The Antrona ophiolite:
History of a piece of Tethys ocean

Anna Zappatini, Jörg Hermann

University of Bern, Institute of Geology, Baltzerstrasse 1+3, 3012 Bern, Switzerland

INTRODUCTION

The Antrona ophiolite is situated in the Western Alps at the border between Switzerland and Italy. As a remnant of oceanic lithosphere, it consists of ultramafic, mafic and sedimentary rocks which were once part of the Alpine Tethys ocean. During the convergence of the Adriatic and European plates, the rocks of the Antrona ophipolite were subducted. Some of the subducted rocks escaped their recycling to the mantle and thus ended up in the Alpine orogen.

Subduction-related high-pressure metamorphism has been reported for the Antrona ophiolite. Specific metamorphic conditions and ages remain poorly constrained. From its structural position in the Alpine nappe stack, the paleogeographic location of the Antrona ophiolite is ambiguous: It could have belonged either to the Piemont-Ligurian ocean or the Valais ocean.

RESEARCH QUESTIONS

- What were the peak conditions? What is the retrograde history of the rocks?
- What are the protolith and metamorphic ages?
- Did the Antrona ophiolite belong to the Piemont-Ligurian or Valais ocean?

APPROACH

Classical petrological methods like microscopy, SEM-EDX and EPMA are applied to study the fate of the Antrona ophiolite in detail. Geothermobarometric tools aid to constrain the metamorphic conditions. U-Pb geochronology of zircons delivers ages and information about the timing of processes.

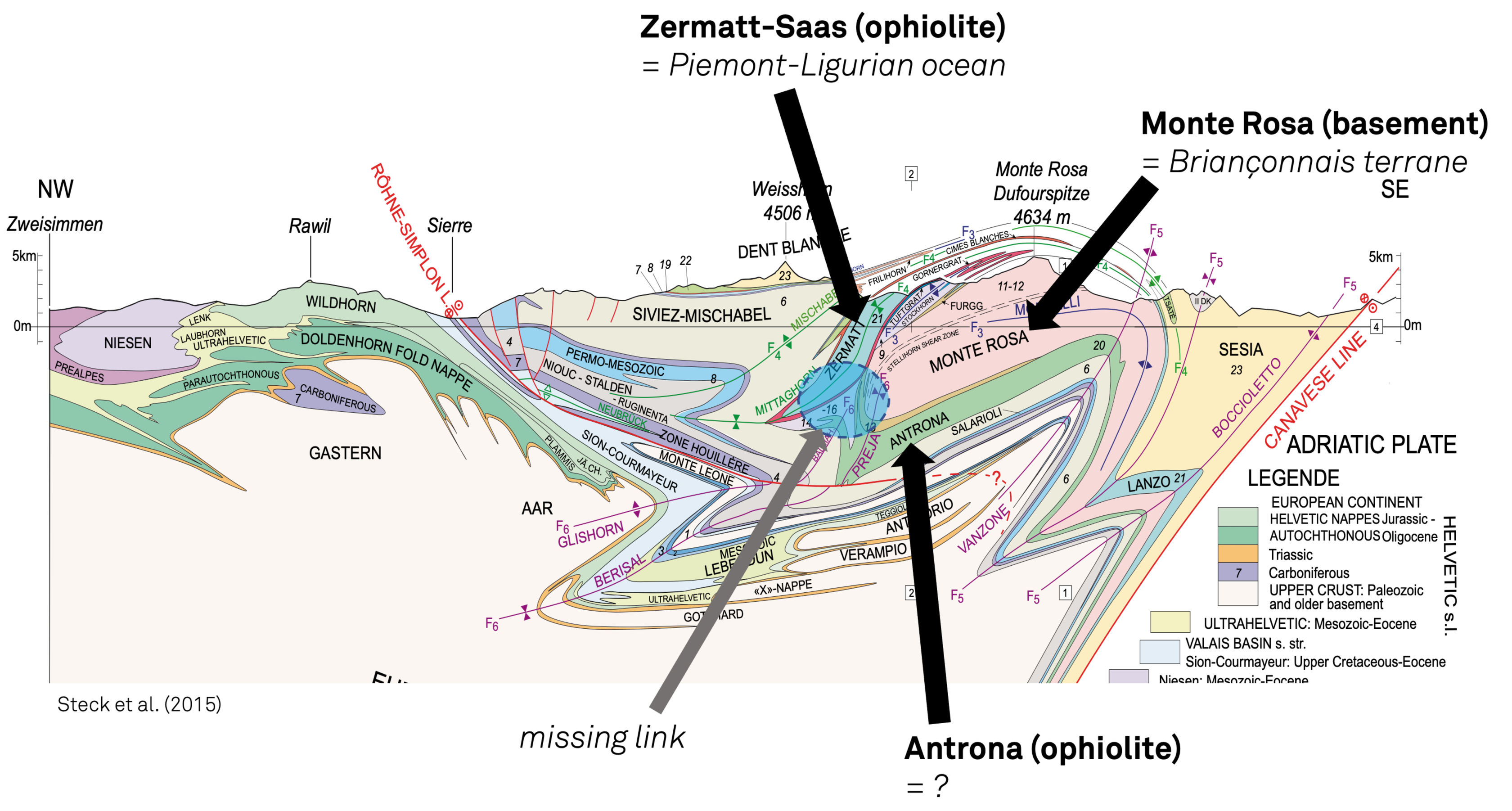
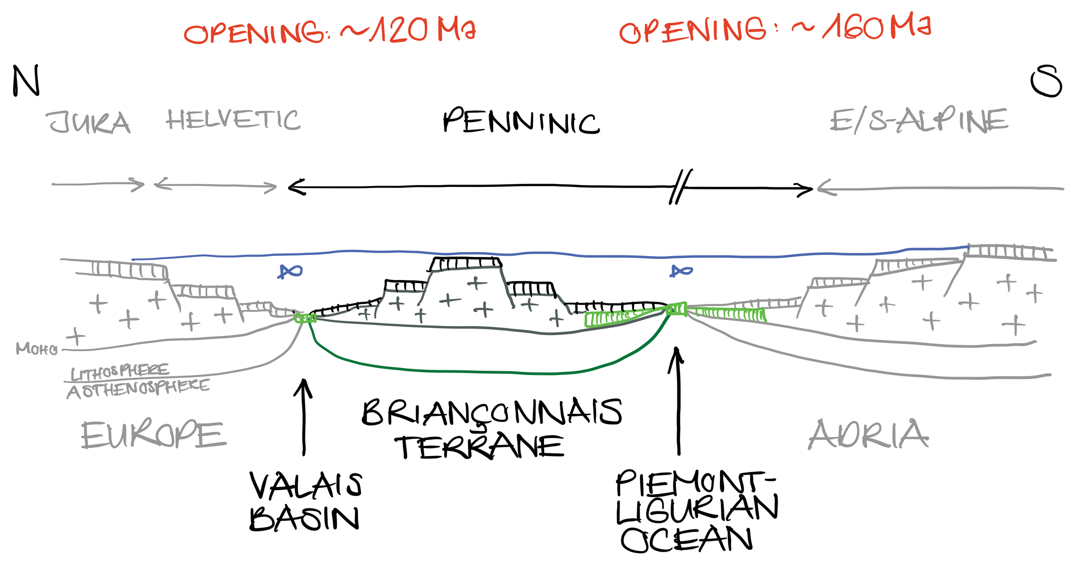


Fig. 1 (top): NW-SE profile through the Alps with indication of the relevant units. Adapted from [1].

Fig. 2 (right): Sketch of possible paleogeographic positions of the Antrona ophiolite in a late Cretaceous N-S profile. The positions of Monte Rosa and Zermatt-Saas are less disputed in literature.



RESULTS

1. Ultramafic rocks (Peridotite, serpentinite)

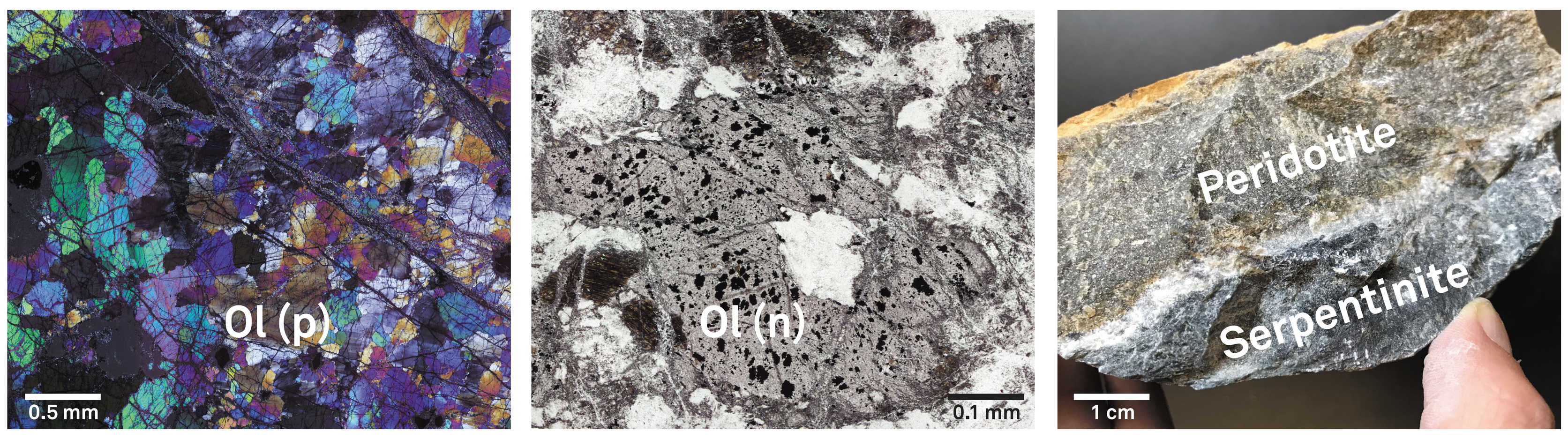


Fig. 3a (left): Mantle olivine (Ol (p)) in a peridotite which survived the subduction and collision. (XPL)

Fig. 3b (center): Metamorphic olivine (Ol (n)) formed during subduction. Note the magnetite specks. (PPL)

Fig. 3c (right): Sample containing both peridotite (upper part) and serpentinite (lower part), separated by a narrow white band rich in tremolite.

→ Prograde dehydration reaction Atg + Brc → Ol + H_2O

→ Incomplete retrograde hydration in the tremolite stability field

2. Mafic rocks (Eclogite-facies metabasalts, partly retrogressed)

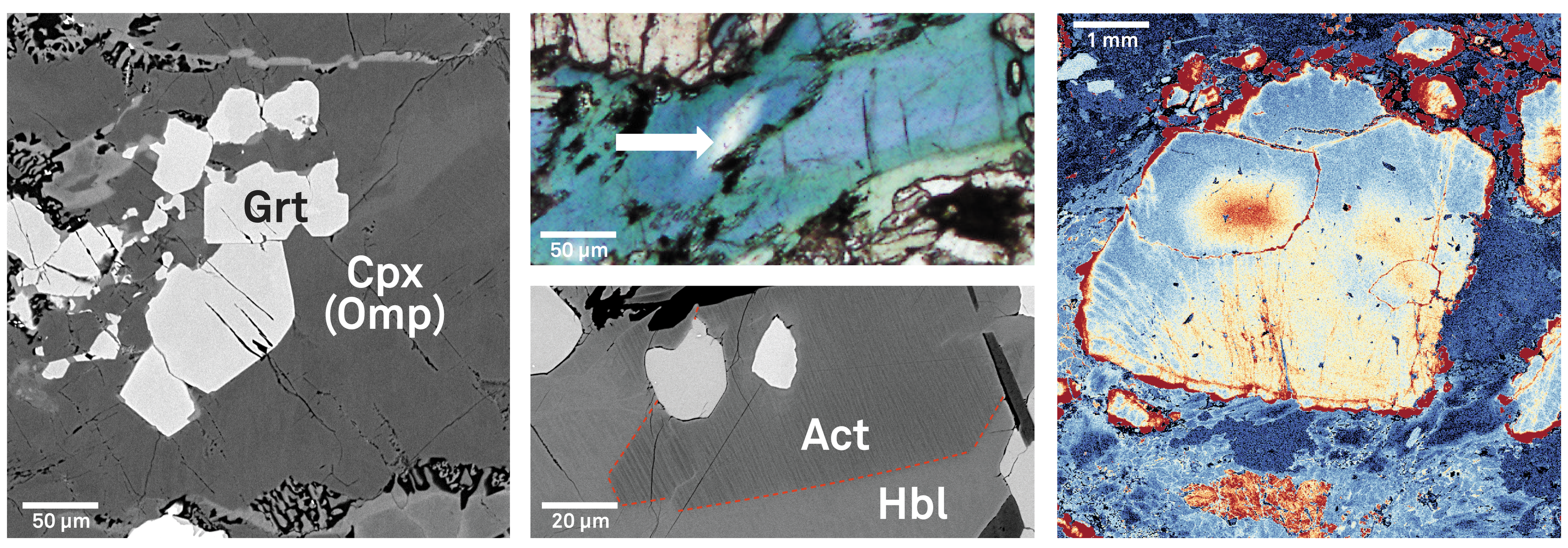


Fig. 4a (left): Garnet and Omphacite in textural equilibrium. (SEM-BSE image)

Fig. 4b (center top): Relict magmatic orthoamphibole. (Indicated by white arrow. Plane-polarized light)

Fig. 4c (center bottom): Retrograde amphibole zoning. (Indicated by red dashed line. SEM-BSE image)

Fig. 4d (right): EMPA element map of Mn zoning in garnet showing a late resorption (red rims). (EMPA-WDS)

→ Prograde metamorphism to eclogite facies

→ metamorphic conditions: 545 - 560 °C for > 13 kbar (Grt-Omp therm.)

→ Retrogression involves a late heating episode (Actinolite → Hornblende)

3. Zircon (U-Pb) geochronology (eclogite sample)

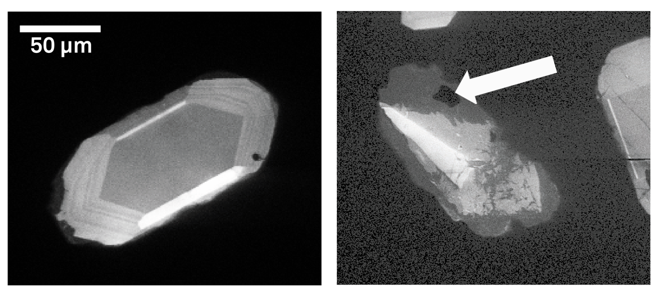


Fig. 5a (left): Magmatic zircon. (CL image)

Fig. 5b (right): Metamorphic zircon rim around magmatic core. Rutile (HP) inclusion indicated by arrow. (CL image)

→ **magmatic age: 154.82 ± 0.32 Ma** (MSWD 0.73, n=46)

→ **metamorphic age: 41.1 ± 0.94 Ma** (MSWD 1.40, n=32)

CONCLUSION

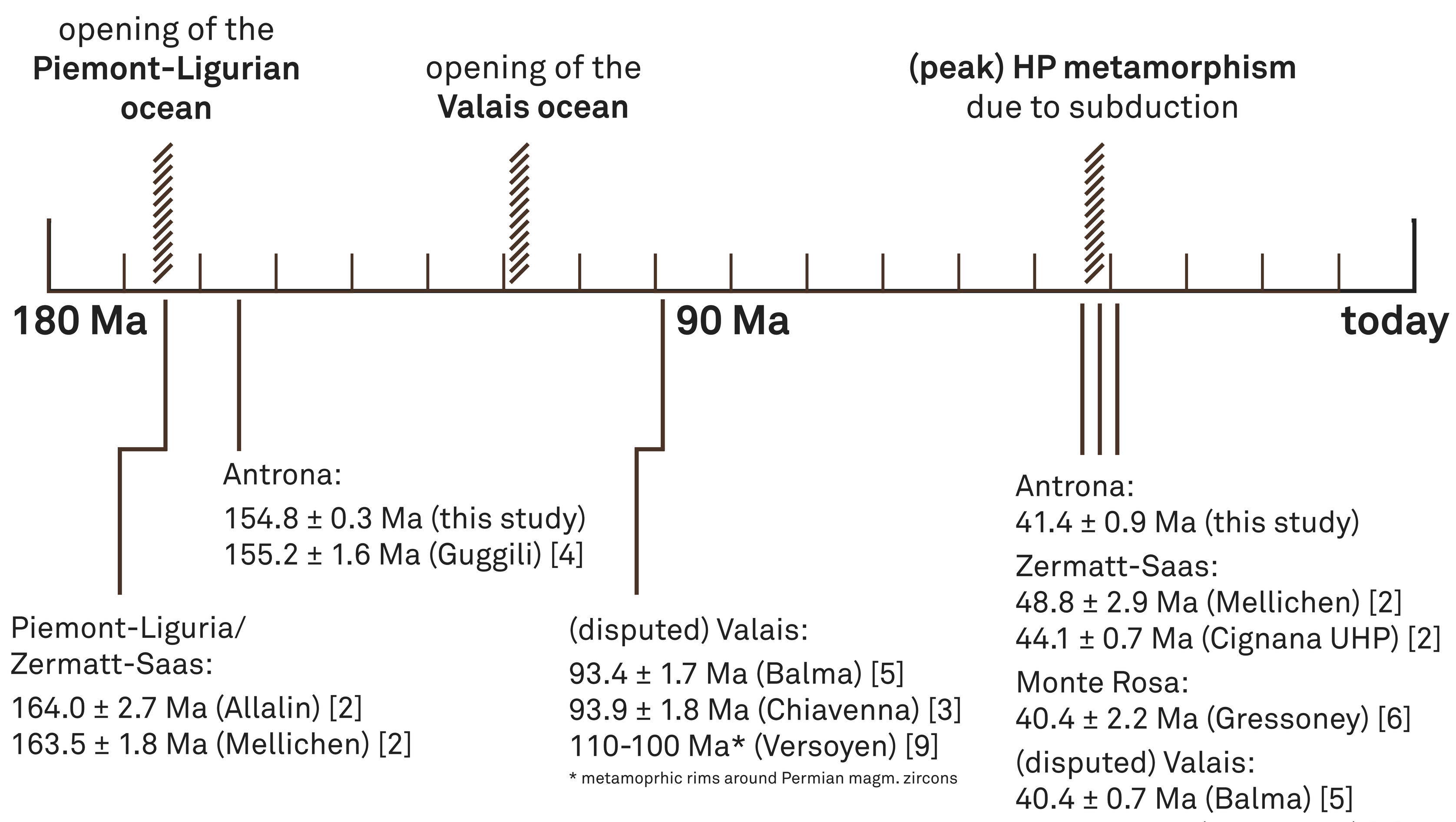
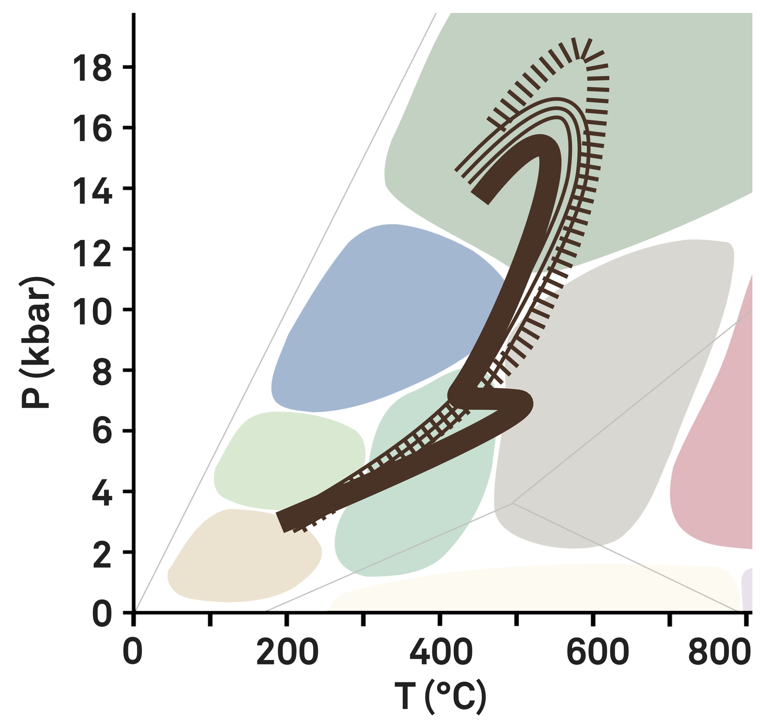


Fig. 6 (top): Summary of the geochronological data from this study and literature.

Fig. 7 (right): Estimated P-T path of the Antrona ophiolite (solid line, this study), the Monte Rosa nappe (triple line, [7]) and the Zermatt-Saas ophiolite (dashed line, [8]) .



KEY TAKEAWAYS

1. **Antrona = Piemont-Ligurian ocean**
2. **Metamorphic timing and conditions similar to Zermatt-Saas, Monte Rosa**

References

[1] A. Steck, H. Masson, M. Robyr (2015) Tectonics of the Monte Rosa and surrounding nappes (Switzerland and Italy): Tertiary phases of subduction, thrusting and folding in the Pennine Alps. Swiss J Geosci 108:3–34

[2] D. Rubatto, D. Gebauer, M. Fanning (1998) Jurassic formation and Eocene subduction of the Zermatt±Saas-Fee ophiolites: implications for the geodynamic evolution of the Central and Western Alps. Contrib Mineral Petrol 132:269–287

[3] A. Liati, D. Gebauer, M. Fanning (2003) The youngest basic oceanic magmatism in the Alps (Late Cretaceous; Chiavenna unit, Central Alps): geochronological constraints and geodynamic significance. Contrib Mineral Petrol 146:144–158

[4] A. Liati, D. Gebauer, M. Fanning (2005) Jurassic ophiolites within the Valais domain of the Western and Central Alps: geochronological evidence for re-rifting of oceanic crust. Contrib Mineral Petrol 149: 446–461

[5] A. Liati, N. Froitzheim (2006) Assessing the Valais ocean, Western Alps: U-Pb SHRIMP zircon geochronology of eclogite in the Balma unit, on top of the Monte Rosa nappe. Eur J Mineral 18:299–308

[6] T.J., Lapen, C.M. Johnson, L.P. Baumgartner et al. (2007) Coupling of oceanic and continental crust during Eocene eclogite-facies metamorphism: evidence from the Monte Rosa nappe, western Alps. Contrib Mineral Petrol 153:139–157

[7] J. D. Vaughan-Hammon, C. Luisier, L.P. Baumgartner, S.M. Schmalholz (2021). Peak Alpine metamorphic conditions from staurolite bearing metapelites in the Monte Rosa nappe (Central European Alps) and geodynamic implications. Journal of Metamorphic Geology, 39:897-917

[8] S. Angiboust, P. Agard, L. Jolivet, O. Beyssac (2009) The Zermatt-Saas ophiolite: the largest (60-km wide) and deepest (c. 70–80 km) continuous slice of oceanic lithosphere detached from a subduction zone? Terra Nova 21:171–180

[9] M. Beltrando, D. Rubatto, R. Compagnoni, G. Lister (2007) Was the Valaisan Basin floored by oceanic crust? Evidence of Permian intra-plate magmatism in the Versoyen Unit (Valaisan Domain, NW Alps). Ofioliti 32:85–99

UNIVERSITÄT
BERN