Università degli Studi di Ferrara

DOTTORATO DI RICERCA IN

"Scienze della Terra"

CICLO XXX

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Emplacement of the Middle Triassic Monzoni Intrusive Complex (Dolomites, Italy): Insights from Analogue Models and Field Observations

Settore Scientifico Disciplinare: GEO/07

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Anni 2014/2017

Acknowledgments

My time as a PhD student has been a hard but rewarding journey. I cannot believe that this moment has arrived, that I am able to present my thesis and to write down these words. Through this life-time experience, there were many people that travelled along this road with me, even if some of them far away. This thesis would not have been reached without their support and company, and for this reason I would love to dedicate my special thanks to each and every one.

First of all, I would like to thank my supervisor, Prof. Massimo Coltorti, for giving me the opportunity to start the new PhD project even if time was an enemy, for his support and guidance, for funding big part of the project and for dealing with the related formalities in crucial moments during the PhD period. I am especially grateful to Prof. Piero Gianolla, for transferring me his passion for his second home, the Dolomites, for his daily positivity and smile every time I was visiting his office, for funding big part of the project in order to teach to this Greek barbarian girl the geology (local food and grappa) of Monzoni. If I had to describe the experience collected together with Dr. Alberto Riva during the PhD related activities (fieldwork, university, lab) I would probably write a book. It has been an honour to become Alberto's first PhD student and I am deeply grateful to him for providing me with guidance and trust in this work, until the last minute. Finally, I would love to thank Prof.ssa Costanza Bonadiman for her support, the scientific directions to the study area of Monzoni and her strong belief in the potential of my work.

Furthermore, I want to express my thankfulness to the members of the HelTec-GFZ in Potsdam, for their help with the creation of the, quit many, "analogue-models" of the Monzoni Pluton. I would like to attribute special acknowledgments to Dr. Matthias Rosenau, for his warm welcome, training and introduction to the analogue modelling techniques, for providing me with his knowledge and facilities, for his constructive comments of my thesis revision and his valuable contribution to the synthesis of the related scientific manuscript. To Michael Rudolf, for guiding me through this experimental journey, Frank (the tank) Neumann for building, preparing and repairing the experimental and Thomas Ziegenhagen for his scientific support and discretion to my elevation models.

I would also love to give my special acknowledgments to Prof. Eugenio Carminati, for his guidance, the encouraging comments of the thesis revisions and for introducing me, together with Prof. Massimo Mattei to the AMS techniques and the opportunity to join them during fieldwork, to Prof.ssa Francesca Cifelli, Prof. Michele Lustrino and Hassan Abbas for their scientific assistance during the manuscript authorship and to Dr. Marcello Caggiati for his valuable scientific contribution during the field and the creation of the geological map.

Special acknowledgments I would like to attribute to the members of the Oslo University, that welcomed and offered me their lab facilities, especially to Dr. Olivier Galland, for his guidance through the experimental processes and the valuable scientific discussions, to Frank, Øystein and Tobias for their presence and effort. I am also grateful to Prof. Dimitrios Sokoutis, whom I had the great pleasure to meet during my visit to the University of Utrecht and to the Trento province for providing the permission for sampling in the UNESCO protected site of the Dolomites.

I am also thankful to the committee members Proff. Saccani, Zanetti, Nava, Conte for their attention and thorough reading and especially to Prof. Kondopoulou for her suggestions on the AMS part.

Making a PhD, makes you forget that there is also life besides the Monzoni Intrusion. Fortunately, there are family and friends making sure I was not completely loosing contact with the real world. First of all, I would love to deeply thank my parents, Grigoris and Rea, for their constant support ever since I started to pursue my dream of becoming a geologist, for believing in me and above all, for sending me during these three years boxes full of "mama's greek food", and of course my beloved sister Elsa, her husband Kostas and my little nieces Anna and Panorea, for having transmitted their positivity via Skype! I would love to give special thanks to my friends and neighbours Matteo Mancinelli and Dr Matteo Turisini, for *having shared these memorial PhD years with* me *and their endless support (even after midnight). Despite the physical distances, I am sure that even if I had to do 100 PhDs, my best friend Kostas Leptokaropoulos would still be by my side and love me as much as I do, and I thank him for this! Special thanks to my close friend Katerina, for giving me confidence and making me feel like home with her presence, to Ambra Mantovani for dedicating me her personal time and effort during the first year in Ferrara and to my friends and "yellow floor" colleagues: Beatrice, Valentina, Jack, Luca, Pierpaolo, Carmen and Edoardo for all the good times and memories. Of course, I want to thank my best friends Annemarie and Martina, for being always close and giving me their best smile in order to go on, to Sabine for her warm hospitality and generosity during my stay at her picturesque house in Potsdam, to my friends Kostis, Ilias, Voula and Susanna for all the great time we spent at GFZ and not only and to Nanna for letting me stay at her house during my visit in Oslo. Finally, I am sincerely thankful to Mattia for surrounding me with love and holding me up when I was falling during the final stages of this Ph.D.*

Σας ευχαριστώ όλους από καρδιάς

“Σα βγεις στον πηγαιμό για την Ιθάκη, να εύχεσαι νά ‘ναι μακρύς ο δρόμος, γεμάτος περιπέτειες, γεμάτος γνώσεις”.[…] Πλούσιος με όσα κέρδισες στον δρόμο, μη προσδοκώντας πλούτη να σε δώσει η Ιθάκη. Η Ιθάκη σ’ έδωσε τ’ ωραίο ταξείδι.”

Κ.Π. Καβάφη

“Ιθάκη”

“*As you set out on the way to Ithaca, may the way be long, full of adventure, full of knowledge.* […] *wealthy with all you have gained on the way, not expecting Ithaka to make you rich. Ithaka gave you the marvellous journey”*

C. P. Cavafy

“Ithaka”

Abstract

The Dolomites form the central-eastern portion of the Southern Alps, in Northern Italy. The stratigraphic framework of the Dolomitic area includes mainly Permian to Cretaceous terrains, while it is largely dominated by the magnificent Triassic carbonate platforms and basinal systems. The area of the Dolomites recorded several tectonic and magmatic events, from Permian up to Cretaceous. During the Middle Triassic transtensional tectonics, associated with differential subsidence and uplifting, the south-western part of the Dolomites has witnessed a massive and short-lived Ladinian (Middle Triassic) tectono-magmatic event, forming a series of significant magmatic features. The Monzoni, Predazzo and Cima Pape Intrusive Complexes are situated in the southwestern Dolomites and represent the main intrusive expressions of the Ladinian magmatism. This PhD project offers new insights regarding the emplacement mechanisms of the Monzoni Intrusive Complex, by combining fieldwork data and analogue models on magma emplacement.

The Monzoni pluton is located parallel to San Pellegrino Valley and appears elongated, with an NE-SW orientation, covering an area of approximately 4.0 km^2. The main characteristics of Monzoni pluton, that is the elongated shape and the shoshonitic orogenic affinity, suggest a potential correlation and emplacement control by the Triassic developing and/or reactivated inherited strike-slip structure. The generation, ascent and emplacement of Monzoni pluton and its relation to strike-slip faulting, is still a matter of debate. The lack of direct field observations attributed to the volcano-tectonic activity, keeps the mechanisms of magma–strike-slip fault interactions poorly understood.

Updated geological maps, based on field campaign data, bring new insights regarding intrusion, fault-controlled boundaries and deformational pattern of the pluton and host-rock formations. In addition, investigations on anisotropy of magnetic susceptibility (AMS) on Monzoni pluton, reveal zonation within the pluton and indicate the presence of magmatic feeder in the north-eastern part of the intrusion. Finally, the 3D modelling of the Monzoni Intrusive Complex, projecting all geological data, constrains the pluton's volume to 4.35km^3 and offers a simplified profile-view projection of the pluton/host-rock system.

The Monzoni Intrusive Complex, due to its excellent three-dimensional exposure, is particularly suited for the study of volcano-tectonic systems allowing the application

and comparison to analogue models. During this project we conducted sandbox-type analogue modelling experiments on magma emplacement along crustal scale strike-slip fault zones. We investigate two tectonic regimes, strike–slip and transtension, and three temporal relationships between magmatism and tectonics; pre-tectonic, syn-tectonic and post-tectonic intrusion. Experimental results show that there is a strong interaction between tectonic structures, evolving or inherited, and magmatism and that the geometrical characteristics of the experimental plutons represent a good indicator for the classification of plutons, defining the timing and tectonic setting of emplacement. The combination of all applied methodologies suggests magmatic emplacement in transtensional tectonic regime with two possible kinematic scenarios; a left lateral strike –slip direction along the N70° fault set or a right-lateral strike slip direction, along the N30° faults.

La messa in posto del Complesso Intrusivo Medio-Triassico dei Monzoni (Dolomiti, Italia): Approfondimenti mediante Modelli Analogici ed Osservazioni di Campagna

Riassunto

Le Dolomiti formano la parte centro-orientale delle Alpi meridionali, nel Nord Italia. L'organizzazione stratigrafica dell'area dolomitica comprende principalmente terreni dal Permiano al Cretaceo, mentre è in gran parte dominata dalle magnifiche piattaforme carbonatiche triassiche e dai relativi bacini. L'area delle Dolomiti ha registrato numerosi eventi tettonici e magmatici, dal Permiano fino al Cretaceo. Durante la tettonica transtensionale del Triassico medio, associata a subsidenza differenziale, la parte sud-occidentale delle Dolomiti è stata soggetta a un evento tettonico-magmatico Ladinico (Medio Triassico) di breve durata, sviluppando una serie di rilevanti strutture magmatiche. I complessi intrusivi di Monzoni, Predazzo e Cima Pape sono situati nelle Dolomiti sud-occidentali e rappresentano le principali espressioni intrusive del magmatismo Ladinico. Questo progetto di dottorato offre nuove conoscenze sui meccanismi di messa in posto del Complesso Intrusivo dei Monzoni, combinando dati sul campo e modelli analogici su postazioni di magma.

Il plutone dei Monzoni, che si trova parallelo alla Valle di San Pellegrino, appare allungato, con orientamento NE-SO, coprendo un'area di circa 4,0 km^2. Le principali caratteristiche del plutone dei Monzoni, la forma allungata e l'affinità shoshonitica orogenica, suggeriscono una potenziale correlazione e controllo della messa in posto da parte di strutture trascorrenti ereditate o medio-triassiche.

La generazione, l'ascesa e la messa in posto del plutone dei Monzoni e il suo rapporto con le strutture trascorrenti, sono ancora oggetto di dibattito. La mancanza di osservazioni dirette sul campo attribuite all'attività vulcano-tettonica, rende difficile la comprensione dei meccanismi di interazione tra faglie e magmatismo.

Le mappe geologiche aggiornate basate sui nuovi dati di terreno, forniscono nuove informazioni sui limiti di intrusione controllati da faglie e sul modello deformativo delle formazioni incassanti e del plutone. Inoltre, indagini su anisotropia di suscettività magnetica (AMS) sull'intrusione dei Monzoni, rivelano la zonazione all'interno del plutone e indicano la presenza di un condotto di alimentazione principale nella parte

nord-orientale dell'intrusione. Infine, la modellazione geologica 3D del complesso intrusivo dei Monzoni, coerente con i dati geologici, limita il volume del plutone a 4.35 km^3 e offre una visione - semplificata dei rapporti tra plutone e rocce incassanti.

Il Complesso Intrusive di Monzoni, grazie alla sua eccellente esposizione tridimensionale, è particolarmente adatto allo studio di sistemi vulcano-tettonici, permettendo anche l'applicazione e il confronto con modelli analogici. Durante questo progetto, sono stati condotti esperimenti di modellazione analogica di tipo sandbox, su lungo zone di taglio trascorrenti a scala crostale. Sono stati distinti due regimi tettonici, trascorrenza pura e transtensione, e tre relazioni temporali tra magmatismo e tettonica; intrusione pre-tettonica, sin-tettonica e post-tettonica. I risultati sperimentali mostrano che esiste una forte interazione tra le strutture tettoniche, in evoluzione o ereditate, ed il magmatismo e che le caratteristiche geometriche dei plutoni sperimentali rappresentano un buon indicatore per la classificazione dei plutoni, definendo i tempi e l'ambiente tettonico della messa in posto. La combinazione di tutte le metodologie applicate, suggerisce la messa in posto del plutone durante un regime tettonico transtensionale con due possibili scenari cinematici; una transtensione sinistra - direzione N70° o una transtensione destra lungo faglie N30°.

Summary

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