Supplementary Material S1. Field relations and mineralogy of the andalusite-garnet-sillimanite-staurolite schist

The studied area comprises micaceous and quartz-micaceous schists, metaquartzites, and low-grade metamorphic rocks (phyllites and metapsammites). The alternation of layers with distinct chemical compositions is interpreted as the preservation of the primary compositional bedding (S_0) of the protoliths.

Two main foliations were recognized in the andalusite-garnet-sillimanite-staurolite schist: S_1 and S_2. In this unit, the most pervasive structure is S_2, while S_1 is locally preserved in microlithons. The S_2 foliation exhibits a W–E to WNW–ESE strike. Additionally, S_2 was later overprinted by kink bands and open folds at the millimetre scale, without associated metamorphic mineral growth.

S_1 foliation is defined by aligned flakes of biotite (Bt_1) and muscovite (Ms_1). The M_1 metamorphic event would be recorded by this early mineral assemblage, consisting of biotite–muscovite–quartz–plagioclase. Moreover, decussated centimetric andalusite porphyroblasts are frequent in the schist, which are pre-tectonic with respect to S_2 foliation together with a first stage of garnet growth (Grt_1 preserved as cores of large garnet porphyroblasts). The composition of Grt_1 is [X_{Alm} 0.745–X_{Sps} 0.139–X_{Prp} 0.080–X_{Grs} 0.035] (mineral data from Serra-Varela et al. 2024). This metamorphic event is defined as M_2.

M_3 metamorphic event is represented by represented by garnet (Grt_{2-3})–staurolite–sillimanite–biotite (Bt_2)–muscovite (Ms_2)–plagioclase–quartz. This metamorphic event is associated to the S_2 foliation, which is defined by the alignment of biotite (Bt_2) and muscovite (Ms_2) flakes, along to fibrolite. Garnet and staurolite are present as millimetric porphyroblasts. Two chemical varieties of garnet were defined: Grt_2–Grt_3, representing the mantle and rim of large porphyroblasts and small garnets in the matrix. Grt_2 is defined by a chemical composition of [X_{Alm} 0.750–X_{Sps} 0.112–X_{Prp} 0.083–X_{Grs} 0.056] whereas Grt_3 has a composition of [X_{Alm} 0.839–0.842, X_{Sps} 0.021–0.023, X_{Prp} 0.090–0.097 and X_{Grs} 0.038–0.050] Staurolite porphyroblasts exhibit sigmoidal inclusion trails continuous with the external S_2, suggesting syn-kinematic growth with this foliation. Partial replacement of andalusite by coarse-grained muscovite (Ms_3) and minor biotite (Bt_3) is post-S_2 and most likely represents a retrograde metamorphic stage.

Table S2

ANALYTICAL CONDITIONS

Accelerating voltage 15 kV
Current 100 nA
Spot size 1 mm

Element	Analytical line	Crystal	Peak position (mm)	(nm)	Lower background (-) (mm)
Th	*M* a	PETJ	132,409	0.41381	1,600
Y	*L* a	PETJ	206,648	0.64488	4,000
U	*M* b	PETJ	118,906	0.37160	3,980
Pb	*M* a	PETH	169,305	0.52860	3,213

Element	Counting time on peak (s)	Counting time at each background position (s)	average detection limit (ppm, 1s)	average detection limit (oxide wt.%, 1s)	Standard	Origin
Th	250	125	84	0.010	ThO_2	synthetic
Y	50	15	122	0.015	YPO_4	synthetic
U	300	150	62	0.007	U_3O_8	synthetic
Pb	300	150	32	0.003	crocoite ($PbCrO_4$)	Dundas, Tasmania, Australia

Data processing routine: *CITZAF (based on phi-rho-z, and provided by JEOL)*
Fixed composition for matrix corrections

oxide	**wt.%**
P_2O_5	30.43
SiO_2	0.26
La_2O_3	11.53
Ce_2O_3	25.42
Pr_2O_3	2.86
Nd_2O_3	10.26
Sm_2O_3	2.01
Gd_2O_3	1.69
Er_2O_3	0.16
Tb_2O_3	0.28
Dy_2O_3	0.96
Yb_2O_3	0.07

Overlap corrections

Overlapping line	*Overlapped line*	*Factor*
Th *M* g	U *M* b	0.01044
Th *M* x1,2	*Pb M* a	0.00175
Y *L* g2,3	*PbM* a	0.01371

Upper background (+) (mm)	detector gas	Gain	High.V	Base line window	Windows mode
2,560	P-10	32	1700	0.7	Integral
4,000	P-10	32	1700	0.7	Integral
3,980	Xenon	64	1730	0.7	Integral
3,213	Xenon	64	1700	1.0	Integral