frontiers | Frontiers in Earth Science

TYPE Editorial
PUBLISHED 21 November 2022
DOI 10.3389/feart.2022.1092337

Check for updates

OPEN ACCESS

EDITED AND REVIEWED BY
Michel Grégoire,
UMR5563 Géosciences Environnement Toulouse (GET), France

*CORRESPONDENCE
W. P. Leeman,
Leeman@rice.edu

SPECIALTY SECTION
This article was submitted to Petrology, a section of the journal Frontiers in Earth Science

RECEIVED 07 November 2022
ACCEPTED 09 November 2022
PUBLISHED 21 November 2022

CITATION
Leeman WP, Agostini S, Barnes JD, Li H-Y, Marschall HR and Ryan JG (2022), Editorial: Fluid-mobile element tracers of subduction processes—the record in volcanic arc magmas and exposed subduction complexes. *Front. Earth Sci.* 10:1092337.
doi: 10.3389/feart.2022.1092337

COPYRIGHT
© 2022 Leeman, Agostini, Barnes, Li, Marschall and Ryan. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Editorial: Fluid-mobile element tracers of subduction processes—the record in volcanic arc magmas and exposed subduction complexes

W. P. Leeman[1]*, S. Agostini[2], J. D. Barnes[3], H.-Y. Li[4], H. R. Marschall[5] and J. G. Ryan[6]

[1]Department of Earth and Environmental Science, Rice University, Houston, TX, United States, [2]Istituto di Geoscienze e Georisorse, Consiglio Nazionale delle Ricerche, Pisa, Italy, [3]Department of Geological Sciences, Jackson School of Geosciences, University of Texas at Austin, Austin, TX, United States, [4]State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry (GIG) and Chinese Academy of Sciences (CAS), Guangzhou, China, [5]Institut für Geowissenschaften, Goethe Universität, Frankfurt, Germany, [6]Department of Geology, University of South Florida, Tampa, FL, United States

KEYWORDS

subduction, fluid-mobile elements, volcanic arcs, slab contributions, mantle evolution

Editorial on the Research Topic
Fluid-mobile element tracers of subduction processes—the record in volcanic arc magmas and exposed subduction complexes

Subduction zones occur where tectonic plates converge, and underthrust lower plate materials are recycled back into the Earth's mantle. Modern subduction zones are associated with distinctive magmatic activity that produces volcanic arcs (e.g., the Pacific "Ring of Fire") and associated intrusive complexes. Subduction-related magmatic processes commonly are viewed as contributing to the formation of continental crust over geologic time. Thus, knowledge of how subduction zones work is fundamental to understanding important aspects of Earth's evolution, including how and to what extent recycling of subducted materials (e.g., oceanic crust and sediments) over time has affected the composition of the Earth's mantle. An important direct source of such information comes from investigations of 1) magmatic and fluid outputs in volcanic arcs, and 2) exposed sections of uplifted subduction terranes, including relict fragments of ancient slabs.

Extensive literature on modern volcanic arcs supports the contention that involvement of subducted H_2O plays a dominant role in determining the compositions of most arc magmatic suites. However, the diversity of magma types found in volcanic arcs suggests that other factors may be important (cf. Leeman, 2020). For example, to what extent is the nature of arc magmatism controlled by competing tectonic processes (e.g., subduction erosion), *versus* variations in compositions of slab-derived contributions to arc magma sources (cf. Agostini et al., 2008; Marschall and Schumacher, 2012; Codillo et al., 2018; Barnes et al., 2019; Straub et al., 2020; Li et al., 2021)?

This special issue focuses on physical and chemical processes associated with subduction, with emphasis upon the record that can be deduced directly from magmatic products in modern volcanic arcs, and from subduction-related rocks and associated fluids, that may be reflective of the fluid and material contributors to arc magma source domains. Such information provides an essential foundation upon which realistic petrogenetic and physical models can be further developed and evaluated. Specifically, how are magmatic sources established, and what processes are involved? What tools effectively track the role of H_2O and other volatiles through the arc magmatic cycle, from source to eruption? In detail, what is the interplay between subducted fluids and volatiles (directly, *via* hydrous minerals, or *via* melts) and other material components that contribute to the production and evolution of arc magmas? Importantly, how and to what extent are these components extracted from subducted materials and/or adjacent mantle domains (cf. Morris et al., 1990; Ryan and Chauval, 2014; Sugden et al., 2019; Straub et al., 2020)?

Considering the spectrum of magma types seen overall in volcanic arcs (cf. Schmidt and Jagoutz, 2017), a first-order question regards whether they represent melts of compositionally distinct source domains, or are they to some extent products of evolutionary processes (e.g., differentiation, contamination, etc.). And, if the latter, to what extent are arc magmas modified during their ascent and/or storage? Papers in this collection address aspects of this issue.

Wei et al. focus on relatively evolved high-K calcalkalic type dacites from Meiji Atoll, that are interpreted to represent partial melts of lower continental crust of the South China block in response to Paleo-Pacific subduction during Triassic time. Crustal melting is attributed to intrusion of and underplating by subduction-related mafic magmas. This is a common theme in many modern arcs.

Cooper and Inglis utilize Fe isotopic data (δ^{56}Fe) to evaluate formation of magmas from two Lesser Antilles volcanic centers (Martinique and Statia) in terms of both sub-arc mantle source heterogeneity and potential modifying effects of crustal processes (differentiation, mixing, contamination, etc.). In this case, plutonic xenoliths were investigated to more directly ascertain processes occurring in the magmatic plumbing systems as well as crustal heterogeneities. It is concluded that magmatic processes in the sub-arc crust can overprint and/or distort source variability in δ^{56}Fe inherited from sub-arc mantle sources. Decoupling between Fe isotopes and radiogenic isotopes suggests that the former are not sensitive to crustal and/or sediment assimilation.

Bouvier et al. focus on the utility of Cl isotope data for melt inclusions (MIs) from Stromboli volcano. δ^{37}Cl values are found to correlate with bulk compositional variations of the MIs, and suggest mixing between two distinct magmatic compositions: 1) high-K alkali basalt attributed to melting of an amphibole-bearing mantle source, and 2) evolved shoshonitic melt enriched in a sediment-derived component. This approach potentially can help address sources of heterogeneity in arc magmas in general.

Atlas et al. look in detail at compositional variability of sediment packages along the Lesser Antilles arc and the extent to which spatial differences may be reflected along the volcanic chain. Trace element compositions of the arc magmas appear to correlate significantly with spatial variations in the nature of sediments on the subducting plate. Thus, they conclude that varied enrichments of fluid-mobile elements (FMEs) and large-ion lithophile elements (LILE) in the arc lavas reflect lateral differences in relative contributions of subduction components from north to south.

Selles et al. describe temporal evolution of lavas of Nevado de Longavi (NLV) volcano (S. Chile Andes). Here, the Mocha Fracture Zone (MFZ)—a significant oceanic transform fault—potentially supplies an anomalously high fluid flux. Obliquity of the MFZ to the plate convergence vector results in its southward migration beneath NLV during the past 1.2 Ma. Secular variations at NLV in concentrations of FMEs, H_2O content, and oxygen fugacity reflect the waxing and waning proximity of the MFZ—with involvement of serpentine-derived fluids and sediment-derived melts, presumably products of H_2O-flux melting. This work indicates that influx of slab-derived fluids can be effective over relatively short timeframes.

Ribeiro et al. address potential relations between temporal arc magmatic activity and climate in the Izu arc. Assuming that dehydration and/or melting of subducting slabs controls decarbonation and carbonate dissolution, they use trace element slab-fluid markers (e.g., Ba/Th, Cs/Th, etc.) as proxies for variation in slab-derived CO_2 captured by arc magmas. For Izu basaltic lavas, such proxy ratios suggest relative steadiness in outgassed CO_2 outputs over the past 40 Ma. These results indicate that the contribution of island arcs to long-term climate changes are minimal given that steady state CO_2 arc outputs are likely balanced by chemical weathering and tectonic erosion.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Agostini, S., Ryan, J. G., Tonarini, S., and Innocenti, F. (2008). Drying and dying of a subducted slab: Coupled Li and B isotope variations in western anatolia cenozoic volcanism. *Earth Planet. Sci. Lett.* 272 (1-2), 139–147. doi:10.1016/j.epsl.2008.04.032

Barnes, J. D., Cullen, J. C., Barker, S., Agostini, S., Penniston-Dorland, S., and Lassiter, J. C., (2019). The role of the upper plate in controlling fluid-mobile element (Cl, Li, B) cycling through the Hikurangi forearc, New Zealand. *Geosphere* 15, 1–17. doi:10.1130/GES02057.1

Codillo, E. A., Roux, L., de, V., and Marschall, H. R. (2018). Arc-like magmas generated by mélange-peridotite interaction in the mantle wedge. *Nat. Commun.* 9, 2864. doi:10.1038/s41467-018-05313-2

Leeman, W. P. (2020). Old/new subduction zone paradigms as seen from the Cascades. *Front. Earth Sci. (Lausanne).* 8, 535879. doi:10.3389/feart.2020.535879

Li, H. Y., Zhao, R. P., Li, J., Tamura, Y., Spencer, C., and Stern, R. J., (2021). Molybdenum isotopes unmask slab dehydration and melting beneath the Mariana arc. *Nat. Commun.* 12, 6015. doi:10.1038/s41467-021-26322-8

Marschall, H. R., and Schumacher, J. C. (2012). Arc magmas sourced from mélange diapirs in subduction zones. *Nat. Geosci.* 5 (12), 862–867. doi:10.1038/ngeo1634

Morris, J. D., Leeman, W. P., and Tera, F. (1990). The subducted component in island arc lavas: Constraints from Be isotopes and B-Be systematics. *Nature* 344, 31–36. doi:10.1038/344031a0

Ryan, J. G., and Chauvel, C. (2014). "The subduction-zone filter and the impact of recycled material on the evolution of the mantle," in *Treatise on geochemistry*. 2nd Ed. (Amsterdam, Holland: Elsevier), 479–508.Chap. 3.13.

Schmidt, M. W., and Jagoutz, O. (2017). The global systematics of primitive arc melts. *Geochem. Geophys. Geosyst.* 18, 2817–2854. doi:10.1002/2016gc006699

Straub, S. M., Gómez-Tuena, A., and Vannucchi, P. (2020). Subduction erosion and arc volcanism. *Nat. Rev. Earth Environ.* 1, 574–589. doi:10.1038/s43017-020-0095-1

Sugden, P. J., Savov, I. P., Agostini, S., Wilson, M., Halama, R., and Meliksetian, K. (2020). Boron isotope insights into the origin of subduction signatures in continent-continent collision zone volcanism. *Earth Planet. Sci. Lett.* 538, 116207. doi:10.1016/j.epsl.2020.116207