Crystal-chemical and petrological constraints on the growth of Si-poor R^+AlSiO_4 species found in eclogite at Liset, Norway: lisetite, davidsmithite & trinepheline

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In the chemical system K-Na-Ca-Al-Si-O-H, eight IMA-recognised mineral species lie in the basal triangle Kls-Tnph-An (plotting atomic K-Na-[$\square_{0.5}Ca_{0.5}$], where □ = vacancy) with the key equality Al=Si and the common formula R^+AlSiO_4 (with R^+ including K, Na or [$\square_{0.5}Ca_{0.5}$]) (Fig. 1). This plane lies directly below the inclined plane of the plagioclase triangle Or-Ab-An in a 3D pyramid with Si plotted at the apex. Tnph, Jd, Ab & Qz are of course *collinear* on the join Tnph-Qz and give rise to the familiar reactions: Ab = Jd + Qz (1) and Jd = Tnph + Ab (2).

Pure compositions of Si-poor Tnph, Dsm & Lis are *collinear* on the K-free join Tnph-An, *i.e.,* they are related chemically by the simple ionic exchange {[$\square_{0.5}Ca_{0.5}$] = Na^+}. All of these species have tetrahedrally-coordinated Al^{iv} typical of low P/T *ratios* (*e.g.,* in igneous rocks), in contrast to jadeite with Al^{vi} typical of high P/T of the blueschist- or eclogite-facies (*cf.* the factor $f_{Al} = Al^{vi}/[Al^{vi}+Al^{iv}]$, indicative of P/T *ratios*).

Kalsilite	$KAlSiO_4$	Kls	$Tnph_0Kls_{100}$	K K K K $Al^{iv}{}_4Si_4O_{16}$
Nepheline	$K_{0.25}Na_{0.75}AlSiO_4$	Nph	$Tnph_{75}Kls_{25}$	K NaNaNa$Al^{iv}{}_4Si_4O_{16}$
Trinepheline	$NaAlSiO_4$	Tnph	$Tnph_{100}An_0$	NaNaNaNa$Al^{iv}{}_4Si_4O_{16}$
Fabriesite	$Na_3Al_3Si_3O_{12}.2H_2O$	Fab	$Tnph+0.67H_2O$	NaNaNaNa$Al^{iv}{}_4Si_4O_{16}$
Davidsmithite	$CaNa_6Al_8Si_8O_{32}$	Dsm	$Tnph_{75}An_{25}$	$\square_{0.5}Ca_{0.5}$ NaNaNa$Al^{iv}{}_4Si_4O_{16}$
Lisetite	$CaNa_2Al_4Si_4O_{16}$	Lis	$Tnph_{50}An_{50}$	□ Ca NaNa$Al^{iv}{}_4Si_4O_{16}$
Anorthite	$CaAl_2Si_2O_8$	An	$Tnph_0An_{100}$	□ Ca □ Ca $Al^{iv}{}_4Si_4O_{16}$
Lawsonite	$CaAl_2Si_2O_7(OH)_2.H_2O$	Lws	$An + 2H_2O$	□ Ca □ Ca $Al^{iv}{}_4Si_4O_{16}$

Figure 1 – R^+AlSiO_4 species presented like the structure of nepheline with O = 16

Lis and Dsm were first discovered occurring in certain amphibolite-facies retrogressed layers of the famous 60-metre long Liset Eclogite Pod in Norway. Tnph & Fab were first found in Myanmar, but were later discovered also at Liset (new EMP data, this paper). Numerous unusual species of clinoamphibole and mica also occur there. The dominant retrogressed symplectitic paragenesis is {aluminotaramite +/- preiswerkite + plagioclase}, but many other minerals also occur (e.g. Al-titanite; corundum). This pod, which reveals the earlier HP or UHP paragenesis {garnet-(jadeite or omphacite)-quartz-coesite(?)-kyanite-zoisite-paragonite-nyböite}, occurs enclosed within typical amphibolite-facies gneisses close to Liset hamlet (near to Selje village) in the Coesite-Eclogite-Province in the Western Gneiss Region. Lis, Dsm, Tnph & Fab are intimately associated on sub-millimetric scales in certain layers at Liset. Lis & Dsm have recently been recorded in some high-T (so low P/T *ratio*) rocks or industrial materials.

This paper examines why an "excess-silica" quartz-eclogite gave rise to these rare Si-poor species during retrogression. It discusses several hypotheses of crystal-chemical or petrological constraints on the growth of these rare ultra-sodic R^+AlSiO_4 species to help to understand why they formed at Liset and not (yet) in other eclogites worldwide: *e.g.* protolith; low K- & Mg-contents of bulk-rock compositions; Na-mobility and Al-immobility; shearing that led to distinct Grt- or Cpx-rich layers; reaction (2) from the Jd component in Cpx (or within Pg) produced the Si-poor Tnph-Dsm-Lis phases whilst the Si-rich Ab component migrated into the matrix plagioclase.