

Supporting information for:

COH fluids and melts drive mantle refertilization and organic synthesis in nascent subduction zones

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Figure S1: Additional FEG-SEM BSE images of garnet-hosted polycrystalline inclusions in HTb metasediments. (a) and (b) Type I inclusions. (c) Mixed Type I–II inclusion. Note the close spatial association between plagioclase and paragonite in (b) and (c). (d) Type I inclusion. (e) Type II inclusion. Note the cracks filled with abundant chlorite. (f) Large granitic inclusions located within the garnet, adjacent to the studied polycrystalline inclusions, and interpreted as a crystallized melt pocket. Abbreviations after Whitney and Evans (2010).

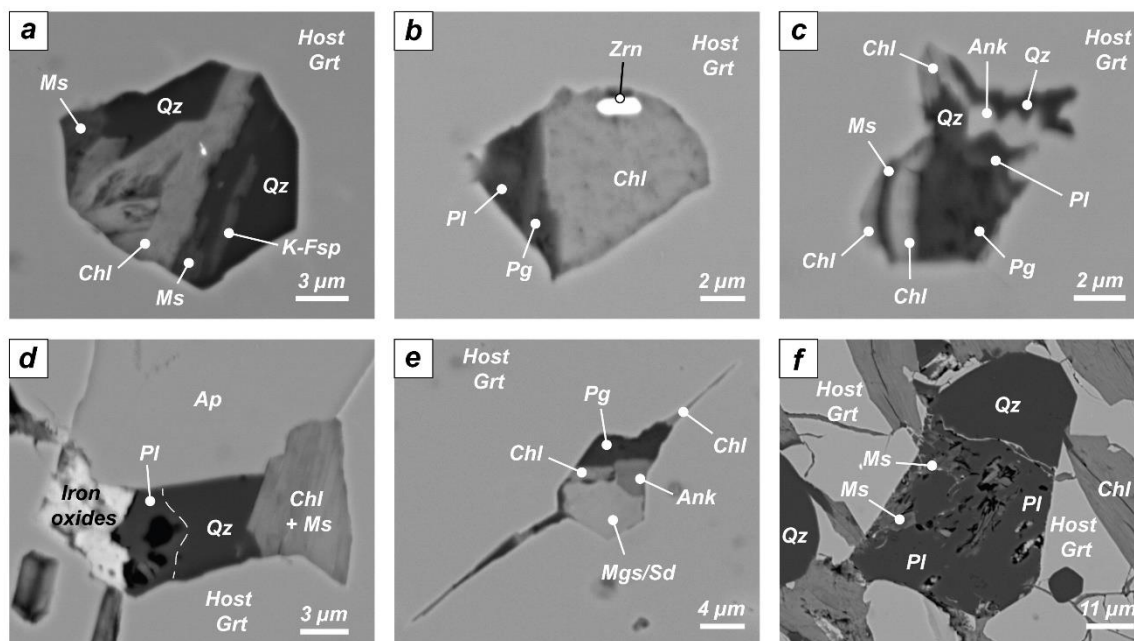
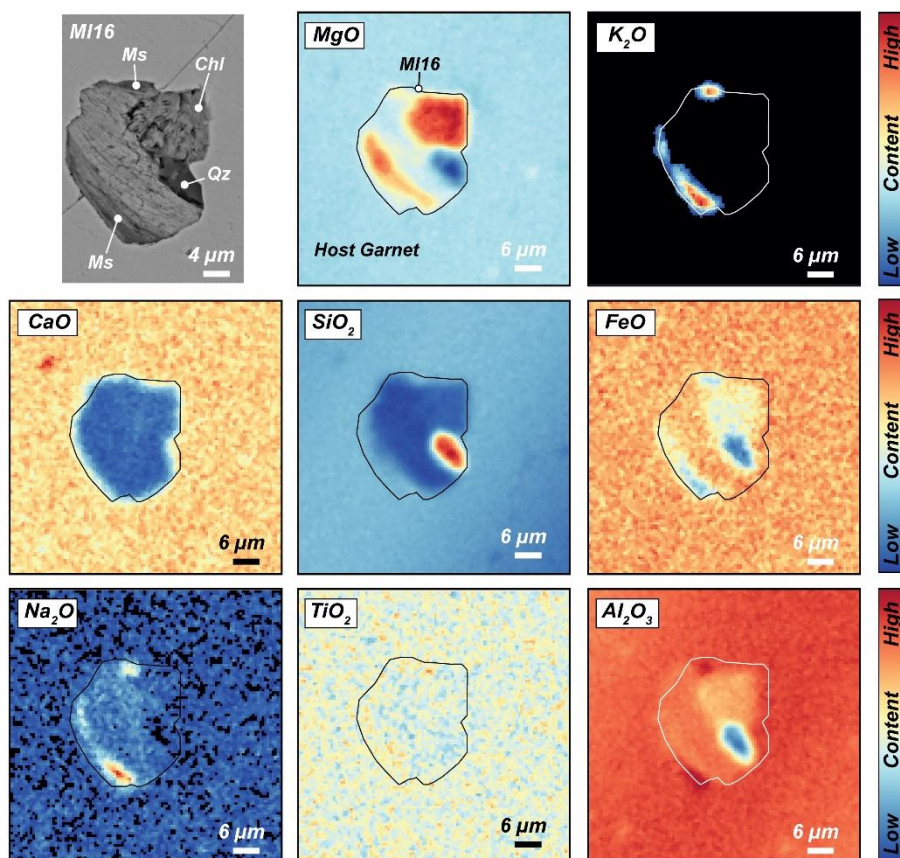
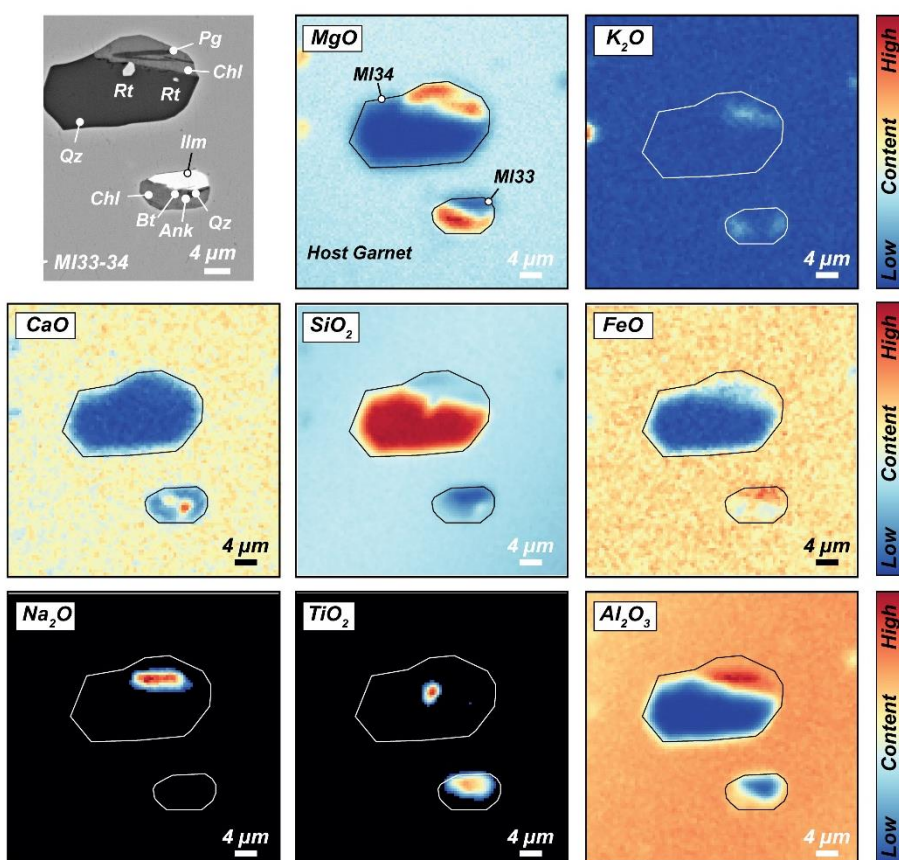
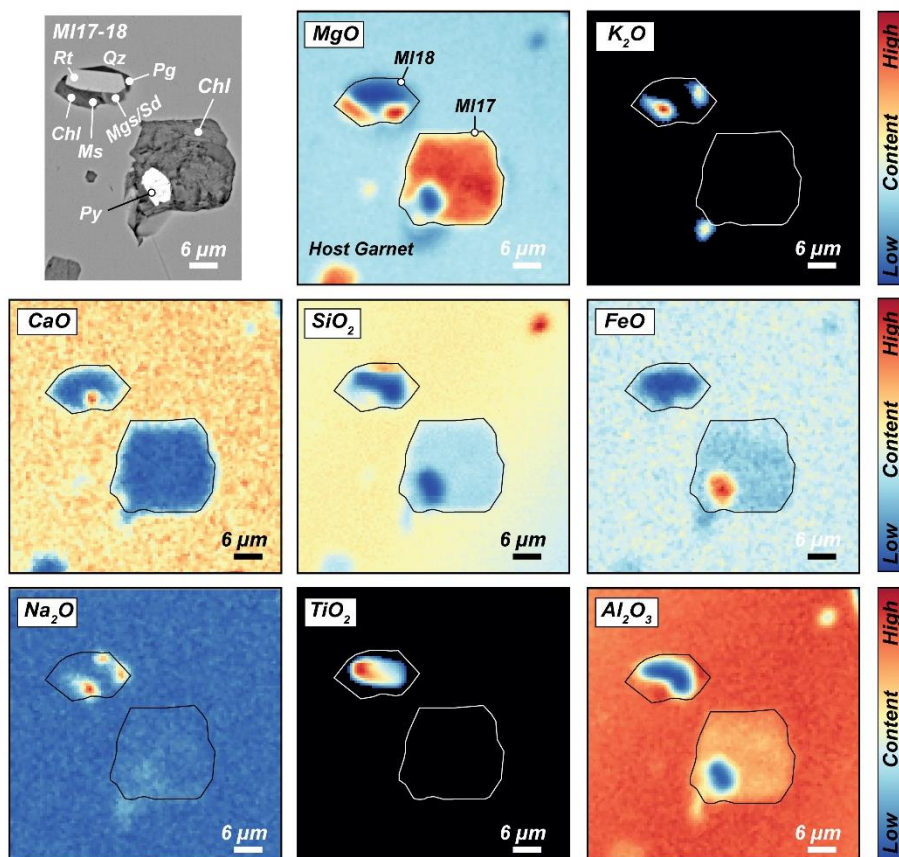
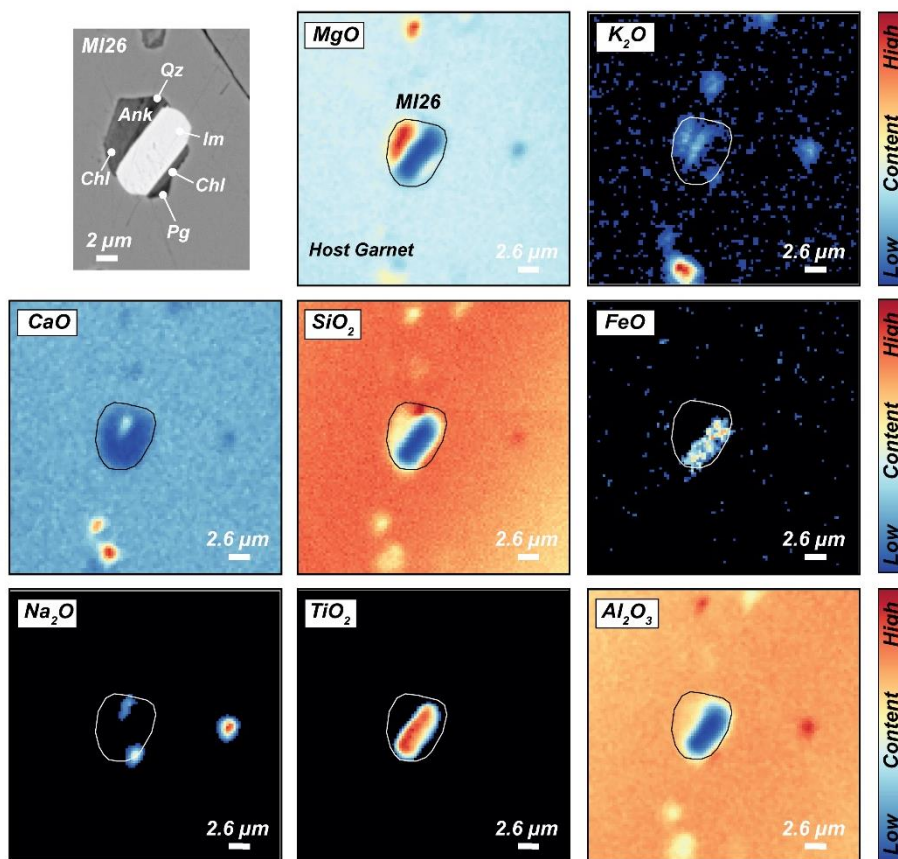
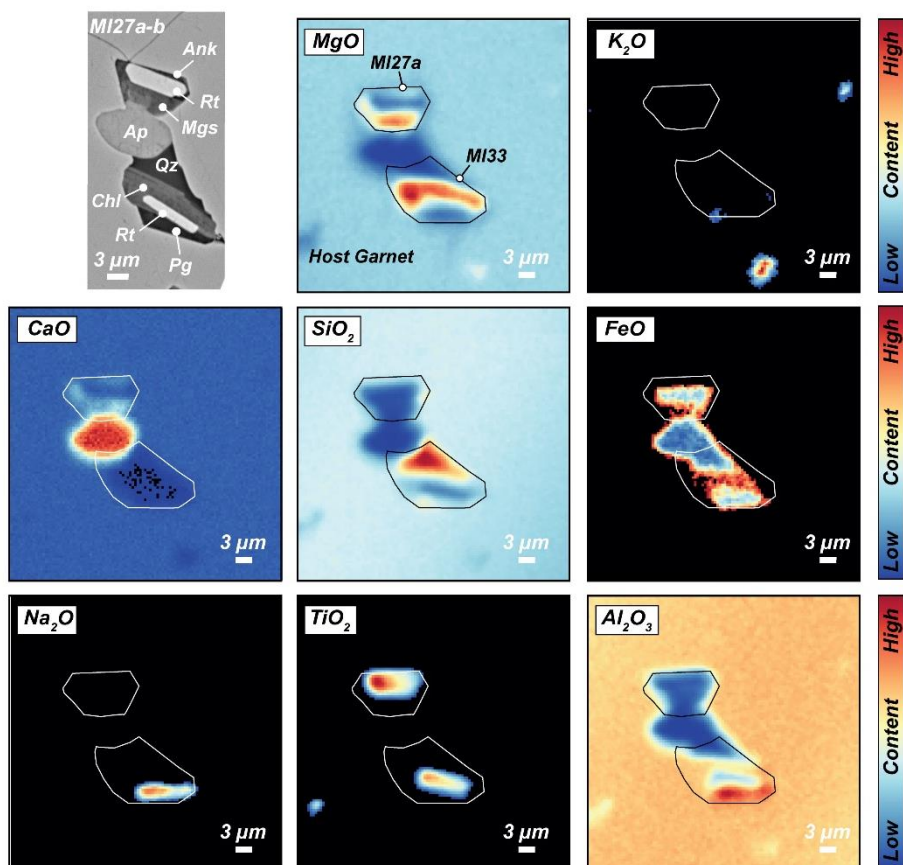


Figure S2: Representative EPMA-WDS chemical maps of HTb garnet-hosted polymineralic inclusions (sample SE13-123L). Abbreviations after Whitney and Evans (2010).







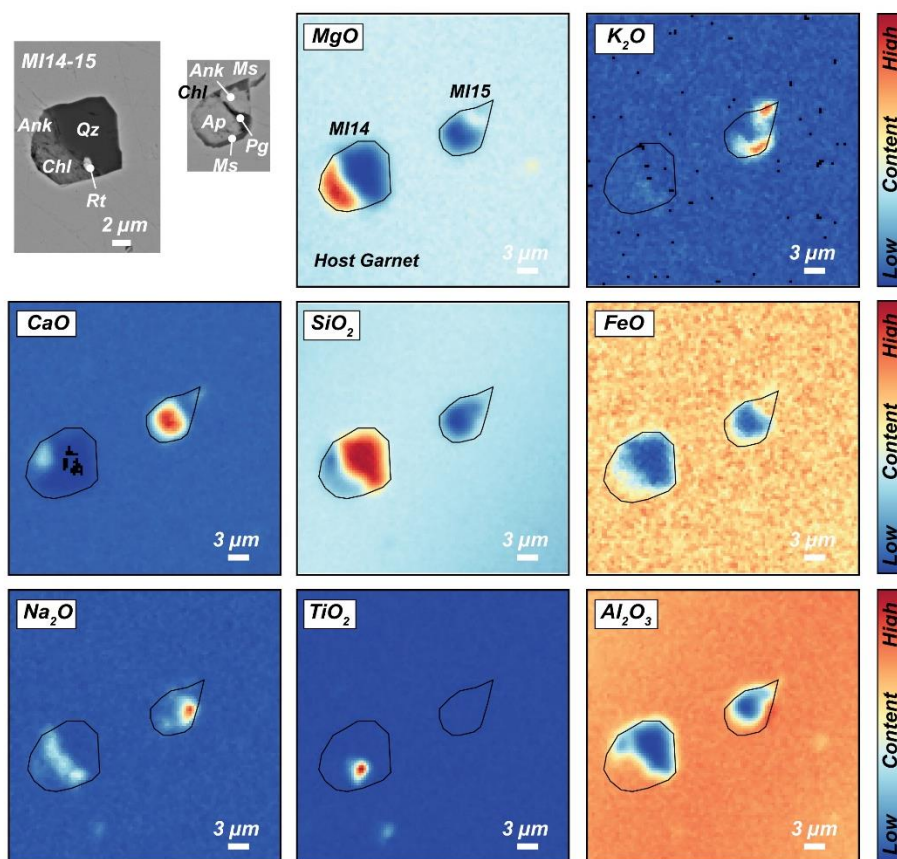


Figure S3: Ternary compositional diagrams (molar) for HTb polyminerals based on WDS-EPMA maps.

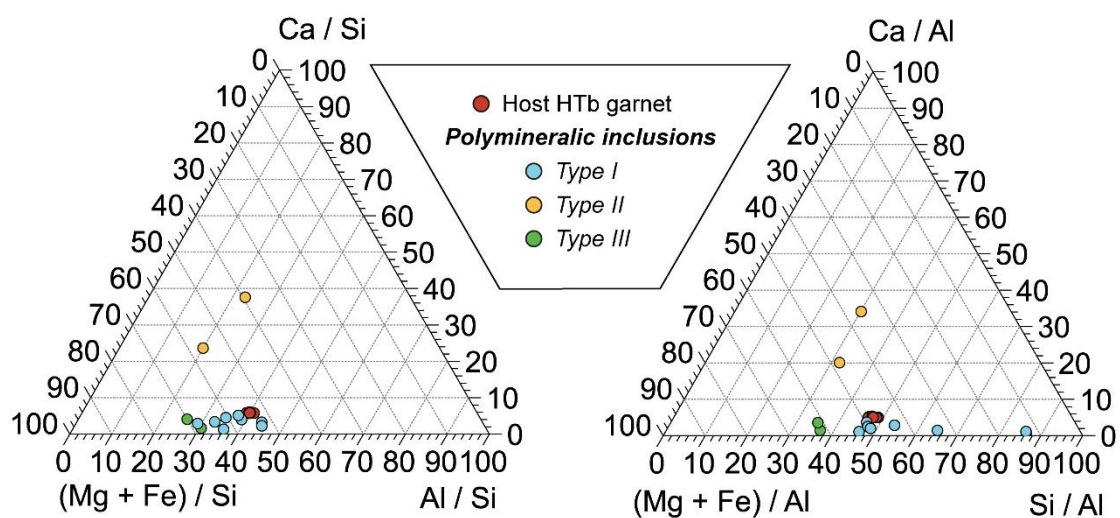


Figure S4: Primary multiphase inclusions clusters trapped within HTa garnet mantles. (a) Microphotograph of an HTa metamafic rock highlighting the occurrence of a mutiphase inclusion cluster within a garnet crystal. Early pseudosecondary/secondary inclusion trails restricted to the garnet crystals also occur (b) WDS-EPMA map of MgO content in garnet highlighting garnet zoning pattern and the location of the primary inclusion clusters within high temperature ($\sim 850^\circ\text{C}$; Soret et al., 2017) garnet mantles.

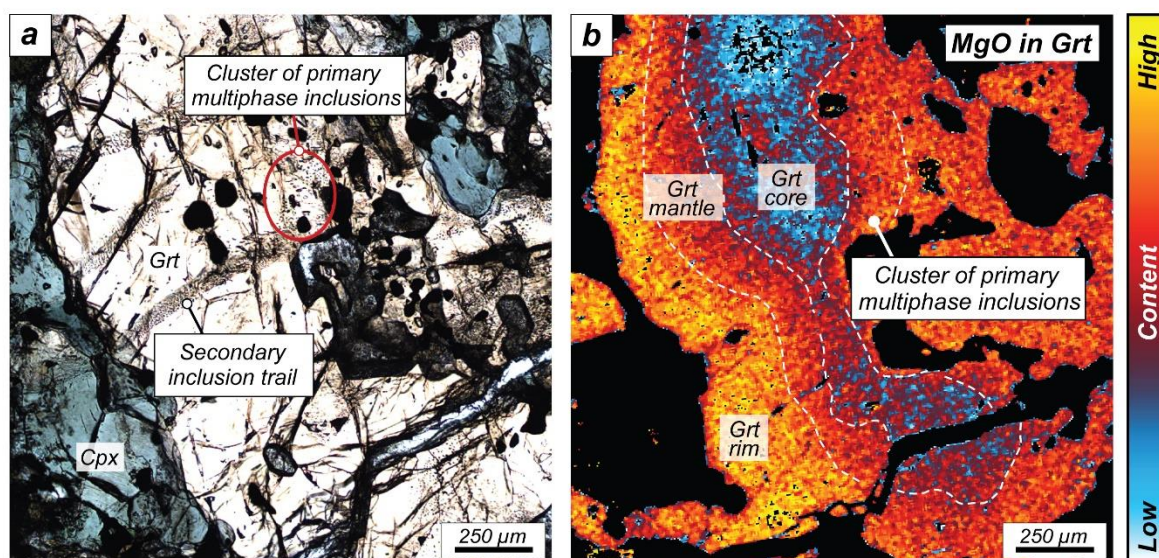


Figure S5: Histogram of molar $\text{CO}_2\text{-CH}_4$ proportion in HTa garnet-hosted multiphase inclusions.

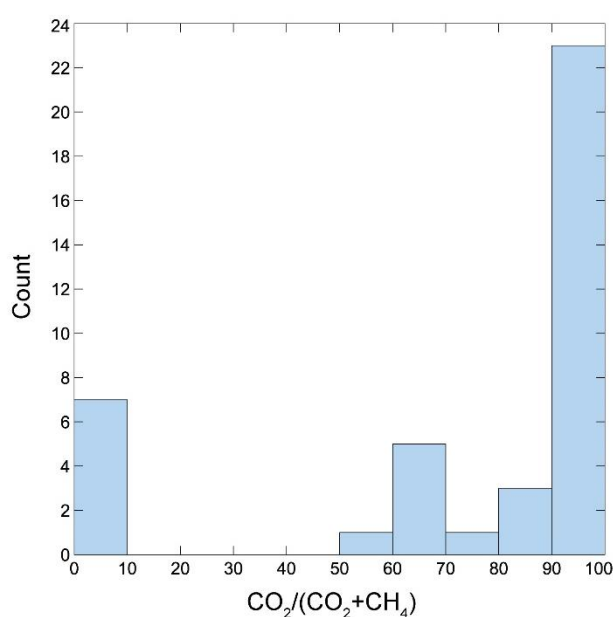


Figure S6: Raman spectrum of hydrocarbons identified in a HTa garnet-hosted primary multiphase inclusion. vein. CH₂ is identified by its characteristic symmetrical (~2850 cm⁻¹) and asymmetrical (~2890 cm⁻¹) stretching vibrations while CH₃ is identified by its characteristic symmetrical (~2920–2930 cm⁻¹) and asymmetrical (~2960–2970 cm⁻¹) stretching vibration (e.g., Okotrub et al., 2021). This spectrum significantly differs from the Raman spectra of any glue and resin used for thin section preparation (see Herviou et al., 2021).

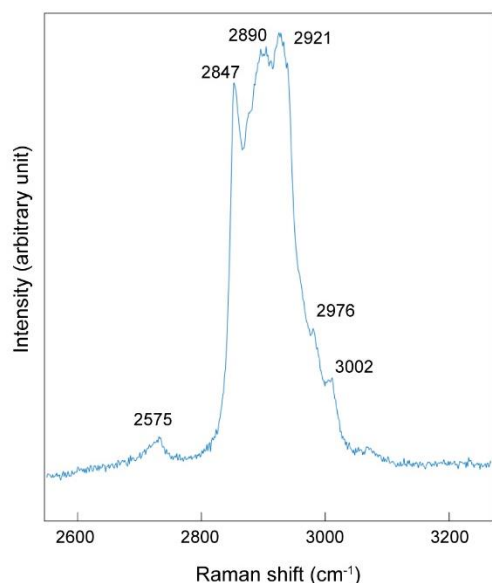


Figure S7: Characterization of pseudosecondary multiphase inclusions in HTa metamafic rocks. (a) Microphotograph of a pseudosecondary trail highlighting the multiphase nature (fluid + solid phases) of the inclusions. (b) Representative Raman spectra of the fluid species and solid phases observed in the pseudosecondary multiphase inclusions. Abbreviations after Whitney and Evans (2010).

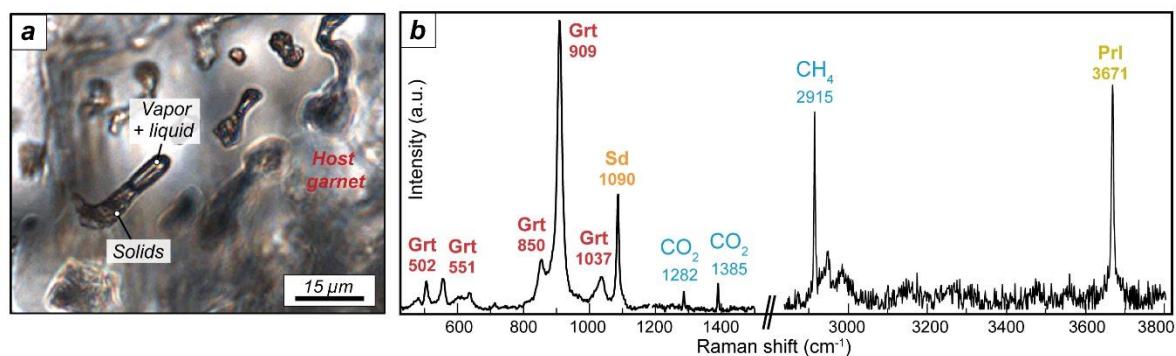


Table S1: Location of the analyzed samples

Sample	Locality	Unit	Latitude	Longitude	Sample type
SE1367	Sumeini	HTa	24.69758	56.06400	Metamafic rock
SE2005	Sumeini	HTa	24.69761	56.06503	Metamafic rock
SE2014	Sumeini	HTa	24.69608	56.06719	Metamafic rock
SE13-123L	Khubakhib	HTb	25.44575	56.09903	Metasediment
SE1419	Sumeini	HTb	24.69661	56.06269	Metasediment

Table S2: Detailed phase occurrence of all analyzed polyminerale inclusions. Abbreviations after Whitney and Evans (2010).

[illegible]

Table S3: Compositions of polymineralic inclusions reconstructed from WDS-EPMA maps.

	SiO ₂ (wt.%)	TiO ₂ (wt.%)	Al ₂ O ₃ (wt.%)	FeO (wt.%)	MgO (wt.%)	CaO (wt.%)	Na ₂ O (wt.%)	K ₂ O (wt.%)	Total
MI16 (<i>Type I</i>)	30.39	0.67	19.58	27.55	6.63	0.83	0.18	0.65	86.48
MI17 (<i>Type III</i>)	22.54	0.69	17.20	29.68	9.70	0.82	0.18	0.24	81.04
MI18 (<i>Mixed Type I-II</i>)	19.89	32.63	11.72	15.26	4.31	1.52	0.36	1.29	86.98
MI34 (<i>Type I</i>)	80.11	2.67	6.57	7.81	1.92	0.49	0.51	0.23	100.30
MI33 (<i>Type III</i>)	22.96	16.21	14.73	35.21	5.83	2.32	0.17	0.36	97.80
MI27a-b (<i>Mixed Type I-II</i>)	27.11	11.46	12.27	16.15	4.78	14.08	0.64	0.19	86.68
MI26 (<i>Mixed Type I-II</i>)	20.53	24.30	12.73	37.05	4.17	1.68	0.35	0.39	101.21
MI27bis (<i>Type I</i>)	31.67	0.76	16.11	25.95	6.36	1.60	0.19	0.35	82.97
MI26bis (<i>Type I</i>)	35.10	0.83	18.09	22.78	4.83	1.75	0.28	1.78	85.45
MI28bis (<i>Type I</i>)	15.40	32.54	9.42	40.92	2.82	1.23	0.20	0.17	102.71
MI14 (<i>Mixed Type I-II</i>)	58.72	2.48	10.84	14.79	3.56	2.69	0.41	0.20	93.70
MI15 (<i>Type II</i>)	14.23	0.65	10.13	17.37	2.05	27.65	0.70	0.98	73.76
Average host garnet	35.24	0.70	21.74	33.60	4.46	3.50	0.14	0.15	100.00

Table S4: Results of the bulk fluid inclusion extraction and isotope analysis including the average CH₄ and CO₂ concentrations, expressed in ppm, measured after sample milling/crushing, and the average $\delta^{13}\text{C}_{\text{CH}_4}$ and $\delta^{13}\text{C}_{\text{CO}_2}$ values expressed in ‰ relative to the VPDB. The average values and standard deviations are calculated over two replicated measurements and gas injections (n), except for the values marked by an asterisk based on a single injection and measurement. The blank levels of atmospheric CH₄ and CO₂ in the extraction apparatus prior to every analysis varied between 0.01 to 0.04 ppm of CH₄, and 6 to 12 ppm of CO₂ for the milling technique, and 0.5 to 1.5 ppm of CH₄ and 90 to 100 ppm of CO₂ for the crushing technique.

Sample	Weight (g)	Extraction technique	CH ₄ (ppm)	1 σ	$\delta^{13}\text{C}$ -CH ₄ VPDB (‰)	1 σ	n	CO ₂ (ppm)	1 σ	$\delta^{13}\text{C}$ -CO ₂ VPDB (‰)	1 σ	n
SE1367	21	Crushing	747	21	-11	0.2	2	93	6	NA	NA	2
SE2014	20	Crushing	550	10	-8.1	0.1	2	119*	0.3*	1.1*	2.5*	1
SE2014	105	Ball milling	292	16	-11.5	0.1	2	21	2	NA	NA	2
SE2005	104	Ball milling	126	1	-10.2	0.02	2	18	10	NA	NA	2

Table S5: Solution models used for thermodynamic modeling.

Phase	Perple_X abbreviation	Reference
Biotite	Bi(HGP)	Holland et al. (2018)
Chlorite	Chl(W)	White et al. (2014)
Chloritoid	Ctd(W)	White et al. (2014)
Dolomite	Do(HP)	Holland and Powell (1998)
Epidote	HP11	Holland and Powell (2011)
Feldspar	feldspar	Fuhrman and Lindsley (1988)
Garnet	Gt(HGP)	Holland et al. (2018)
Magnesite	M(HP)	Holland and Powell (1998)
White mica	Mica(CHA)	Coggon et Holland (2002); Auzanneau et al. (2010)
Staurolite	St(W)	White et al. (2014)
Fluid	COH-Fluid	Hybrid equation of state derived from Connolly and Cesare (1993)
Melt	melt(HGPH)	Holland et al. (2018)

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