration of Lu (ppm), and subscripts C and R represent rim and core, respectively. Accordingly, % Lu_R = 100 - Lu_C.

Estimated age of core (Ma) was determined by solving for Y using the following equation:

$$(\%\ Lu_C \times Y) + (\%\ Lu_R \times 14) = \text{Lu-Hf\_age} \qquad \text{Eq. 4}$$

where Y is the estimated age of garnet core (Ma), 14 (Ma) represents the estimated age of the garnet rim (see text for details), and Lu-Hf_age is the isotopically-measured bulk garnet age (Ma).

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Table A1. Major and minor element data for garnet collected by EMPA used to calculate garnet compositions in Fig. 3.

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO*	MnO	MgO	CaO	Na_2O	K_2O	TOTAL
AD43A											
spot 164	41.00	0.05	20.49	0.00	29.65	1.99	1.50	7.21	0.05	0.00	101.93
165	37.37	0.11	20.73	0.03	28.55	1.16	2.74	8.76	0.01	0.00	99.47
166	37.63	0.18	20.78	0.00	26.41	0.98	2.47	11.27	0.04	0.01	99.76
167	37.66	0.18	20.92	0.00	25.88	0.84	2.38	11.97	0.01	0.00	99.82
169	37.55	0.15	20.73	0.03	25.89	0.82	2.35	11.75	0.02	0.00	99.30
170	37.59	0.15	20.90	0.04	25.94	0.84	2.28	11.91	0.01	0.00	99.64
171	37.67	0.11	21.15	0.00	25.84	0.86	2.23	11.75	0.01	0.01	99.62
175	37.72	0.16	20.89	0.01	25.97	0.85	2.16	11.96	0.04	0.00	99.77
176	37.53	0.16	20.81	0.02	26.05	0.87	2.18	11.95	0.03	0.00	99.60
177	37.56	0.17	20.82	0.00	25.83	0.88	2.14	11.95	0.03	0.01	99.37
178	37.56	0.14	20.84	0.03	26.27	0.92	2.17	11.90	0.01	0.02	99.87
179	37.69	0.16	20.83	0.00	26.02	0.85	2.12	11.93	0.02	0.00	99.60
180	37.65	0.19	20.81	0.02	26.11	0.91	2.15	11.93	0.03	0.00	99.79
181	37.67	0.17	20.78	0.04	25.93	0.85	2.15	11.97	0.02	0.00	99.56
182	37.65	0.13	20.81	0.02	25.90	0.85	2.16	11.91	0.02	0.00	99.44
183	37.66	0.16	20.75	0.03	25.96	0.90	2.17	12.03	0.02	0.01	99.71
184	37.56	0.15	20.85	0.03	25.81	0.86	2.19	12.07	0.01	0.00	99.52
185	37.77	0.11	20.95	0.00	25.87	0.88	2.25	11.91	0.02	0.00	99.74
186	37.76	0.08	20.95	0.03	26.16	0.84	2.33	11.63	0.01	0.00	99.80
187	37.57	0.06	20.22	0.02	26.81	0.86	2.34	11.67	0.04	0.01	99.59
190	37.43	0.03	21.06	0.02	27.35	0.88	2.62	10.13	0.03	0.01	99.56
191	37.63	0.06	21.02	0.06	26.27	0.92	2.39	11.13	0.02	0.00	99.48
193	37.77	0.15	20.95	0.03	26.12	0.85	2.29	11.71	0.02	0.01	99.90
194	37.70	0.12	21.02	0.00	25.84	0.83	2.28	11.94	0.01	0.00	99.69
195	37.91	0.18	20.80	0.02	25.85	0.86	2.26	11.93	0.02	0.00	99.82
196	37.85	0.21	20.88	0.01	25.84	0.88	2.22	11.94	0.02	0.00	99.84
197	36.70	0.20	20.02	0.04	25.69	0.95	2.01	11.85	0.06	0.00	97.53
198	37.83	0.21	20.83	0.00	25.62	0.88	2.17	12.06	0.05	0.02	99.67
199	37.83	0.22	20.84	0.04	25.81	0.88	2.16	12.07	0.04	0.02	99.91
200	37.70	0.21	20.85	0.00	25.83	0.90	2.16	12.01	0.04	0.01	99.70
201	36.92	0.33	20.46	0.02	25.54	0.88	2.26	11.72	0.04	0.00	98.13
203	37.85	0.20	20.75	0.04	25.89	0.88	2.07	12.01	0.05	0.02	99.76
204	37.85	0.12	20.84	0.05	26.03	0.93	2.07	12.10	0.02	0.00	99.99
205	37.73	0.18	20.94	0.05	25.80	0.86	2.09	11.98	0.04	0.00	99.67
206	37.72	0.16	20.87	0.08	25.96	0.86	2.09	12.05	0.05	0.00	99.83
207	37.68	0.17	20.79	0.11	25.94	0.84	2.08	12.07	0.04	0.00	99.70
209	37.79	0.21	20.83	0.12	25.73	0.85	2.09	12.16	0.04	0.00	99.81
210	37.64	0.18	20.81	0.05	26.05	0.78	2.08	12.12	0.03	0.00	99.73
211	37.76	0.17	20.80	0.06	26.06	0.79	2.09	12.11	0.03	0.00	99.88
212	37.79	0.07	21.08	0.00	26.02	0.77	2.19	11.80	0.05	0.01	99.78
213	37.76	0.12	20.76	0.04	26.11	0.72	2.15	11.88	0.01	0.00	99.54
214	37.17	0.12	20.19	0.06	24.73	0.70	2.31	13.45	0.11	0.02	98.87
215	37.85	0.11	19.65	0.05	24.74	0.65	1.99	11.67	0.01	0.01	96.75
216	37.79	0.12	20.91	0.03	25.87	0.70	2.14	12.08	0.01	0.00	99.65
217	37.90	0.11	20.99	0.01	25.96	0.69	2.17	12.30	0.02	0.01	100.16
218	37.78	0.16	20.89	0.01	25.92	0.68	2.17	12.21	0.02	0.02	99.86
219	37.79	0.06	21.07	0.00	25.93	0.65	2.20	12.26	0.03	0.02	100.00
220	37.68	0.14	20.83	0.02	25.65	0.61	2.20	12.23	0.03	0.00	99.38
221	37.72	0.10	20.97	0.05	25.80	0.56	2.24	12.25	0.03	0.02	99.74
222	37.76	0.12	20.85	0.02	25.77	0.59	1.95	12.24	0.04	0.02	99.37
223	37.81	0.09	21.06	0.02	26.07	0.55	2.24	12.07	0.02	0.00	99.91
224	37.77	0.07	21.10	0.00	25.82	0.54	2.26	12.28	0.02	0.00	99.86
225	37.85	0.12	21.03	0.03	25.71	0.49	2.30	12.28	0.03	0.01	99.83
226	37.78	0.10	20.86	0.01	25.72	0.44	2.36	12.24	0.04	0.00	99.55
227	37.85	0.07	20.96	0.06	25.69	0.42	2.42	12.26	0.03	0.00	99.76
228	37.87	0.08	20.93	0.02	25.60	0.42	2.59	12.12	0.02	0.01	99.65
229	37.94	0.07	21.07	0.02	25.65	0.40	2.76	11.86	0.03	0.00	99.80

230	37.97	0.06	21.07	0.07	25.96	0.37	2.99	11.30	0.02	0.00	99.79
231	37.88	0.08	20.93	0.04	26.71	0.35	3.16	10.40	0.03	0.00	99.56
232	37.90	0.10	21.14	0.00	27.33	0.42	3.29	9.79	0.01	0.00	99.97
233	37.92	0.08	21.04	0.00	27.59	0.39	3.33	9.69	0.01	0.01	100.08
234	36.99	0.07	20.27	0.02	26.92	0.41	3.71	9.61	1.36	0.04	99.41
235	37.94	0.07	21.08	0.00	27.82	0.42	3.21	9.50	0.01	0.00	100.01
237	37.94	0.09	21.06	0.03	27.72	0.38	3.40	9.33	0.01	0.01	99.96
238	37.94	0.11	21.12	0.04	27.89	0.43	3.35	9.16	0.01	0.00	100.06
239	37.97	0.11	21.02	0.00	27.91	0.55	3.27	9.11	0.03	0.01	99.97
240	38.00	0.09	21.05	0.00	27.97	0.68	3.17	9.01	0.02	0.01	99.98
241	37.88	0.07	20.95	0.02	29.25	0.96	2.86	8.17	0.02	0.02	100.21
AD43B											
spot 25	37.36	0.06	20.92	0.02	29.75	0.81	2.45	8.24	0.01	0.01	99.63
26	37.72	0.08	21.13	0.03	27.18	0.17	2.95	10.57	0.01	0.01	99.85
27	37.68	0.10	21.13	0.03	26.04	0.32	2.11	12.33	0.03	0.00	99.76
28	37.82	0.09	21.06	0.04	25.90	0.42	2.13	12.43	0.03	0.01	99.93
29	37.69	0.12	21.00	0.07	26.12	0.79	2.04	12.02	0.03	0.00	99.88
30	37.75	0.21	20.94	0.00	25.69	1.32	2.04	11.76	0.05	0.00	99.74
32	37.82	0.28	20.86	0.03	25.43	2.25	2.08	11.45	0.03	0.00	100.23
33	37.57	0.22	20.80	0.03	25.51	2.53	2.13	11.05	0.04	0.00	99.88
34	37.73	0.27	20.89	0.02	25.91	2.28	2.19	11.07	0.04	0.01	100.41
38	37.43	0.14	20.95	0.01	27.15	1.37	2.37	10.26	0.01	0.00	99.69
41	37.59	0.09	20.83	0.00	27.23	1.31	2.85	9.84	0.03	0.00	99.78
42	37.62	0.05	21.11	0.02	26.49	1.31	3.01	9.90	0.01	0.01	99.53
43	37.57	0.25	20.87	0.04	25.47	1.62	2.62	11.23	0.01	0.00	99.68
44	37.61	0.33	20.72	0.06	24.19	2.69	2.33	11.61	0.07	0.00	99.60
45	37.52	0.23	20.72	0.06	24.91	2.82	2.17	11.12	0.04	0.01	99.61
46	37.50	0.27	20.77	0.04	25.25	2.56	2.15	11.22	0.05	0.00	99.80
47	37.52	0.32	20.83	0.01	25.37	1.98	2.21	11.37	0.04	0.01	99.65
48	37.14	0.18	20.60	0.04	28.65	1.59	1.76	9.41	0.09	0.01	99.47
52	37.62	0.17	20.90	0.06	26.04	0.89	2.02	11.93	0.02	0.00	99.64
53	37.74	0.17	20.97	0.03	25.72	0.58	2.15	12.44	0.04	0.00	99.82
AD43D											
spot 75	37.63	0.13	20.88	0.00	27.22	1.47	3.50	8.53	0.01	0.00	99.34
76	37.65	0.12	20.88	0.03	27.73	1.33	4.02	7.81	0.01	0.01	99.58
77	37.75	0.10	21.08	0.02	27.32	1.19	4.20	7.99	0.00	0.00	99.65
78	37.81	0.15	20.98	0.00	27.41	1.14	4.26	8.27	0.00	0.00	99.99
79	37.96	0.16	21.15	0.02	25.64	0.94	4.17	9.73	0.01	0.00	99.76
81	38.05	0.15	21.12	0.03	25.25	0.81	4.27	10.10	0.01	0.00	99.78
82	37.93	0.16	21.09	0.00	25.52	0.83	4.33	9.89	0.03	0.00	99.77
83	38.03	0.15	21.04	0.04	26.03	0.84	4.42	9.27	0.00	0.00	99.81
84	38.21	0.18	21.20	0.02	25.43	0.73	4.47	10.01	0.01	0.00	100.23
86	38.09	0.11	21.33	0.00	24.41	0.58	4.61	10.56	0.02	0.00	99.69
87	38.19	0.16	21.38	0.03	24.22	0.56	4.58	10.68	0.05	0.00	99.84
88	38.15	0.18	21.18	0.00	23.70	0.62	4.39	11.09	0.02	0.05	99.36
89	38.04	0.12	21.11	0.00	25.88	0.67	4.80	9.38	0.02	0.01	100.03
90	38.06	0.16	21.39	0.04	24.45	0.55	4.65	10.50	0.02	0.00	99.82
91	38.11	0.11	21.45	0.00	24.37	0.51	4.79	10.46	0.01	0.00	99.82
92	38.07	0.20	21.35	0.01	24.26	0.47	4.83	10.69	0.01	0.00	99.90
93	38.15	0.10	21.34	0.00	23.41	0.45	4.58	11.63	0.01	0.00	99.66
94	38.01	0.16	21.41	0.00	23.66	0.43	4.75	11.12	0.00	0.00	99.52
95	38.25	0.15	21.26	0.01	23.99	0.50	4.82	10.90	0.02	0.00	99.90
96	38.18	0.14	21.34	0.01	23.84	0.42	4.77	11.02	0.01	0.00	99.72
97	38.26	0.14	21.35	0.03	23.89	0.47	4.78	10.99	0.01	0.01	99.92
98	38.30	0.10	21.46	0.02	23.82	0.44	4.56	11.42	0.00	0.00	100.12
99	38.28	0.12	21.39	0.02	24.35	0.43	4.88	10.38	0.02	0.00	99.87
100	38.24	0.17	21.39	0.00	24.24	0.41	4.90	10.33	0.03	0.00	99.72
101	38.07	0.18	21.37	0.01	23.94	0.42	4.80	10.87	0.01	0.01	99.68
104	38.30	0.15	21.34	0.03	24.31	0.37	4.98	10.47	0.01	0.00	99.97
105	38.34	0.16	21.40	0.06	24.23	0.38	4.98	10.47	0.02	0.00	100.04
106	38.02	0.11	21.46	0.04	24.17	0.38	4.95	10.30	0.01	0.00	99.45
107	38.03	0.10	21.24	0.05	23.67	0.38	4.60	11.34	0.01	0.01	99.44

108	38.08	0.11	21.34	0.00	25.01	0.45	4.53	10.34	0.01	0.00	99.86
110	37.95	0.14	21.33	0.00	24.94	0.40	4.50	10.17	0.00	0.01	99.44
111	38.14	0.24	21.24	0.02	24.38	0.41	4.64	10.63	0.01	0.01	99.71
112	38.18	0.18	21.36	0.02	24.77	0.40	4.90	10.21	0.01	0.00	100.03
113	38.34	0.17	21.50	0.03	24.64	0.43	4.88	10.30	0.03	0.01	100.32
114	38.36	0.12	21.46	0.06	24.52	0.38	5.07	10.08	0.01	0.00	100.04
115	38.25	0.13	21.33	0.00	24.61	0.36	5.11	10.14	0.01	0.00	99.91
116	38.37	0.14	21.37	0.00	23.31	0.41	4.62	11.67	0.00	0.00	99.88
117	38.38	0.12	21.31	0.00	24.58	0.41	5.04	10.10	0.00	0.00	99.90
118	38.37	0.12	21.41	0.00	24.53	0.45	5.03	10.07	0.02	0.00	100.00
120	38.21	0.13	21.33	0.01	24.74	0.44	4.85	10.07	0.01	0.00	99.80
121	38.46	0.10	21.52	0.00	24.86	0.47	4.80	9.99	0.03	0.00	100.22
123	38.16	0.19	21.36	0.00	24.84	0.44	4.70	10.20	0.03	0.01	99.92
125	38.26	0.10	21.58	0.00	24.63	0.45	4.86	10.23	0.01	0.01	100.12
126	38.06	0.13	21.35	0.00	24.70	0.47	4.92	10.28	0.01	0.00	99.90
127	38.06	0.10	21.36	0.00	24.23	0.45	4.79	10.48	0.00	0.00	99.44
128	38.15	0.07	21.36	0.04	24.04	0.45	4.73	10.83	0.00	0.00	99.66
129	38.05	0.15	21.38	0.01	24.69	0.50	4.88	10.32	0.01	0.00	99.96
130	38.16	0.19	21.33	0.01	24.55	0.48	4.86	10.17	0.03	0.00	99.77
131	38.32	0.20	21.31	0.05	24.57	0.53	4.93	10.15	0.02	0.01	100.09
132	38.15	0.18	21.36	0.04	23.84	0.50	4.50	11.47	0.00	0.00	100.05
133	38.20	0.14	21.33	0.04	24.33	0.53	4.78	10.43	0.01	0.00	99.78
134	38.17	0.13	21.33	0.00	24.72	0.55	4.82	10.28	0.02	0.01	100.02
135	38.41	0.13	21.43	0.03	24.77	0.56	4.90	9.92	0.01	0.00	100.16
136	38.21	0.14	21.27	0.04	23.62	0.52	4.28	12.11	0.01	0.00	100.18
137	38.12	0.14	21.46	0.05	25.02	0.58	4.79	9.92	0.02	0.00	100.08
138	38.04	0.16	21.20	0.00	24.81	0.72	4.63	10.15	0.01	0.01	99.73
139	38.04	0.16	21.35	0.00	24.96	0.74	4.57	10.08	0.03	0.00	99.90
140	38.07	0.11	21.16	0.02	25.25	0.83	4.59	9.74	0.02	0.00	99.80
141	38.01	0.10	21.43	0.03	25.81	0.86	4.59	9.13	0.00	0.00	99.97
142	38.00	0.04	21.44	0.00	26.98	0.97	4.87	7.65	0.00	0.01	99.96
143	37.88	0.02	21.37	0.03	27.47	1.07	5.08	6.45	0.00	0.01	99.37
149	38.12	0.02	21.18	0.03	27.49	1.21	4.87	6.53	0.01	0.00	99.46
150	38.09	0.01	21.44	0.02	27.86	1.16	4.94	6.72	0.00	0.00	100.23
151	38.11	0.01	21.38	0.04	27.18	1.14	4.77	7.43	0.00	0.00	100.07
152	38.06	0.02	21.40	0.00	26.64	1.01	4.63	8.36	0.00	0.01	100.13
153	38.15	0.09	21.29	0.07	25.26	0.89	4.31	10.03	0.01	0.00	100.08
154	38.06	0.08	21.31	0.02	25.39	0.88	4.36	9.54	0.01	0.00	99.63
155	37.79	0.10	21.09	0.01	26.42	1.04	4.41	8.69	0.00	0.01	99.55
156	37.80	0.10	21.02	0.00	26.94	1.17	4.37	8.41	0.01	0.01	99.84
157	37.90	0.08	21.24	0.05	26.28	1.16	4.18	9.00	0.01	0.01	99.91
158	37.81	0.17	20.99	0.01	25.36	1.17	3.92	9.68	0.01	0.00	99.11

Analyses conducted on the Cameca SX-100 at the University of California, Santa Barbara. *Total Fe is recorded as FeO.

Table A2. Lu and Hf LA-ICPMS transect data for garnets shown in Fig. 2

Sample, spot #	Lu (ppm)	error (2σ abs)	Hf (ppm)	error (2σ abs)
AD43A				
1	2.090	0.130	0.053	0.031
2	2.780	0.230	0.012	0.024
3	3.820	0.200	0.162	0.033
4	1.850	0.110	0.126	0.051
5	1.660	0.110	0.081	0.033
6	3.380	0.160	0.079	0.031
7	2.800	0.170	0.056	0.026
8	3.950	0.270	0.095	0.052
9	5.220	0.290	0.660	0.240
10	3.600	0.240	0.057	0.048
11	3.790	0.160	0.099	0.041
12	4.270	0.180	0.090	0.031
13	3.540	0.180	0.067	0.034
14	1.360	0.130	0.056	0.049
15	1.040	0.110	0.026	0.038
AD43B				
1	1.430	0.110	0.061	0.045
2	0.815	0.091	bdl	bdl
3	0.365	0.076	bdl	bdl
4	0.282	0.060	bdl	bdl
5	0.348	0.083	0.080	0.059
6	0.656	0.098	0.106	0.047
7	0.768	0.085	0.078	0.045
8	0.730	0.110	0.039	0.028
9	0.796	0.097	0.017	0.040
10	1.070	0.100	bdl	bdl
11	0.733	0.079	bdl	bdl
12	0.462	0.082	bdl	bdl
13	0.930	0.160	0.035	0.032
14	0.690	0.065	bdl	bdl
15	0.720	0.110	0.029	0.022
16	0.692	0.052	0.041	0.033
17	1.010	0.092	0.012	0.027
18	0.559	0.076	0.026	0.038
19	0.718	0.084	0.134	0.075
20	0.980	0.110	bdl	bdl
21	0.395	0.065	bdl	bdl
22	0.285	0.053	bdl	bdl
23	0.298	0.057	0.046	0.031
24	0.193	0.042	0.030	0.030
25	0.187	0.063	0.013	0.027
26	0.361	0.090	0.016	0.028
27	0.351	0.075	bdl	bdl
28	0.185	0.059	0.059	0.021
29	0.138	0.037	bdl	bdl
30	0.098	0.043	bdl	bdl
31	1.010	0.240	bdl	bdl
32	0.149	0.044	bdl	bdl
33	0.960	0.160	bdl	bdl
34	0.463	0.057	bdl	bdl
35	0.820	0.140	0.092	0.087
36	0.520	0.100	bdl	bdl
37	0.564	0.074	bdl	bdl
38	0.229	0.076	bdl	bdl
39	0.446	0.085	0.020	0.017
40	0.660	0.120	bdl	bdl
41	0.760	0.110	0.061	0.034
42	0.368	0.098	0.020	0.027

AD43D				
1	0.550	0.180	0.226	0.033
2	0.828	0.070	0.239	0.037
3	0.699	0.067	0.171	0.028
4	0.638	0.074	0.136	0.023
5	0.651	0.078	0.243	0.033
6	0.559	0.046	0.185	0.028
7	0.586	0.061	0.142	0.028
8	0.545	0.059	0.185	0.031
9	0.643	0.056	0.173	0.034
10	0.559	0.054	0.132	0.034
11	0.550	0.044	0.196	0.041
12	0.894	0.089	0.158	0.032
13	0.686	0.040	0.198	0.035
14	0.208	0.043	0.247	0.038
15	0.470	0.055	0.113	0.028
16	0.811	0.060	0.272	0.032
17	1.073	0.071	0.240	0.052

Data collected using a Photon Machines 193 nm Ar-F Excimer laser and a Nu Instruments AttoM high resolution ICP-MS (single collector). bdl-below detection limit.

Table A3. Values used for garnet Lu-Hf age mass balance calculations. See Supplementary text for equations.

	AD43A	**AD43B**	**AD43D**
mean garnet radius (mm)*	1.075 (n=19)	3.0 (n=3)	1.15 (n=3)
mean garnet volume (mm^3) (Eq. 1)	5.20	113	6.37
estimated rim width (mm)*	0.15	0.3	0.1?
core [Lu] (ppm)**	~ 4	~1.0	~0.8
mean garnet core radius (mm) (Eq. 2)	0.925	2.7	1.05
core volume (mm^3) (Eq. 1)	3.32	82.5	4.85
rim [Lu] (ppm)**	~1	~0.4	~0.4
rim volume (mean garnet volume – core volume) (mm^3)	1.88	30.5	1.52
% Lu in core (Eq. 3)	88	87	86
% Lu in rim (Eq. 3)	12	13	14
Estimated age of core (Ma) (Eq. 4)	***37***	***39***	***37***

*Determined from garnets in thin section, and may not represent true cross-sectional radii.
**Estimated from core and rim values measured by LA-ICPMS, see Fig. 5 and supplementary data for explanation.