

Metasomatism in Oceanic and Continental Lithospheric Mantle*

The generation of magmas and fluids at various depths in the Earth, their role in shaping the interior/exterior of our planet, and their unmistakable record in mantle specimens are topics that have come of age. Investigations of mantle melting have evolved from simple documentation of compositions of terrestrial materials to field and laboratory experiments for determining the controls on such melting processes. Natural specimens have allowed us to quantify melting processes in the mantle, and we have made unprecedented progress in understanding mantle metasomatism. Simply put, mantle metasomatism is a consequence of melt/fluid flow through the mantle, which results in melt–rock and fluid–rock interaction. The subject matter of the volume edited by Coltorti and Grégoire, mantle metasomatism has received widespread attention in the literature on orogeny, ophiolites, and xenoliths.

The editors have compiled 14 contributions on mantle metasomatism. The volume begins with an excellent synopsis by **Coltorti and Grégoire**, two geologists who have devoted a large part of their careers to understanding mantle melting. The lead article, by **Piccardo**, summarizes research in Alpine geology and addresses Jurassic Alpine ophiolites. Lithospheric extension and passive upwelling caused mantle melting, and MORB-type melts reacted with the overlying peridotite. The paper concludes with a model consisting of accretion and melting. **Ishimaru and Arai** discuss calcic amphiboles in mantle-wedge spinel peridotites from the Kamchatka region. Since the reequilibration temperatures of the xenoliths are in the 900–1000°C range, tremolite must have formed during retrogression, after high-temperature metasomatism. The authors suggest that the melt responsible for metasomatism was derived from a siliceous and sulphur-bearing subducting slab. **Ntaflos and coworkers** describe recrystallized spinel peridotite xenoliths from the Viliga volcanic area in Russia. Bulk-rock rare earth element (REE) concentrations are elevated, and owing to the lack of similar enrichment in clinopyroxene, the authors conclude that intergranular fluids/melts are responsible for the bulk-rock REE signature. Model calculations indicate that 2–15% melting is required for the observed REE concentrations. On the basis of geochemistry, **Seghedi and coauthors** infer that an unusual lamproite from Romania was derived from melting of a garnet harzburgite that was preconditioned by alkaline melts. **Orejana and Villaseca** describe pyroxenite xenoliths, from lamprophyres and diabases of the Spanish Central System, containing Ti-bearing phlogopite and pargasite-kaersutite series amphiboles. They suggest that metasomatism was due to the influx of carbonated, siliceous, or hydrous fluids/melts, perhaps derived from the fractional crystallization of a primary, carbonated, hydrous, alkaline magma. Melt–rock interaction may have caused high radiogenic Nd isotope concentrations in the metasomatized xenoliths. **Galán and others** discuss spinel peridotite, harzburgite, and pyroxenite xenoliths hosted in alkaline, mafic lavas from Spain and conclude that, prior to at least two episodes of cryptic metasomatism, melt was extracted from these rocks. Metasomatism related to both siliceous and carbonatitic fluids/melts affected mainly harzburgites. **Demény and colleagues** describe the major element and isotope compositions of amphibole, biotite, pyroxene, and feldspar from gabbros and basalts at La Palma, Canary Islands. A Sr isotope ratio in amphibole similar to that of average mantle and the stable isotope compositions of pyroxene and amphibole suggest their derivation from Earth's mantle. On the other hand, meteoric water affected the isotope compositions of biotite and feldspar. Based on hydrogen isotopes, the authors propose the involvement of a mantle plume. **Touron and others** discuss spinel peridotite and harzburgite xenoliths from the Massif Central (France). Trace element concentrations and O–Sr–Nd isotope data from clinopyroxene and amphibole suggest variable degrees of metasomatism and melt extraction in the mantle.

Perinelli and coauthors discuss petrography and mineral chemistry of spinel peridotite xenoliths from the Hyblean plateau, Sicily. Melt has been extracted from these xenoliths, which also show evidence of cryptic metasomatism. The authors conclude that the rocks interacted with alkaline silicate and hawaiite-like melts and that the temperature conditions were not consistent with a thermal plume. **Ismail and others** describe amphibole-bearing spinel harzburgites and rare lherzolites and wehrlites from a volcanic province in Syria. They propose

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that carbonated silicate melts, during interaction with the rocks, evolved to highly carbonated liquids. **Beccaluva and others** describe reaction textures and metasomatic overprinting in spinel lherzolite xenoliths (enclosed in alkali basalt–hawaiite lavas) from Libya. Similar trace element concentrations in bulk rocks and clinopyroxene suggest enrichment due to melt invasion. The specimens record long-term isotope depletion and HIMU-type (that is, high U/Pb) chemistry. The authors dismiss a mantle plume origin for the observed features.

Perinelli and colleagues discuss experiments at elevated pressures and temperatures. To explore melt–rock interaction, melanephelinites from Antarctica were reacted with lherzolite and wehrlite. The most significant chemical changes occur in clinopyroxene, olivine, and spinel, leading the authors to conclude that the perpetrator melt modified its own chemistry during reaction with the crystalline assemblage during the experiments. **Bonadiman and others** describe mantle peridotite xenoliths from two localities in Scotland. On the basis of the isotope composition of clinopyroxene from one location, the authors infer metasomatism by a melt derived from a subducted slab consisting of altered oceanic crust and some sediment. The geochemistry of clinopyroxene from the second location suggests interplay between kimberlitic and carbonatitic melts. In the final contribution, **Ashchepkov and others** use mineral-chemical data from xenoliths/xenocrysts and previously calibrated experiments to formulate four new monomineralic thermobarometers: jadeite-diopside, garnet, Cr-spinel, and ilmenite. Based on these, the authors propose that the sections above and below a ubiquitous pyroxenite layer in Yakutian mantle are, respectively, fertile and depleted. The observations are explained by melt-percolation processes.

This well-written book is illustrated with numerous color photographs, and simple tables are included in several chapters. Some chapters have black-and-white illustrations that work well. The book is 361 pages long, hard bound, and hefty, and appears to be free of typographical errors. However, the book also has a number of shortcomings. For example, most of the melt–rock reaction scenarios reflect a divorce between major and minor elements. Although major element data are presented, the models are based almost entirely on trace elements. In one chapter, the authors propose that carbonatitic fluids/melts involved in metasomatism evolve from alkaline silicate parent magmas, while in the next chapter, exactly the opposite – alkaline silicate daughter melts produced from carbonatitic parents – is preferred. Therefore, the proposed modes of metasomatism, in various guises, are mutually contradictory. Although the book is supposedly devoted to both continental and oceanic mantle, about 85% of the contributions focus on the former. Surprisingly, the book lacks contributions on mantle melting and phase equilibria, as well as on experimental studies of the genesis of hydrous fluids, carbonatitic melts, their interaction with different lithologies in the mantle in various tectonic settings, the record of melts/fluids entrapped in diamonds, and the effect of metasomatism on the fabric of mantle specimens. For geologists who are not members of the Geological Society, the book, at £90, is expensive.

My criticisms do not imply that the book is not good and not worth purchasing. The compilation is a valuable, detailed documentation of case studies and includes introductory paragraphs in several chapters. Every geology library should have a copy, and the book will be of use to graduate students, postdoctoral fellows, and teachers/professors of geochemistry and petrology.

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