

FOREWORD

MARCO BELTRANDO
10.12.1978 - 08.12.2015

The death of Marco was not only a deep distress for the parents Pier Angelo and Beatrice, the brother Stefano, the partner Cristina Mariani and the little son Marcello, and for the many friends, but also a grave mourning for the entire scientific community of Geosciences tragically deprived a young, enthusiastic, curious and very brilliant researcher.

During his too short career, Marco reached very important results about the recognition of hyper-extended margins in the collisional belt of the Western Alps, which was of major importance for the understanding of other orogenic belts all around the world. Another major result was the recognition of heating-cooling cycles in rift systems. In both of these fields, Marco was at the forefront of the research as shown by his numerous invitations to international conferences. Based on rigorous field surveys, Marco was easily able to connect structural geology and tectonics with petrology, geochronology and stratigraphy. His great capacity of linking the observations at the micro-scale to those at the meso- and macro-scale allowed him to shed new light on the 3D evolution of both extensional and collisional systems. Marco Beltrando was on his way to become one of the leaders in his field and represented a new generation of Alpine geologists.

https://www.researchgate.net/profile/Marco_Beltrando



Marco above Lago di Loie (Cogne, Val d'Aosta) with Mont Blanc in the background (July 30, 2013).

CURRICULUM VITAE ET STUDIORUM

1998: After a brilliant high school curriculum, Marco enrolled in a degree course in Geological Sciences at the University of Torino.

2002: Laurea in Scienze Geologiche (*M.Sc. equivalent in Geology*) at the University of Torino, with a thesis entitled: “**Geologic and structural survey of the peridotitic massif of Balmuccia, Ivrea-Verbanò Zone (western Alps)**”. Tutor: Roberto Compagnoni (Torino, I); co-tutor: Reinoud Vissers (Utrecht, NL). Votation: 110/110 e lode, menzione e dignità di stampa (*summa cum laude with special mention and recommendation for publication*).

2000: “Erasmus” grant spent at the Utrecht University, NL

2002: “Ugo Pognante award” for the best experimental MSc/PhD thesis of geologic and petrologic subject on the Alpine-Himalayan mountain belt.

2003: Optime award of the Industry Association of Turin granted to the best MSc dissertation at the University of Turin.

2007: Ph.D. degree at Research School of Earth Sciences, the Australian National University, Canberra (Australia). Tutor: Gordon Lister, co-tutor Roberto Compagnoni. Title: “**On the evolution of the Western Alps: Pressure cycles and deformation mode switches**”.

April 2008 and March 2009: *Research fellow* at École et Observatoire des Sciences de la Terre (EOST), Université Luis Pasteur, Strasbourg (France).

May 2008-July 2010: *Research fellow* at Department of Mineralogical and Petrological Sciences, University of Torino.

November 2010-September 2012: *Research fellow* at CNR-IGG of Pisa, Section of Torino in the framework of the project: “**⁴⁰Ar/³⁹Ar thermochronology of distal rifted margins: the fossil Alpine Tethys example preserved in the Alps**”.

2012: *National scientific qualification* to participate in a competition for a position of *Associate Professor* in the fields of Structural geology, Stratigraphy, Sedimentology and Paleontology.

October 2012: *Research fellow* at Department of Earth Sciences, the University of Torino.

December 4th 2015, he obtained a tenure-track position for *Associate professor* at the University of Torino, Department of Earth Sciences, where in the last 4 years he taught Structural Geology and Regional Geology of the Alps as a researcher at the Structural Geology Group led by Rodolfo Carosi.

On **December 8th,** four days after this competition, along an easy path in his loved Canavese area, a mountain accident suddenly terminated the Marco’s life and his brilliant scientific and teaching career.

Member of the Organizing Committee and leader of related excursions of the **10th Alpine Workshop CorseAlp 2011** (Saint Florent, France, April 2011), and the **10th International Eclogite Conference** (Courmayeur, Italy, 2013).

He carried out an intense **teaching activity** in a broad spectrum of Earth Science subjects to support official courses at Monash University, Melbourne (Prof. Gordon Lister, 2003), at Australian National University, Canberra (Prof. Rich-

ard Arculus, 2004), at Université Luis Pasteur, Strasbourg (France). In Italy, he was charged of parts of the courses of *Applied Structural Geology* and *Regional Geology* for the master’s degree of Applied Geological Sciences, the University of Torino.

Marco gave **invited lectures** at international meetings (32nd Int. Geological Conf., Firenze 2004; EGU Vienna 2007 and 2010; AGU Fall Meeting, San Francisco 2012 and 2015) and at several foreign and Italian universities.

“For his sound contributions on the evolution of the Alpine orogeny”, **Marco was dedicated a new mineral:** the Mg-end member **magnesiobeltrandoite-2N3S**, that gave the new **Beltrandoite** root-name in the högbomite supergroup¹. Marco’s many friends with the collaboration of the Rivarolo Alpine Club dedicated a new **bivouac** to him (**Bivacco Beltrando**) built on Punta Rava (2439 m a.s.l.) along the watershed ridge between the Verdazza stream (Val Soana) and the Savenca stream (Valchiusella).

List of papers, geological maps and field reports authored/co-authored by Marco

1. Forster M., Lister G., Compagnoni R., Giles D., Hills Q., Betts P., **Beltrando M.** and Tamagno E., 2004. Mapping of oceanic crust with “HP” to “UHP” metamorphism: The Lago di Cignana Unit (Western Alps). In: G. Pasquarè and C. Venturini (Eds.), G. Groppelli (Ass. Ed.). Mapping Geology in Italy, APAT- Dip. Difesa del Suolo - Servizio Geol. d’Italia, Roma 2004, 2006, Map 33, 279-286. Printed by S.EL.CA.-Firenze. <http://www.isprambiente.gov.it/it/pubblicazioni/pubblicazioni-di-pregio/mapping-geology-in-Italy>
2. **Beltrando M.**, Hermann J., Lister G. and Compagnoni R., 2007. On the evolution of orogens: Pressure cycles and deformation mode switches. *Earth Planet. Sci. Lett.*: 256(3-4), 372-388.
3. **Beltrando M.**, Rubatto D., Compagnoni R. and Lister G., 2007. Was the Valaisian basin floored by oceanic crust? Evidence of Permian magmatism in the Versoyen Unit (Valaisian domain, NW Alps). *Ophioliti*, 32(2), 85-99.
4. **Beltrando M.**, Lister G., Hermann J., Forster M. and Compagnoni R., 2008. Deformation mode switches in the Penninic units of the Urtier Valley (Western Alps): Evidence for a dynamic orogen. *J. Struct. Geol.*, 30(2), 194-219.
5. **Beltrando M.**, Lister G.S., Forster M., Dunlap W.J., Fraser G. and Hermann J., 2009. Dating microstructures by the ⁴⁰Ar/³⁹Ar step-heating technique: Deformation-pressure-temperature-time history of the Penninic Units of the Western Alps. *Lithos*, 113(3-4), 801-819.
6. Groppo C., **Beltrando M.** and Compagnoni R., 2009. The *P-T* path of the ultra-high pressure Lago Di Cignana and adjoining high-pressure meta-ophiolitic units: insights into the evolution of the subducting Tethyan slab. *J. Metam. Geol.*, 27(3), 207-231.

¹ Cámara F., Cossio R., Regis D., Cerantola V., Ciriotti M.E., Compagnoni R. (2018) Beltrandoite, a new root-name in the högbomite supergroup: The Mg-end member magnesiobeltrandoite-2N3S. *Eur. J. Mineral.*, 30, 545-558.

7. **Beltrando**, M., Lister, G., Rosenbaum, G., Richards, S. and Forster, M.A., 2010. Recognizing episodic lithospheric thinning along a convergent plate margin: The example of the Early Oligocene Alps. *Earth Science Reviews*, 103(3-4), 81-98.
8. Mohn, G., Manatschal, G., Muntener, O., **Beltrando**, M. and Masini, E., 2010. Unravelling the interaction between tectonic and sedimentary processes during lithospheric thinning in the Alpine Tethys margins. *Int. J. Earth Sci.*, 99(1), 75-101.
9. **Beltrando**, M., Rubatto, D. and Manatschal, G., 2010. From passive margins to orogens: The link between Ocean-Continent Transition zones and (Ultra-)High-Pressure metamorphism. *Geology*, 38(6), 559-562.
10. **Beltrando** M., Compagnoni R. and Lombardo B., 2010. (Ultra-)High-pressure metamorphism and orogenesis: An Alpine perspective. *Gondwana Research*, 18(1), 147-166.
11. **Beltrando** M., Rubatto D. and Manatschal G., 2010. From passive margins to orogens: The link between Ocean-Continent Transition zones and (Ultra-)High-Pressure metamorphism. *Geology*, 38(6), 559-562.
12. Vitale Brovarone A., Malavieille J., **Beltrando** M., Molli G. and Compagnoni R., 2011. Geology and petrology of Ocean Continent Transition (OCT) zones metamorphosed under eclogite facies conditions. In: J. Malavieille, G. Molli, A. Vitale Brovarone, O. Beyssac (Eds.) *CorseAlp 2011 - Field Trip Guidebook*. J. Virtual Explorer, Electronic Edition, ISSN 1441-8142, vol. 39, paper 2, 1-18.
13. Vitale Brovarone, A., **Beltrando** M., Malavieille J., Giuntoli F., Tondella E., Groppo C., Beyssac O. and Compagnoni R., 2011. Inherited ocean-continent transition zones in deeply subducted terranes: Insights from Alpine Corsica. In: A. Montanini, G.B. Piccardo, R. Tribuzio, H.J.B. Dick (Eds.) *Alpine Ophiolites and Modern Analogues, Continental Rifting to Oceanic Lithosphere*. 30 September-2 October 2009, Parma, Italy. *Lithos*, 124(3-4), 273-290.
14. Rubatto D., Regis D., Hermann J., Boston K., Engi M., **Beltrando** M. and McAlpine S.R.B., 2011. Yo-yo subduction recorded by accessory minerals in the Italian Western Alps, *Nature Geoscience*, 4, 338-342.
15. Mohn G., Manatschal G., **Beltrando** M., Masini E. and Kusznir N., 2012. Necking of continental crust in magma-poor rifted margins: Evidence from the fossil Alpine Tethys margins, *Tectonics*, 31(1), TC1012.
16. **Beltrando** M., Frasca G., Compagnoni R. and Vitale Brovarone A., 2012. The Valaisan controversy revisited: Multi-stage folding of a Mesozoic hyper-extended margin in the Petit St. Bernard pass area (Western Alps). *Tectonophysics*, 579, 17-36.
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18. Vitale Brovarone A., Beyssac O., Malavieille J., Molli G., **Beltrando** M. and Compagnoni R., 2013. Stacking and metamorphism of continuous segments of subducted lithosphere in a high-pressure wedge: The example of Alpine Corsica (France). *Earth-Science Reviews*, 116, 35-56.
19. **Beltrando** M., Di Vincenzo G. and Ferraris C., 2013. Preservation of sub-microscopic structural relicts in micas from the Gran Paradiso Massif (Western Alps): Implications for ^{40}Ar - ^{39}Ar geochronology. *Geochim. Cosmochim. Acta*, 119, 359-380.
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22. Barnes J.D., **Beltrando** M., Lee C.T.A., Cisneros M., Loewy S. and Chin E., 2014. Geochemistry of Alpine serpentinites from rifting to subduction: A view across paleogeographic domains and metamorphic grade. *Chemical Geology*, 389, 29-47.
23. **Beltrando** M., Compagnoni R., Barnes J., Frezzotti M.L., Regis D., Frasca G., Forster M. and Lister G., 2014. From passive margins to orogens: The link between zones of Exhumed Subcontinental Mantle and (U)HP metamorphism. Day 2 - The UHP Lago di Cignana Unit, Zermatt-Saas Zone. 10th Int. Eclogite Conf., Pre-Conf. Excursion, 3 September 2013, GFT - Geological Field Trips, 6 (1.1), 1-61. ISSN: 2038-4947. (doi: 10.3301/GFT.2014.01) <http://www.isprambiente.gov.it/it/publicazioni/periodici-tecnici/geological-field-trips/from-passive-margins-to-orogens>
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28. Seymour N.M., Stockli D.F., **Beltrando** M. and Smye A.J., 2016. Tracing the thermal evolution of the Corsican lower crust during Tethyan rifting. *Tectonics*, 35(10), 2439-2466.
29. Decarlis A., **Beltrando** M., Manatschal G., Ferrando S. and Carosi R., 2017. Architecture of the Distal Piedmont-Ligurian Rifted Margin in NW Italy: Hints for a Flip of the Rift System Polarity. *Tectonics*, 36(11), 2388-2406.
30. Decarlis A., Fellin M.G., Maino M., Ferrando S., Manatschal G., Gaggero L., Seno S., Stuart F.M., and **Beltrando** M., 2017. Tectono-thermal evolution of a distal rifted margin: Constraints from the Calizzano Massif (Prepiedmont-Briançonnais Domain, Ligurian Alps). *Tectonics*, 36(12), 3209-3228.
31. Chenin P., Manatschal G., Decarlis, A., Schmalholz S.M., Duretz T. and **Beltrando** M., 2019. Emersion of distal domains in advanced stages of continental rifting explained by asynchronous crust and mantle necking. *Geochemistry, Geophysics, Geosystems*, 20(8), 3821-3840.
32. **Beltrando** M., 2021. Can the scale of observation hide complexities in the deformation history of a terrane? An example from the Balmuccia Peridotite Massif, Ivrea Zone (NW Italy). *Ophioliti* (this volume).

Co-editor of the volumes:

1. **Beltrando M.**, Lister G.S., Ganne J., Boullier A.-M. (Eds.) Evolution of the western Alps: insights from metamorphism, structural geology, tectonics and geochronology. *J. Virtual Explorer*, Vol. 16, 2004.
2. **Beltrando M.**, Peccerillo A., Mattei M., Conticelli S., Doglioni C. (Eds.) The Geology of Italy. Tectonics and Life along Plate Margins. *J. Virtual Explorer*, Vol. 36, 2010.
3. **Beltrando M.**, Manatschal G., Mohn G., Masini E. (Eds.) A field guide across the margins of Alpine Tethys. *J. Virtual Explorer*, Vol. 49, 2015.

This **Special Section of Ofioliti** contains a collection of seven research papers dedicated to the memory of Marco Beltrando, all inspired by his work. The unifying theme, "Late Variscan to Alpine orogenic evolution: the role of rift inheritance", is developed in these papers through different structural, petrological, geochemical and geochronological approaches.

The first article of the Special Section is a posthumous, unpublished work of *Marco Beltrando*, who carried out a detailed structural study of the worldwide famous Balmuccia peridotite massif from the Ivrea-Verbanò zone (Italian Southern Alps). In this paper he proposed a method to overcome the difficulty of recognizing distinct events when high-strain deformation is superimposed over a pre-existing pattern. Application to the websteritic dikes intruding the peridotite allowed him to reconstruct a multistage tectonic evolution of the Balmuccia mantle body during the late- to post- Variscan phases of lithospheric extension.

Compagnoni et al. investigated the peculiar corundum-bearing assemblages occurring in a mafic-ultramafic igneous body from the Etsch-Levaz slice (ELS) in the Western Italian Alps. A mineralogical and microstructural study coupled to pressure-temperature phase diagram projections allow the authors to reconstruct in detail the Alpine (prograde-to-retrograde) high pressure evolution leading to the observed mineral associations, which also included the newly discovered Mg-beltrandoite.

Barale et al. carried out a field-based geochemical study of hydrothermal dolomitization in the Provençal domain of the Maritime Alps, through a multidisciplinary analytical approach. Insights into the nature and origin of the involved fluids are thus provided. Constraints on the age of the large scale hydrothermal circulation responsible for the dolomitization point to a Lower Cretaceous fault activity along the southern part of the Western Tethys passive margin.

Lower crustal remnants of the Western Tethys rifted margins are exposed in the Ivrea-Verbanò Zone, hence providing a unique opportunity to investigate rift-related tectonics. In this framework, *Simonetti et al.* present a review of the Triassic-Jurassic geochronological and thermochronological data available for different sections of the Ivrea-Verbanò Zone and discuss their implications for Mesozoic rifting-related tectonics and processes of lower crustal extension.

Vitale et al. report the recent finding of two small bodies of fresh, pseudotachylite-bearing mantle peridotites in the San Petrone lawsonite-bearing eclogitic unit (Alpine Corsica), which represents a subducted ocean-continent transition (OCT) of the Western Ligurian Tethys. In their study, pre-

orogenic history of the peridotite and subduction-related formation of the pseudotachylites are reconstructed with the aid of petrographic, microstructural and geochemical data. The authors discuss how their new findings may have significant implications for the extent of mantle hydration in the OCTs, H₂ production and release from the slab, and the seismicity of subduction zones.

The last two papers are dedicated to geological and petrological aspects of the debated Valaisian domain in the Western Alps.

Frasca and Compagnoni review the main geological and petrological characteristics of the Lower Penninic Units representing the Valaisian basin remnants in the Italian Western Alps. In particular, a pre-subduction setting is locally well preserved (Punta Rossa Unit). The authors also report new field evidence and petrographic data on metabreccias and pillowed metabasalts from this unit along with new fossil findings, which point to a Mesozoic age for the Valaisian rifting. The new lithostratigraphic observations support formation of the investigated sequence in an ocean-continent transitional setting.

De Broucker et al. present a novel and provocative interpretation of the Versoyen Complex (French-Italian Alps), based on detailed field investigation and structural mapping in the Petit-Saint Bernard Pass area. The complex results from imbrication of four distinct structural units, which include remnants of the Valaisian ocean floor and blocks of continental provenance. According to this study, a pre-Alpine, Early Cretaceous origin in a subduction-related prism during the closure of the Valaisian Ocean is envisaged for this accretionary complex.

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