ECLOGITES IN BASEMENT COMPLEXES OF ROMANIA: CONTEXT AND MINERAL PECULIARITIES

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Eclogites

- witness mineral changes occurring in rocks at mantle depths
- provide a glimpse in the “physiology” of subduction zones and collision belts
- hold clues about exhumation mechanisms and their geotectonic context

- The distribution of the eclogites in the South Carpathians

- Petrologic and structural features
  - host formations
  - mineralogy
  - deformational features
  - precursor rocks
  - P-T conditions

- Mineralogical peculiarities
  - remarkable peak assemblages
  - retrograde overprints
The distribution of the eclogites in the South Carpathians

- In the Leaota Massif – hosted in a subduction-accretion complex
- In the Făgăraș Massif – confined to a structurally concordant metamorphic complex
- In the Lotru Metamorphic Suite, the basement of the Getic Nappe – in two closely-spaced structural levels
- In the Danubian Nappe system, the Poiana Mraconia Complex – blocks

Additionally, eclogites appear in the Baia de Arieș Unit of the Apuseni Mts.
The Leaota Massif – host formations: lithologic units
Leaota Massif – host formations: characteristic metamorphic assemblages structurally below the eclogite-bearing complex

The Albești Granite sole – contact metamorphism, HP overprint

The upper Voinești Fm. – polymetamorphism, HP-trend overprint
Leaota Massif – host formations: metamorphic ages
Leaota Massif – eclogites: precursor rocks → (OF) basalts + gabbro + metapelitic

Rock chemistry

Negulescu et al. (2009) J. Petrology 50, 103-125
The Leaota Massif – eclogites: mineralogy

- **common eclogites**
  - gt – cpx – qtz ± amp ± phe ± zo ± ky ± rt ± tc also low-variance

- **Cr-rich picritic eclogites**
  - Mg, Al, Ti, Cr-rich: gt – cpx – chr – rt – (Cr-)ky – (Mg,Cr-)sta – ep – ttn

- **metapelitic “eclogites”**
  - High-Jd cpx – Alm-rich Gt – phe – rt – amp – (qtz)
Leaota Massif – eclogites: mineralogy

Garnet and clinopyroxene compositions

selected compositions from all types

common eclogites

Negulescu et al. (2002) J. Petrology 50, 103-125

Săbău (2000) Lithos 52, 253-276
Leaota Massif – eclogites: P,T-conditions

Calculation of the P,T-conditions

Intersections of mineral equilibria

The Leaota Massif – eclogites: P,T-conditions

Peak conditions in eclogites and adjacent rocks

Tentative P, T- arrays of selected samples

Peak conditions in eclogites and adjacent rocks

Tentative P, T- arrays of selected samples
Leaota Massif – eclogites: deformation

Deformation: generally feeble, competent blocks in weak matrix. But also:

- Near peak metasomatism and superimposed foliation

- Retrograde metasomatism, deformation, recrystallization, segregations, veining
Lotru Metamorphic Suite – host formations: lithologic units

common eclogites

HT eclogites

The Semenic Unit
- Garnet-, kyanite-, staurolite-bearing micaschists and mica gneisses - The Negovanu Mare Formation

The Delinești Level
- (Leuco)granite concordant sheets
- Pegmatites
- Manganese-silicate rocks and schists
- Oxide-silicate rocks and schists
- Garnet amphibolites
- Eclogites
- Metaperidotites
- Lenticular gneisses - The Brebu Gneiss

The Voineasa Unit
- The Sărăcinu Complex
  - Alkaline orthogneisses, amphibolites, marbles, mica gneisses

- The Steaja Complex
  - Mafic melanitrusives
  - Quartzites - The Piatra Albă Quartzite
  - Pegmatites
  - Sillimanite-bearing mica gneisses, orthogneisses

- The Păltiniș Complex
  - K-feldspar gneisses, mica gneisses ± eclogites

The Valea Câprăreasa Complex
- Eclogites
- Ksp gneisses, augen gneisses
- (Meta)granitoids (gar, phe, kya)
- Feldspathic gneisses, biotite gneisses (+ gar, kya, Ksp)
- Amphibolites - Poiana Sibiului Amphibolites

The Armeniș Unit
- Pegmatites
- Iron oxides (dominantly magnetite), siderite and ankerite rocks
- Calc-silicate rocks
- Marbles
- Biotite-sillimanite ± cordierite gneisses, cummingtonite gneisses, kinzigites - The Armeniș Formation
Lotru Metamorphic Suite – host formations: metamorphic ages

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Lotru Metamorphic Suite – eclogites: mineralogy

- **common eclogites**
  
  gt – cpx – qtz ± amp ± phe ± ky ± zo ± rt and retrograde phases

- **HT - eclogites**
  
  gt – cpx ± qtz ± amp ± zo ± ky ± rt

Gt-cpx assemblage better preserved, symplectites very rare, no kelyphitic rims around garnet
Lotru Metamorphic Suite – eclogites: mineralogy

Garnet and clinopyroxene compositions

HT-eclogites richer in pyrope and poored in jadeite components
Lotru Metamorphic Suite – eclogites: precursor rocks → (OF) basalts (IAT)

basaltic composition, but HFSE-depletion, incompatible Pb; Rb, Th, U, Sr, enriched, P depleted
Lotru Metamorphic Suite – eclogites: PT-conditions

Common eclogites and associated rock
Lotru Metamorphic Suite – eclogites: deformation

Deformation: intense

- Near peak metamorphic compositional segregation and banding

- Post-peak

  folding

  boudinage

  veining
Făgăraș Massif – host formations: lithologic units

K-feldspar gneisses

metamorphosed mafic intrusive complex, intruded at its turn by (meta)granitoids, often preserving spectacular textural relics in metadolerites, metagabbros

K-feldspar gneisses

variegated complex with amphibolites, gneisses, metapelites, eclogites, ultrabasites

pelitic gneisses and schists
Făgăraș Massif – host formations: metamorphic ages

**pre-Variscan**

**Variscan**

Variscan metamorphism Sm-Nd isochron (Drăgușanu & Tanaka, 1999, *J. Geol. 107, 237-248*), and K-Ar amphib data (courtesy of Balogh K.)

**post-Variscan**

Făgăraș Massif
- Discordant granitoids
- Cozia Formation
  - Cumpâna Suite
  - Costul Cremenii Formation
- Muntele Lăcior Complex
  - a-Metagranitoids
  - Lespezi Gneiss
  - Topolog Complex
- Măgura Călineilor Complex
  - Suru, Serbota and Pîrîul Moașa Complexes
Făgăraș Massif – eclogites: mineralogy

- Ca-Mg-(Cr) – rich eclogites
  gt – cpx – ky – zo ± amp ± rt and retrograde phases (amp, spr)

mosaic equilibrium textures
Garnet from two settings: porphyroblast and corona around clinopyroxene. Sorted according to decreasing Mn (prograde growth sequence); garnet in the corona grew away from the cpx aggregate.

Omphacite from three textural setting: in Cr-bearing aggregates, bounded by garnet corona, and inclusions in garnet. Highest jadeite/less Cr in pyroxene included in garnet. Kosmochlor up to 13 mol%. Kyanite up to \( \text{Al}_{1.62}\text{Cr}_{0.38}\text{SiO}_5 \). The corresponding Cr content is up to 15.67 wt%.
Făgăraș Massif – eclogites: precursor rocks → gabbroic cumulates

Rock chemistry

Relict textures
Făgăraș Massif – eclogites: PT-conditions


isobaric heating at peak pressures - subduction zone gone stuck?

Near-peak p-T paths of the eclogites in the "Topolog Formation"

Assemblages on the left are stable on the high side of the P-axis (the high side of the T-axis for vertical reactions)

1): Ca = aQz
2): 2 Gr + Alm = 3 CTs + 3 Hed
3): Alm + 3 Di = Py + 3 Hed
4): 3 Hed + 4 Ky = 4 aQz + 3 CTs + Alm
5): Py + 2 Gr + 3 CTs + 3 Di
6): 2 Ky + Gr = 3 CTs + 3 aQz
7): 3 Di + 4 Ky = 4 aQz + Py + 3 CTs
8): 2 aQz + Gr + Alm = 3 Hed + 2 Ky
9): Gr + Py + 2 aQz = 2 Ky + 3 Di
10): 8 Zo + Alm = 13 CTs + 3 Hed + 3 aQz + 4 H2O
11): 4 Zo = 2 H2O + 4 Qz + Gr + 5 CTs
12): Py + 8 Zo = 4 H2O + 8 Qz + 3 Di + 13 CTs
13): 6 H2O + 12 Qz + 13 Gr + 5 Alm = 15 Hed + 12 Zo
14): 13 Gr + 5 Py + 12 Qz + 6 H2O = 12 Zo + 15 Di
Făgăraș Massif – eclogites: deformation

pervasive deformation and recrystallization at peak conditions – “kyanite jade” formed on plagioclase sites, hosting deformed garnet and clinopyroxene aggregates
Mineralogical peculiarities - remarkable peak assemblages

Leaota Massif – HT-jadeite – rich clinopyroxene

FeK$_\alpha$
MgK$_\alpha$
NaK$_\alpha$
Mineralogical peculiarities - remarkable peak assemblages

Leaota Massif – sodic and sodic-calcic amphiboles

Mineralogical peculiarities - remarkable peak assemblages

Leaota Massif – Cr-bearing silicate phases (alumosilicates, pyroxene, titanite, amphibole, phengite...)

BSE

AIKα

CrKα

TiKα

MgKα
Mineralogical peculiarities - remarkable peak assemblages

Făgăraș Massif – Cr-rich silicates, dominantly kyanite

BSE and cathodoluminescence images, distribution maps of Al, Cr, Ti, Mg and Mn in Cr-kyanite + Cr-clino- pyroxene + chromite + rutile aggregates
Mineralogical peculiarities – retrograde overprints

Leaota Massif – veins and vugs: clinopyroxene, amphibole

Idiomorphic cpx corroded and reacted to compositions lower in Jd: cavities kept open by fluid pressure during exhumation

Mineralogical peculiarities – retrograde overprints

Lotru Metamorphic Suite – retrograde fine-grained intergrowths

peraluminous sapphirine – including a new species of the sapphirine supergroup, Al>Si
(Grew et al., 2008, Mineral. Magazine 72, 839–876)

Săbău et al. (2002) Int. Geol. Rev. 44, 859-876
n: Mg$_{16-n}$Al$_{32+2n}$Si$_{8-n}$O$_{60}$ (Vogt, 1947), R= (Mg,Fe)O:Al$_2$O$_3$:SiO$_2$

“Ferri-preiswerkite” NaMg$_2$Fe$^{3+}$Al$_2$Si$_2$O$_{10}$(OH)$_2$ solid solution

– retrograde vein minerals
Mineralogical peculiarities – retrograde overprints

Făgăraș Massif – retrograde fine-grained intergrowths

peraluminous sapphirine
– retrograde vein assemblages

zoisite
pericline