Proposal for the establishment of a Task Force of the

International Lithosphere Program (ILP) for 2021-2025

Continental Lithosphere: a Broadscale Investigation (CoLiBrI)

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I. Introduction

The continental lithosphere is being investigated by several geoscience disciplines; yet due to the differences inherent to the scales of the respective approaches, communication and data exchange between disciplines is below optimal. With this task force (TF), we would like to create an international platform to exchange on the structure, properties and evolution of the continental lithosphere, and especially its lower part. Our motivation is clearly field-observation based, especially on seismology and gravity, and we intend to foster discussions on petrological perspectives, laboratory data, computational modelling, and other geophysical methods as well. Our primary sites of investigation are the European Alps and surroundings (e.g., Carpathians, Pannonian Basin), which we would like to compare to other regions such as the Himalayas, Caledonides, Pyrenees and North America.

The fundaments for this TF are set by broad international cooperation projects.

The AlpArray multidisciplinary program (http://www.alparray.ethz.ch/en/home) involves 17 countries, >50 institutions, >200 researchers and >60 young scientists. Its primary mapping tool, the AlpArray Seismic Network (Hetényi et al. 2018) consisted of over 600 stations for over 2 years, collecting 15 TB of raw data. This has been and will be complemented by several additional regional passive seismic experiments (e.g., AlpArray-EASI, -CASE, -Ivrea, -LiSard, -SWATH-D, -StressTransfer; PACASE, CIFALPS-2, AdriaArray). Beyond seismological targets, answers to questions from geology *sensu lato*, gravimetry (Figure 1), geodynamics, petrology and geodynamic modelling are being investigated, which all contribute to the integrated mapping of the lithosphere.

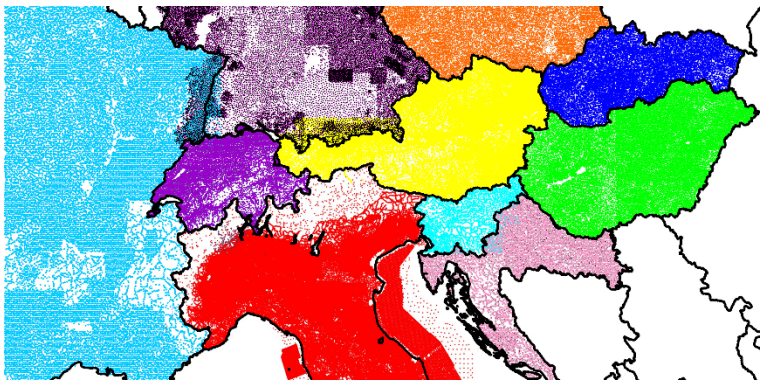

Figure 1: More than 300'000 raw, land gravity data points are being re-collected and homogeneously reprocessed to create the first pan-Alpine gravity maps, with a target resolution of 4 km. © AlpArray Gravity Research Group, 2019.

Another multidisciplinary initiative, the Drilling the Ivrea-Verbano zonE (DIVE; Pistone et al. 2017) aims to core a total of 6 km of lowermost crust and across a paleo-Moho, and to perform numerous related petrological, seismological and other geoscientific analyses. The Moho is the main physical and chemical boundary within the lithosphere, which can be better understood by studying its fine scale details. DIVE is also very well supported internationally. Geophysical and geological site surveys have been carried out at the three sites, which will provide an excellent basis to link large and small scale information (drilling is planned to start in 2021). The required synergy will combine rock physics laboratory data and modelling (e.g., V_P, V_S, density), and this is where the cross-scale interaction can start to deepen.

II. Objective

Key topics to be addressed by the here proposed TF

1. Matching structure and physical properties across disciplines

Information from new, high-resolution geophysical surveys must be interpreted using documented rock properties. For this, the necessary steps for large-scale geophysics are (i) homogeneous processing of datasets, (ii) joint inversion of several physical parameters, (iii) quantification of anisotropy (e.g., Munzarová et al. 2018), (iv) assessment of the possible range of results and uncertainties. Results can then be discussed in terms of physical, thermal, rheological properties, and numerically modelled using laboratory data on rocks. Various databases and modelling tools exist (e.g., Afonso et al. 2016), which also need to be contrasted, and variations need to be discussed. Conversely, the field geophysical results will provide new input to the interpretation of geological structures from the regional to the outcrop scale (e.g., in the Ivrea-Verbano Zone) and also on the appearance of small-scale compositional variabilities in larger scale images. Ultimately, significance has to be estimated for such multidisciplinary data and models.

2. Lithospheric discontinuities

The new field datasets provide a rich source to revisit the structure and definition of the Moho (see above) and of the lithosphere-asthenosphere boundary, a first-order structural discontinuity/transition in the Earth that accommodates differential motion between the plates and the underlying mantle. Various seismological methods provide different information, which have to be contrasted with magnetotelluric, thermal, gravimetry-based and rheological approaches – all of these then have to be discussed from a petrological perspective, including the amount and nature of fluids and their role in modifying the lithosphere. In the same attempt, other discontinuities such as the mid-lithospheric discontinuity (e.g., Karato & Park 2019) can become better characterized and understood.

3. Orogenic continental lithosphere

The European Alps and the neighbouring, broadly deforming regions are our primary focus region due to the richness of available datasets. These will allow us to create multi-disciplinary models of both the shallow (crust) and mantle parts of the lithosphere, whose present-day structural, rheological and physico-chemical characteristics are still debated. Beyond publishing new results, we would like to initiate comparative studies with the Himalayas because of the similarity of the orogenic context, and the North American continent because of the availability of dense seismological data (USArray, and forthcoming CCArray in Canada) and geological information. This will for example allow us to investigate the fate of subducted lithosphere at convergent margins from various types of seismic tomographies (including anisotropy, full waveforms) and joint inversions (e.g., receiver functions with ambient noise tomography, seismology and gravimetry).

Relation to main goals and themes of ILP

Our proposed TF fits under ILP's theme 3 "**Continental Lithosphere**". Its primary goal is to benefit from **recent**ly collected **large** field geophysical **datasets** at various scales to foster discussion between specialists of various sub-disciplines towards **integrated mapping** using modern approaches to unravel structure of Earth's crust and upper mantle, as well as **interdisciplinary** interpretation. The results will bear on **mantle dynamics** as undertaken initiatives already include such research axes. The field of application is the structure and evolution of the lithosphere in the Alpine area and comparison with other orogens.

III. Cooperation

Our research on the continental lithosphere will continue in an international and multidisciplinary frame. The primary guarantee are the existing co-operations including acquisition of new, large scale datasets, such as AlpArray and other major arrays. Further benefits through this TF will come from integrating other data, too, such as magnetotellurics, heat flow, petrological and geochemical data. Annual workshops will be realized related to these research programs, and we foresee *ad hoc* meetings at major conferences.

The primary additional activity will be the organization of two, week-long summer school *cum* conference programs, one in 2021, and one in 2024. The idea is to start with a 3-day conference aimed for scientists and young researchers (PhD, post-doc), who then stay for additional 4 days for detailed discussions and hands-on training with data (geophysical data processing, various modelling tools [petrology, geodynamics]) and research management.

In addition, throughout the years of funding, we will convene special sessions on the TF themes at major geosciences conferences under the ILP label. At one or few reasonable occasions, we aim at editing a special volume in an open access journal.

For all these activities, we will collaborate with the ILP Coordinating Committee on the Himalayas, led by M. Karplus (Univ. Texas, USA), who is amongst our TF partners.

IV. Outreach

We aim at setting up a simple yet comprehensive website for the TF activities and output. For high-school and undergraduate students, we plan to prepare educational flyers on what we know – and what we do not know – about the continental lithosphere, and its relation to plate tectonics (which is a core element of the curriculum). These flyers will be translated to several languages. We will contact school-book editorial houses for assistance in publishing.

For the *Lithospheric Discontinuities* topic, we will start our activities with a series of webinars summarizing our current understanding of what these boundaries are from various perspectives ranging across disciplines (seismology, petrology) and scales.

As a new activity, we propose *Science Café* or *Lithosphere on tap* type local outreach event, advertised through social media and arranged in a café, bar or pub near the location of a conference or university. This will be a free, public event, with an entertaining short lecture, a quiz with a prize, and hopefully good ambience between participants.

V. Key partners within this planned task force *– in alphabetical order, grouped by institute*

Almqvist, Bjarne, U. Uppsala, Sweden
Bianchi, Irene, U. Vienna, Austria
Braitenberg, Carla, U. Trieste, Italy
Cattin, Rodolphe + Tiberi, Christel, U. Montpellier, France
Chen, Yun + Liang, Xiaofeng, Inst. of Geology and Geophysics, Chinese Acad. Sci., China
Chevrot, Sébastien, U. Toulouse, France
Czuba, Wojciech, Inst. of Geophysics, Polish Acad. Sci., Poland
Dérerová, Jana + Vozár, Ján + Zahorec, Pavol, Earth Sci. Inst., Slovak Acad. Sci., Slovakia
Götze, Hans-Jürgen, U. Kiel, Germany
Handy, Mark + Tilmann[0.5], Frederik, FU Berlin, Germany
Karplus, Marianne, U. Texas El Paso, USA
Kovács, István János + Szűcs, Eszter + Wéber, Zoltán, Geodetic and Geophysical Inst., RCAES, Hungary
Kvapil, Jiří + Plomerová, Jaroslava + Vecsey, Luděk, Inst. of Geophysics, Czech Acad. Sci., Czech Republic
Manglik, Ajay, CSIR-NGRI, India
Mendecki, Maciej, U. Silesia, Poland
Molinari, Irene + Piromallo, Claudia, INGV, Italy
Nabelek, John + Trehu, Anne, Oregon State U., Corvallis, USA
Papčo, Juraj, Slovak U. of Technology, Slovakia
Paul, Anne, U. Grenoble Alpes, France
Pistone, Mattia, U. Georgia, USA
Müntener, Othmar + Scarponi, Matteo, U. Lausanne, Switzerland
Stevens, Victoria, U. Cape Town, South Africa
Tilmann[0.5], Frederik + Weber, Michael, GFZ Potsdam, Germany
Vergne, Jérôme, EOST & IPG Strasbourg, France
Webb, A. Alexander G., U. Hong Kong, Hong Kong, China
Zeyen, Hermann, GEOPS, U. Paris Sud + CNRS, France

VI. References

Afonso et al. 2016 J Geophys Res 121. doi:10.1002/2016JB013049
Hetényi et al. 2018 Surv Geophys 39:1009-1033. doi:10.1007/s10712-018-9472-4
Munzarová et al. 2018 Geophys J Int 215:524-545. doi:10.1093/gji/ggy296
Karato & Park 2019 AGU Geophys Monogr Series. doi:10.1002/9781119249740.ch1
Pistone et al. 2017 Sci Drill 23:47-56. doi:10.5194/sd-23-47-2017

Curriculum vitae chair and co-chairs

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Education & professional experience
Ecole Normale Supérieure, Paris, France: MSc (2004), **PhD (2007)** with Chancellery award
U. Leeds, United Kingdom: post-doc (2008)
ETH Zürich: post-doc (2008-2011), senior scientist (2011-2015)
Responsibilities
AlpArray coordination team, AlpArray Seismic Network manager
Drilling the Ivrea-Verbano zonE (DIVE), co-PI
Seismology at school in Nepal, PI
Editor at Acta Geophysica et Geodetica
Le Référentiel Géologique de la France, scientific council
5 recent key publications by the proponent relating to the proposed TF
Hetényi et al. (2018a): The AlpArray Seismic Network – a large-scale European experiment to image the Alpine orogen. Surv Geophys. link
Hetényi et al. (2018b): From mountain summits to roots: Crustal structure of the Eastern Alps and Bohemian Massif along longitude 13.3°E. Tectonophys. link
Pistone, Müntener, Ziberna, Hetényi, Zanetti (2017): Report on the ICDP workshop DIVE (Drilling the Ivrea-Verbano zonE). Sci Drill. link
Hetényi et al. (2016): Segmentation of the Himalayas as revealed by arc-parallel gravity anomalies. Sci Rep. link
Nábělek, Hetényi et al. (2009): Underplating in the Himalaya-Tibet Collision Zone Revealed by the Hi-CLIMB Experiment. Science. link

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Education & professional experience
Department of Geophysics, Faculty of Mathematics and Physics, Charles University, Czech Republic: BSc (2009), MSc (2011), **PhD (2019)** in seismology, supervised by J. Plomerová
Institute of Geophysics, Czech Academy of Sciences: Research assistant (2007-2011); PhD student (2011-2019); Post-doc (2019-)
Institute of Geophysics, ETH Zürich: Research assistant (with E. Kissling) (2013)
Research interests
Earth upper mantle structure; Anisotropy of seismic wave velocities; Seismic tomography
5 recent key publications by the proponent relating to the proposed TF
Munzarová et al. (2018a): Novel anisotropic teleseismic body-wave tomography code AniTomo to illuminate heterogeneous anisotropic upper mantle: Part II - Application to data of passive seismic experiment LAPNET in northern Fennoscandia. GJI. link
Munzarová, Plomerová, Kissling (2018b): Novel anisotropic teleseismic body-wave tomography code AniTomo to illuminate heterogeneous anisotropic upper mantle: Part I – Theory and inversion tuning with realistic synthetic data. GJI. link
Chyba, Plomerová, Vecsey, Munzarová (2017): Tomography study of the upper mantle around the TESZ based on PASSEQ experiment data. PEPI. link
Plomerová, Munzarová, Vecsey, Kissling, Achauer, Babuška et al. (2016): Cenozoic volcanism in the Bohemian Massif in the context of P-and S-velocity high-resolution teleseismic tomography of the upper mantle. Gcubed. link
Munzarová, Plomerová, Babuška, Vecsey (2013): Upper-mantle fabrics beneath the Northern Apennines revealed by seismic anisotropy. Gcubed. link

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Education & professional experience

Comenius University Bratislava: BS (1974), MS (1976), **PhD (1980)**, DrSc (2002) Assoc. Prof. (2005), Prof. (2010)
Visiting professor at Paris (2006), Copenhagen (2001), Cairo (1989).
Bilateral cooperation with: U. Kiel, U. Paris Sud, U. Uppsala, Oregon State U., U. Columbia
International course organization and teaching (Alpine gravity field, Archaeo-geophysics)

Responsibilities

Head of the Department of Applied and Environmental Geophysics, 2005-2011
Vice-dean for Research and Foreign Relations 2011-present
Supervisor of Applied Geophysics in degrees of Bachelor, Magister and PhD study programs
National Council of IUGG (secretary: 1994-2012, president: 2014-2017, member: 2017-)
Editor at 5 different peer-reviewed journals (1985-present)

5 recent key publications by the proponent relating to the proposed TF

Šimonová, Zeyen, Bielik (2019): Continental lithospheric structure from the East European Craton to the Pannonian Basin based on integrated geophysical modelling. T-phys. link
Pánisová et al. (2018): Intraplate volcanism in the Danube Basin of NW Hungary: 3D geophysical modelling of the Late Miocene Pásztori volcano. Int J Earth Sci. link
Šefara, Bielik et al. (2017): 3D density modelling of Gemeric granites of the Western Carpathians. Geologica Carpathica. link
Alasonati Tašárová, Fullea, Bielik, Sroda P (2016): Lithospheric structure of Central Europe: Puzzle pieces from Pannonian Basin to Trans-European Suture Zone resolved by geophysical-petrological modeling. Tectonics. link
Grinč, Zeyen, Bielik, Plašienka (2013): Lithospheric structure in Central Europe: Integrated geophysical modeling. J Geodyn. link

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Education & professional experience

U. Nacional de la Patagonia San Juan Bosco, Comodoro Rivadavia: MSc (2002) with award
Carleton U. Ottawa: **PhD (2006)** with University medal
Inst. of Earth Sci. Jaume Almera, Barcelona, Spain: post-doc (2007-9)
Macquarie U.: lecturer (2009-14), senior lecturer (2014-5), assoc. prof. (2016-8), prof. (2018-)
U. Oslo, Centre of Excellence for Earth evolution and Dynamics: adj. prof. (2016-)

Responsibilities

Head of the Geophysics and Geodynamics group, Dept. Of Earth Sci. Macquarie U.
Organizer of various symposia (Lithosphere-Asthenosphere, Prague 2016; EMCG Adelaide 2014,6)
Editor at Geophysical Journal International, EGU Solid Earth
EGU Division Officer, Geodynamics division (2009-2012)

5 recent key publications by the proponent relating to the proposed TF

Afonso et al. (2019): A global reference model of the lithosphere and upper mantle from joint inversion and analysis of multiple data sets. GJI. link
Afonso et al. (2016, 2013, 2013): 3D multi-observable probabilistic inversion for the compositional and thermal structure of the lithosphere and upper mantle *[trilogy]*:
-III (2016): Thermochemical Tomography in the Western-Central US. JGR. link
-II (2013): II: General methodology and resolution analysis. JGR. link
-I (2013): I: a priori information and geophysical observables. JGR. link
Afonso, Zlotnik, Diez (2015): An efficient and general approach for implementing thermodynamic phase-equilibria information in geophysical and geodynamic studies. Gcubed. link