



Proposal for the establishment of a Task Force of the International Lithosphere Program (ILP) for 2021-2025

DEFORMATION AND MAGMATIC PROCESSES FROM THE LITHOSPHERE TO THE SURFACE: INTEGRATED MULTIDISCIPLINARY APPROACHES

Leaders: Alessandro Tibaldi (University of Milan Bicocca, Italy), Agust Gudmundsson (Royal Holloway University of London, UK), Greg Waite (Michigan Technological University, USA)

1. Introduction

This proposal represents a request for prolongation of the activities carried out by the previous Task Force II, updated by taking into account the most recent advancements in volcanotectonics. Volcanism is one of the more complex geological processes on Earth, as it involves the generation of magma in the mantle or lower crust, its ascent, stopping, arrest, or eruption at the surface (Gudmundsson, 2002; Gudmundsson et al., 2014). Understanding how magma opens its way to the surface or arrests, and how host rocks are deformed during intrusions, is key to better understanding the volcanic threats posed to society, which has become more and more vulnerable to volcanic impacts over the last decade (e.g.: 2010 eruption of Eyjafjallajökull volcano in Iceland). This is mainly due to the rapid demographic development and to modern society's technological dependency (Wilson et al., 2014). The way in which magma moves and evolves through the lithosphere determines whether it will erupt or not; all these processes are extremely complex and their investigation cannot be undertaken by a single group of experts, as it requires a wide array of multidisciplinary studies that combine techniques and concepts from various disciplines. Intrusive, volcanic, and related structural processes have traditionally been studied separately, but in recent years they are increasingly considered as a single system; this bears important implications for the study of lithospheric processes, the formation of mineral deposits associated with siliceous magmas, the formation and dynamics of geothermal reservoirs and, last but not least, for volcanic hazard and risk assessment (Tibaldi et al., 2005). The proposed Task Force has its roots in the consolidated network of scientists from all over the world who have been cooperating, under ILP's umbrella during the last 10 years (Cloething et al., 2012, 2018); besides, the present proposal aims to further expand this network in order to incorporate new, leading-edge techniques that have been developing lately, and to foster the involvement of young researchers. This ILP project aims to promote a discussion forum about the present state of knowledge of tectonic and magmatic processes. Through these efforts, we

also intend to contribute to better defining the most effective techniques and data necessary to enhance our understanding of volcanic hazards.

2. Objectives

This project focuses on the study of four key topics that correspond to the main steps of magma upwelling: magma ascent, magma chamber emplacement, stoping/halting, and eruption. The first step is related to the ascent of magma from the source region through the lithosphere. The second step is the accumulation of magma in deep or shallow reservoirs where crystallisation may lead to formation of plutons, the third step is the process in which magma gradually works its way upward by breaking off and engulfing blocks of the country rock, or comes to a halt due to various causes. The fourth step is the very shallow magma upwelling that brings to volcanic eruptions.

It is broadly accepted that these steps of the magma mass transfer process are closely related to tectonic activity, i.e. the relative motions of lithospheric plates and their effects (Solomon, 1978; Gudmundsson, 1986; Cembrano and Lara, 2009). On the other side, the intrusive and upwelling magma processes can induce deformation of the country rocks (Tibaldi, 1996; Tibaldi et al., 2013). This deformation can be detected, once it becomes shallow (crustal), representing a formidable tool to detect an impending eruption. Each of these specific issues constitutes the topic of important geological, geophysical, geochronological, structural and experimental studies. Although the connection between the discussed aspects is indisputable, their complexity makes very difficult to address them jointly, unless by favouring the dialogue between various scientists with diverse skills and improving our multidisciplinary network.

The new techniques that appeared in the very last years, in fact, require to expand collaboration and networking, with a holistic view especially dedicated to propose new joint national and international projects. These new techniques are: Machine learning, Artificial Intelligence, Virtual Reality (Gerloni et al., 2019), field and aerial Structure from Motion (Bonali et al., 2019), X-rays and similar techniques applied to analogue modelling (Fedorik et al., 2019), and more sophisticated 3D numerical modelling (Beaussier et al., 2019). The present Task Force wants to include and merge these new techniques together with a robust approach to data collection by classical methodologies, above all, field geology, physical volcanology, structural geology, seismology, geophysical exploration, geochronology, and geochemistry. We will spend our efforts to improve future investigations by linking multiple research approaches and technologies.

2.1 Key topics to be addressed by the here proposed TF

More in detail, the action will focus on the following key topics: 1) relations between geodynamic stress field and magma processes; 2) characterisation of mechanism of interactions between magma and host rock within intermediate parts of the plumbing system (lower-upper crust); 3) characterisation of the parameters that guide the structure and dynamics of the shallower part of the plumbing systems (first few kilometres); 4) analyses of the surface deformations induced by magma upwelling in different tectonic scenarios; 5) study of the mechanisms that lead to the arrest of ascending magma or to eruption; 6) definition of the relationships between the above processes and the eruptive style, magnitude and intensity of eruptions, eruptive scenarios and associated hazards; 7) recognition of eruption precursors and improvement of monitoring actions.

To contribute to these specific key topics, our teams will use integrated field and laboratory works. Geophysical and geochemical monitoring tools provide a variety of information that needs to be interpreted as magma movement and/or as interaction of magma with host rocks. Similarly, intensive thermodynamic variables (e.g. P, T and composition) are recorded in the texture and composition of erupted products that can be better understood by a combination of petrological and

physical volcanological methods. Deformation accompanying active volcanic areas can be analysed by seismology and related techniques, and compared with shallow deformation detected by field geological structural studies and monitoring instruments, such as GPS, interferometry, etc. Surface magma-related deformations can be also studied by modern new techniques such as drone surveys with aerial Structure from Motion techniques, as well as automatic classification of structures by Machine Learning and Artificial Intelligence. A combination of all these approaches can lead to a terrific advancement in the understanding of magma and lithospheric dynamics. An involvement in this Task Force of scientists who are expert in volcano surveillance, may improve our forecasting capability.

The main deliverables of the project will be a set of conceptual models on magma ascent and storage in the lithosphere, which will consider the coupling between host rock and magma in different tectonic settings, and will try to explain in a quantitative way the preparation of a new eruption.

The novelty of the project lies on the fact that we propose to study Earth magmatism from a joint and global perspective, rather than from the point of view of each expert or scientific interest. This joint approach will allow us to contribute to the understanding of the relationships among all the physico-chemical and thermo-dynamic processes and the tectonic control affecting magma upwelling or arrest. This approach will provide a global perspective in relation to lithospheric dynamics, and a better understanding of intrusive-volcanism relations.

2.2 Relation to main goals and themes of ILP

ILP offers the perfect framework for this project, as ILP “*seeks to elucidate the nature, dynamics, origin and evolution of the lithosphere through international, multidisciplinary geoscience research projects and coordinating committees*”. Processes such as tectonism, magmatism and volcanism are all themes classically developed under the umbrella of ILP. These also are among the main themes of the IUGG and of the IUGS. These themes will be here studied with emphasis on their inter-relations. Key sites will be selected from most of the continents, representing all the possible geodynamic settings. Hence, we believe that the objectives here proposed address practical problems that involve two of the four main program themes of the ILP, notably: *Geodynamics and Deep Processes*, and *Continental Lithosphere*. At the same time, this project will also foster mutual cooperation between IUGS, IUGG and IAVCEI. The expected benefits of the project are mostly scientific as it addresses a basic research aspect, but we envisage also significant societal benefits as the results obtained will be applied to improve our ability to forecast volcanic eruptions and, consequently, to reduce volcanic risks. This project is international, really interdisciplinary, and inter-institutional. It will promote basic and applied science, providing results of worldwide significance and applicability.

3. Cooperation

3.1 Structure and management

The leader of the project, Prof. Alessandro Tibaldi, will be in charge of establishing the cooperation among the whole network of scientists, and will coordinate the researches especially dealing with the geological-structural aspects, analogue modelling, and the new techniques of ML, AI, and drone surveys. The co-Leader Prof. Agust Gudmundsson will lead the group of scientists more dealing with numerical modelling, and intrusive vs eruptive processes. The co-Leader Prof. Greg Waite will coordinate all the researches especially dealing with geophysics.

3.2 Events, activities, and time-frame

We propose a five-years Task Force project, during which the three coordinators will foster collaboration and exchange of ideas and data among the participants. As any other ILP project, the present one will promote networking tools, emphasising in particular the celebration of a

series of thematic workshops on the different scientific topics included in the project, training schools addressed to young researchers on the different scientific disciplines covered by the project, short-term scientific missions, and dissemination activities. We envisage the following main activities:

1st year: Start-up meeting by Skype with the coleaders and selected participants (one for each main involved institute). Data collection from key sites; analogue and numerical modelling of the various phenomena. Set up of a website dedicated to the project. Organization of sessions at the EUG, IUGG and AGU meetings. Preparation of joint research projects.

2nd year: Data collection; improvements to modelling. Meeting in Milan with co-Leaders of this TF for coordination and verifying of advancements. Publication of results. Website updating. Organization of sessions at IAVCEI Scientific Assembly and other Earth Science meetings. Workshop and training school in summer. Preparation of joint research projects.

3rd year: Field data collection within an expanded international co-operation; improvements to modelling. Publication of a special issue on an international journal. Website updating. Organization of sessions at the EUG, AGU and other meetings. Workshop and training school in summer. Preparation of interdisciplinary research projects.

4th year: Data collection and modelling within an expanded international cooperation. Publications. Updating and maintenance of the website. Session organisation at various meetings. Preparation of interdisciplinary research projects.

5th year: Data collection and modelling within an expanded international cooperation. Publication of a special issue on an international journal. Updating and maintenance of the website. Concluding workshop possibly with the simultaneous presence of other task Forces (a joint ILP-TF meeting).

4. Outreach

The previous Task Force II has had a long experience in outreach activities, with several articles published on newspapers, television interviews, organization of public events aimed at Earth Science popularization. The Leader, Alessandro Tibaldi, has already engaged in a number of outreach activities: For example, the organization of a yearly event of science popularisation, during which University labs and classrooms are kept open during the late afternoon and evening (meetmetonight - <http://www.meetmetonight.it/>); moreover, he has taken care of the organization of a stand at the EGU conference (under the umbrella of EGU's Outreach Committee), which has been planned also for next year, where Immersive Virtual Reality techniques are showcased for volcanotectonic research. Tibaldi is also involved in the production of a scientific documentary for the international television network FOCUS (shooting is planned for June 2020). The documentary, devoted to illustrating the processes that take place at an oceanic divergent margin, will be filmed at various sites along the Iceland emerged ridge. Further outreach activities are carried out by GeoSocial - Science&Media, an Earth Science communication organization, of which Tibaldi is one of the founders; the GeoSocial team keeps a website (<http://www.geo-social.net/>), which is periodically updated through the publication of brief, geoscience-related news articles targeted to the lay public.

Finally, information on the activities of this TF will be disseminated by the new dedicated website; an example of the website created in the framework of previous TF II can be seen at: <http://www.ilptaskforce2.unimib.it/>

5. Key partners within the planned TF

Participant	Institution	Country	Group of work
Alessandro Tibaldi Andres Folguera Federico Pasquaré Mariotto	University of Milan Bicocca Universidad de Buenos Aires Insubria University	Italy Argentina Italy	Field structural geology

Alexandru Szakács Tatiana Izquierdo Andrey Korzhenkov Derek Rust	Sapientia University Universidad de Atacama Russian Academy of Sciences University of Portsmouth	Romania Chile Russia UK	and tectonics
Fabio Bonali Valerio Acocella Oliver Galland Benjamin Van Wyk de Vries	University of Milan Bicocca Rome 3 University Oslo University Université Auvergne Blaise Pascal	Italy Italy Norway France	Analogue modelling
Fabio Bonali August Gudmundsson Kyriaki Drymoni	University of Milan Bicocca The Royal Holloway Royal Holloway Univ. London	Italy UK UK	Numerical modelling
Ulrich Harms Alessandro Cavallo Maria Luce Frezzotti Paola Del Carlo Sergio Rocchi Antonio Castro	Potsdam, GFZ University of Milan Bicocca University of Milan Bicocca INGV-Pisa University of Pisa University of Huelva	Germany Italy Italy Italy Italy Spain	Petro-chemistry and rheology of magmas
Greg Waite Jurgen Neuberger Andrea Rovida Andrey Koryenkov Gulam Babayev Lauren Schafer Joel Ruch Federica Lanza Susanna Falsaperla Maria Manousaki David Rushton Otar Varazanashvili Nino Tsereteli Elena Russo	Michigan Tech. Univ. University of Leeds INGV-Milan Institute of Geology Geology Inst. of Azerbaijan Michigan Tech. Univ. University of Geneva ETH Istituto Naz. Geofisica Vulcanologia Earthquake Planning and Prot. Org. Fugro Geos limited-Wallingford Tbilisi State University Tbilisi State University University of Milan Bicocca	USA UK Italy Russia Azerbaijan USA Switzerland Switzerland Italy Greece UK Georgia Georgia Italy	Seismology and interpherometry
Fakhraddin Kadirov Joachim Gottsmann Greg Waite Aleksey Smirnov Simon Carn Jaume Pous Birgt Müller Victor Alania Rafiq Safarov Samir Mammadov	Nat. Academy of Sciences University of Bristol Michigan Tech. Univ. Michigan Tech. Univ. Michigan Tech. Univ. University of Barcelona Karlsruhe Institute of Technology Tbilisi State University Geology Institute ANAS Geology Institute ANAS	Azerbaijan UK USA USA USA Spain Germany Georgia Azerbaijan Azerbaijan	Geophysics GPS
Malcolm Whitworth Alexander Strom John Gierke Thomas Oommen Paolo Oppizzi	University of Portsmouth Institute of Geology Michigan Tech. Univ. Michigan Tech. Univ. Geolog.ch	UK Russia USA USA Switzerland	Geological engineering
Armann Hoskuldsson Páll Einarsson Ásta Rut Hjartardóttir Ioan Seghedi Bill Rose Luis Lara Lauren Schaefer	University of Iceland Haskoli Islands University Haskoli Islands University Sapientia University Michigan Tech. Univ. SERNAGEOMIN University of Canterbury	Iceland Iceland Iceland Romania USA Chile New Zealand	Volcanology and related hazard assessment
Federico Pasquaré Mariotto Benjamin Van Wyk de Vries	Insubria University Université Auvergne Blaise Pascal	Italy France	Communication and outreach activities
Paraskevi Nomikou	University of Athens	Greece	

Aikaterini Karditsa Cesare Corselli	Hellenic Oceanographers Ass. University of Milan Bicocca	Greece Italy	Marine geology
V. Antoniou Dimitrios Papanikolaou Giuseppe Vizzari Stefania Bandini Danilo Reitano Ugo Becciani Filomena Solitro	University of Athens University of Athens University of Milan Bicocca University of Milan Bicocca INGV INAF Altecspace	Greece Greece Italy Italy Italy Italy Italy	Virtual Reality-Drones Artificial Intelligence Machine Learning

6. Cited references

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- Bonali, F. L., Tibaldi, A., Marchese, F., Fallati, L., Russo, E., Corselli, C., & Savini, A. (2019). UAV-based surveying in volcano-tectonics: An example from the Iceland rift. *Journal of Structural Geology*, 121, 46-64.
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Curriculum vitae chair and co-chair(s)

CV Task Force Leader

Prof. Alessandro TIBALDI, Ph.D.

CURRENT POSITIONS

- **Full Professor** (since 2017) of “Structural geology”, “Neotectonics and volcano-tectonics”, and “Field mapping”, at University of Milan-Bicocca, Italy;
- Since 2010: **Ad-hoc Graduate Faculty**, Dept. Geological/Mining Engineering and Sciences, Michigan Technological University, USA.

CONTACTS

Address: Department of Earth and Environment Sciences, University of Milan-Bicocca, Milan, Italy; e-mail: alessandro.tibaldi@unimib.it, tel. 0039 0264482052; Web-site: <http://www.geo.unimib.it/>

Languages: English (fluent, written and spoken), Spanish (fluent, written and spoken), Italian (mother tongue).

EDUCATION & PROFESSIONAL EXPERIENCES

Education

- 1985 Msc Degree in Geological Sciences, University of Milan;
- 1990 PhD in Earth Sciences, University of Milan Bicocca;
- 1991 Post-PhD fellowship of National Institute of Geophysics, Rome, Italy.

Previous positions

- 2010-2017 Visiting Professor at Buffalo – New York State University, USA;
- 2008-2017 Erasmus Professor at Portsmouth University, United Kingdom;
- 2006-2007 Erasmus Professor at Brunel University, United Kingdom;
- 2000-2016 Associate Professor, University of Milan-Bicocca;
- 1993-1999 Researcher, University of Milan;

Publications

h-index 37 (Google Scholar), **h-index 31** (Scopus); **Papers on peer reviewed international journals:** 161; **Scientific books:** 4; International Books & Encyclopedia Chapters: 13.

Editorships

- Since 2019 **Editor** of Bulletin of Volcanology;
- Since 2015 **Associate Editor** of Frontier in Earth Sciences, Structural Geology and Tectonics;
- Since 2015 **Review Editor** of Frontier in Earth Sciences, Volcanology;
- 2012 **Guest Editor** (together with Sierd Cloetingh) of Journal Global and Planetary Change, Special issue: “From the lithosphere to the surface: processes, hazards and resources”;
- 2006 **Guest Editor** (together with A.F.M. Lagmay) of Journal of Volcanology and Geothermal Research, Special issue: “Interaction Between Volcanoes and Their Basement”.

Honors & Awards

- 2007, **Elsevier Award** for the “2003-2007 most cited paper on Tectonophysics”;
- 2000 “**A. Volta Award**” for Scientific Researches in European and extra-European mountain belts;
- 1999-2012, **Fellows** of the “Institute for Dynamics of Environment Processes”, National Council of Researches;
- 1991 “**Edward A. Flinn Award**” of the International Lithosphere Program;
- 1988 “**M. Oxilia 1987-1988 Award on the Geology and Structure of the Alps**”, Geological Society of Italy.

RESPONSIBILITIES

Coordination of organizations

- Since 2015 **Chairperson - Committee of National Representatives of International Lithosphere Program**;
- 2005-07 **Member of the Italian National Committee** of coordination of all monitoring activities and Italian research projects on active volcanoes under the INGV – Civil Protection Agency agreement;

2005-07 Coordinator of all monitoring and researches at Stromboli and Panarea volcanoes, **Civil Protection Agency – INGV**;
2002-04 Vice-Director of CUDAM - University of Milan Bicocca Dating Center.

Coordinator of Research Grants

2019-21 **European Union**, Program Horizon 2020, NEANIAS project; 2018-20 **European Union**, Program ErasmusPlus KA2, “Bringing the 3D-world into the classroom” (<http://3dtelc.lmv.uca.fr/>); 2015-19 **International Lithosphere Program, Task Force II** “Structural and rheological constraints on magma migration, accumulation and eruption through the lithosphere”; 2016-17 **MIUR** Law 113/91 D.D. 1524/08-07-2015 T4, “Agreement University of Milan Bicocca - Consortium Cometa for the evaluation of leading-edge interactive technologies for improving teaching and popularization of science”; 2016 **European Space Agency**, n. 32309, “Active tectonics and seismic hazard of southwest Caucasus by remotely-sensed and seismological data”; 2015-18 **NATO - Science for Peace**, n. G4934, “Risks to the Enguri hydropower infrastructure in Georgia and their security implications”; 2013-15 **MIUR-National Program Antarctic Research**: “Origin and dispersion of volcanic ashes in the austral hemisphere: a data base for volcanology, chronostratigraphy and palaeoclimate of Earth System”; 2013-14 **European Union** Intensive Program Erasmus: “Integrating field classical and new methodologies for geological hazard assessment and communication”; 2010-14 **International Lithosphere Program**: Task Force II “Volcanoes and society: environment, health and risk”; 2009-14 **Transatlantic project USA-EU Atlantis**: “International collaboration and teaching in Volcanology and Engineering geology”; 2008-10 **NATO - Science for Peace**: “Geo-environmental security of the Toktogul hydroelectric power station region, central Asia”; 2009 **MIUR - Internationalisation of Research**: “Earth Sciences for renewable energetic resources: Italy-Argentina”; 2006-07 **MIUR**: “Structure of the Nisyros (Greece) resurgent caldera”; 2005-09 **International Lithosphere Program**: Task Force II “New tectonic causes of volcano failure and possible premonitory signals”; 2003-05 **NATO-CLG**: “A multidisciplinary approach to recent geologic catastrophes at subduction zones”; 2003-04 **MIUR**: “Structure of Cotopaxi volcano (Ecuador) and past collapses”; 2003-04 **National Civil Protection - Stromboli volcano emergency**: “Analysis of magma paths and dykes”; 2001-05 **International Geological Correlation Program**: “Effects of basement structural and stratigraphic heritages on volcano behaviour and human activities (n. 455)”; 2001-04 **FIRB-MIUR**: “Volcano lateral collapses and mineral resources”; 2000-07 **GNV**: “Lateral collapses at Stromboli Volcano”; 1998-02 **National Geological Survey-CNR**: “Prototype geological map of Stromboli Volcano”; 1996-2000 **CNR**: “Reconstruction of neotectonics for seismic hazard in the Southern Andes of Colombia”.

5 RECENT KEY PUBLICATIONS BY THE PROPONENT RELATING TO THE PROPOSED TF

Bonali FL, A Tibaldi, F Marchese, L Fallati, E Russo, C Corselli, A Savini, 2019. UAV-based surveying in volcano-tectonics: An example from the Iceland rift. *Journal of Structural Geology*, 121, 46-64.

Tibaldi A. and FL Bonali, 2017. Intra-arc and back-arc volcano-tectonics: Magma pathways at Holocene Alaska-Aleutian volcanoes. *Earth-Science Reviews*, 167, 1-26.

Russo E, GP Waite, A Tibaldi, 2017. Evaluation of the evolving stress field of the Yellowstone volcanic plateau, 1988 to 2010, from earthquake first-motion inversions. *Tectonophysics*, 700, 80-91.

Tibaldi A, FL Bonali, C Corazzato, 2017. Structural control on volcanoes and magma paths from local-to orogen-scale: The central Andes case. *Tectonophysics*, 699, 16-41.

Tibaldi A, FL Bonali, FA Pasquaré Mariotto, 2016. Interaction between transform faults and rift systems: a combined field and experimental approach. *Frontiers in Earth Science*, 4, 33.

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EDUCATION & PROFESSIONAL EXPERIENCES

I have an MSc in Structural Geology and Rock Mechanics from Imperial College London and a PhD in Tectonophysics from Imperial College London (University of London). Previously I was research professor of Volcanology at the Nordic Volcanological Institute, University of Iceland, then professor and Chair of Hydrogeology of Solid Rocks at the University of Bergen (Norway), and before I took up my present position, Head of Department and Chair of Structural Geology and Geodynamics at the University of Gottingen (Germany). I have worked much on the relations between seismotectonics, volcanotectonics, and associated hazards and risks, but also on landslides and related topics. In particular, I have participated in many European projects on seismic and volcanic risk. The book *Volcanotectonics: Understanding the Structure, Deformation, and Dynamics of Volcanoes* (co-author Valerio Acocella) published in 2016 by Cambridge University Press, focuses on the physics and hazards of volcanoes, their eruptions, deformation, and earthquakes. An earlier book, *Rock Fractures in Geological Processes*, also published by Cambridge University Press, covers the field of brittle deformation with emphasis on fracture mechanics and fluid transport with application to fractured and porous rocks.

I have extensive experience in field studies of volcanoes, faults zones, and fluid-filled reservoirs of various types, as well as in analytical and numerical modelling of geological structures and processes. In particular, I have worked for many years on groundwater aquifers and geothermal reservoirs. In addition to my work on energy sources such as conventional hydrocarbon reservoirs and geothermal reservoirs, I have in recent years, in collaboration with colleagues at EPFL, explored the relations between various geometric aspects of the built environment (urban areas) and energy demand, CO₂ emissions, and the potential for solar energy.

I am a fellow of the Iceland Academy of Sciences and an elected member of Academia Europaea (the European Academy of Sciences, Humanities and Letters).

RESPONSIBILITIES

I am Chief Editor of the journal *Frontiers in Structural Geology and Tectonics* and Associate Editor of *Terra Nova*, *Bulletin of Volcanology*, *Frontiers in Volcanology*, and *Scientific Reports*.

I am also on the editorial board (Review Editor) of *The Scientific World Journal*, *Tectonophysics*, and *Journal of Volcanology and Geothermal Research*.

Reviewer for: *Nature*, *Nature Geoscience*, *Science*, *Science Advances*, *Geology*, *Journal of Geophysical Research*, *Tectonics*, *G-cubed*, *Geophysical Research Letters*, *Earth and Planetary Science Letters*, *Bulletin of the Geological Society of America*, *International Journal of Earth Sciences*, *Journal of Structural Geology*, *Journal of Geodynamics*, *Pure and Applied Geophysics*, *Geophysical Journal International*, *Theoretical and Applied Fracture Mechanics*, *Journal of Geophysics and Engineering*, *International Journal of Geographical Information Science*, *Journal of African Earth Sciences*, *Sustainability*, *Engineering Fracture Mechanics*, *Computers & Geosciences*, *Geosphere*, and others.

Reviewer of grant applications for: NERC, NSF, National Geographic, The Iceland Science Foundation, The Swiss National Science Foundation (SNSF), The French National Science Foundation (ANR), The Norwegian Science Foundation, AXA, and others.

Appointed advisor to the Scientific Advisory Board for Emergencies (SAGE), Government Office for Science, in connection with risks associated with the 2014-2015 Bardarbunga-Holuhraun eruption.

Frequently interviewed on radio, by newspapers, and on television in connection with volcanic eruptions and earthquakes. In particular, several interviews on Sky News.

Provide 'educational material' on volcanic eruptions for bodies such as 'Discover the World Education', particularly on volcanic eruptions.

5 RECENT KEY PUBLICATIONS BY THE PROPONENT RELATING TO THE PROPOSED TF

Alshehri, A. & Gudmundsson, A., 2019, Thermal mapping of the 2009 dyke emplacement at Harrat Lunayyir, Saudi Arabia. *Arabian Journal of Geosciences*. 12, p. 1-18, 602.

Assouline, D., Mohajeri, N., Gudmundsson, A. & Scartezzini, J-L., 2019. A machine learning approach for mapping the very shallow theoretical geothermal potential. *Geothermal Energy*. 7, p. 1-50, 19.

Bazargan, M. & Gudmundsson, A., 2019. Dike-induced stresses and displacements in layered volcanic zones. *Journal of Volcanology and Geothermal Research*. p. 1-45.

Scudero, S., De Guidi, G. & Gudmundsson, A., 2019. Size distributions of fractures, dykes, and eruptions on Etna, Italy: Implications for magma-chamber volume and eruption potential. *Scientific Reports*. 9, p. 1-9, 4139.

Karaoglu, O., Browning, J., Bazargan, M. & Gudmundsson, A., 2016. Numerical modelling of triple-junction tectonics at Karliova, Eastern Turkey, with implications for regional magma transport. *Earth and Planetary Science Letters*, 452, p. 157-170.

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EDUCATION & PROFESSIONAL EXPERIENCES

Professional Preparation

St. Norbert College De Pere, WI Mathematics BA, 1996
University of Utah Salt Lake City, UT Geophysics MS, 1999
University of Utah Salt Lake City, UT Geophysics PhD, 2004
US Geological Survey Menlo Park, CA Mendenhall Postdoctoral Fellow 2004-2007

Appointments

2013-Present Associate Professor, Michigan Technological University, Houghton MI
2018 Affiliate Scientist, US Geological Survey Hawaiian Volcano Observatory
2007-2013 Assistant Professor, Michigan Technological University, Houghton MI
2004-2007 Mendenhall Postdoctoral Fellow, US Geological Survey, Menlo Park, CA

RESPONSIBILITIES

- Developed and continuing to deliver a laboratory about the energy radiated from volcanic eruptions. The experiment highlights the interdisciplinary nature of Earth science and the utility of quantitative data. By instrumenting a liquid nitrogen volcano with accelerometers and recording the explosion with an array of microbarometers, we calculate physical parameters related to the explosion.
- NSF CAREER award in 2011 to promote teaching, outreach, and interdisciplinary research on volcano dynamics. I coordinated fieldwork at open-vent volcanoes Fuego and Pacaya in Guatemala, together with the Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología, which is tasked with monitoring Guatemalan volcanoes and assessing hazards. Among the goals of this work is increased hazard mitigation capacity through improved use of existing monitoring equipment.
- Led week-long workshop for formal and informal educators during summer 2014 on the geology and geophysics of the Mid-continent Rift System. Objective was to embolden educators in Midwest states with skills to teach about geophysics and applications to tectonic history of N. America.
- Recognized as the Michigan Technological University Outstanding Graduate Faculty Mentor for the 2012-2013 academic year.

5 RECENT KEY PUBLICATIONS BY THE PROPONENT RELATING TO THE PROPOSED TF

Avouris, D.M., S.A. Carn, and G.P. Waite (2017), Triggering of volcanic degassing by large earthquakes, *Geology*, 45(8), 715-718, doi:10.1130/G39074.1.

Waite, G.P., and F. Lanza (2016), Nonlinear inversion of tilt-affected very long period records of explosive eruptions at Fuego volcano, *Journal of Geophysical Research: Solid Earth*, 121, doi:10.1002/2016JB013287.

Medici, E.F., J.S. Allen, and G.P. Waite (2014) Modeling shockwaves generated by explosive volcanic eruptions, *Geophysical Research Letters*, 41, 414-421, doi:10.1002/2013GL058340

Waite, G.P., P.A. Nadeau, and J.J. Lyons (2013), Variability in eruption style and associated very-long-period events at Fuego volcano, Guatemala, *Journal of Geophysical Research*, 118, 1526-1533, doi:10.1002/jgrb.50075.

Nadeau, P. A., J. L. Palma, and G. P. Waite (2011), Linking volcanic tremor, degassing, and eruption dynamics via SO₂ imaging, *Geophysical Research Letters*, 38, L01304, doi:10.1029/2010GL045820.