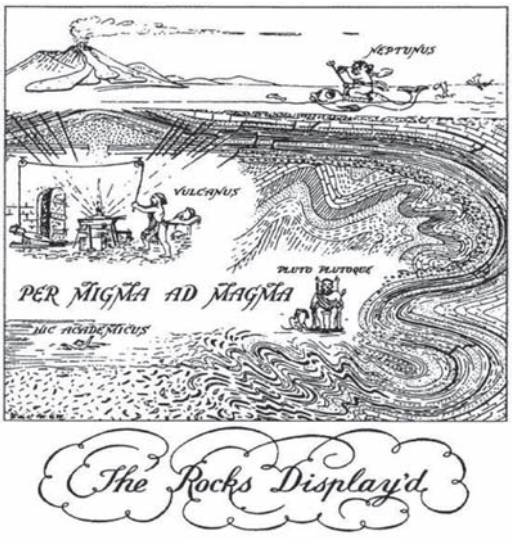
MIGMA VERSUS MAGMA

John W. Valley

Much has been written about the great Granitization Controversy of the mid-twentieth century and of the Neptunist–Magmatist conflict, 150 years earlier. In one, granites were proposed to be metamorphic rocks and in the other, sedimentary.

The idea that most granites formed without melting seems strange today, but it held great sway among geologists for over 100 years. In truth, evidence abounds in high-grade metamorphic terrains for small-scale granitization. Granitizers went further, however, and asserted that entire granitic plutons form in this manner and that they could not be intrusive because of "the room problem." Related controversies questioned the genesis of migmatites, anorthosites, granulites, and mafic fronts, to name but a few. There are current analogies in the study of pegmatites, as this issue of *Elements* describes.

This year marks the 100th anniversary of N. L. Bowen's first experimental work (Bowen 1912), and it offers an opportunity to reflect on how laboratory studies, once scorned as "peering into little crucibles," have emerged as the final arbiter of these and other scientific questions. Bowen, the greatest experimental petrologist ever, was driven by the need to understand fundamental processes responsible for the diversity of igneous rocks. There are a number of fine reviews of his career (e.g. Eugster 1980; Young 1998, 2003), but the original work deserves our attention. The reader of Bowen's papers is rewarded by glimpses of a humorous and lively mind, in addition to lucid and insightful accounts of his experiments. While best known for experiments, Bowen also spent a great deal of time in the field. He wrote forcefully about the implications of experiments for magmatic processes and equally clearly about what



Frontispiece of *The Granite Controversy*, by H. H. Read (1957), drawn by D. A. Walton. This cartoon portrays both the Neptunism and Granitization theories, whereby granites were interpreted as sedimentary or metamorphic rocks and only volcanic systems were considered igneous. Reproduced with permission from Elsevier

was denied. Where a less skillful writer might have said, "My opponents invoke magic," Bowen famously contended (Bowen 1928, p. 282): "To many petrologists a volatile component is exactly like a Maxwell's demon; it does just what one may wish it to do." The riposte was both apt and prophetic. At the time, he was concerned with the effect of fluid on the liquid line of descent of a magma and not, as the quote might suggest, with the hydrothermal formation of granite. But two decades later, Bowen's attention was fixed on granitization and the subsolidus formation of batholiths. In his GSA Presidential Address, Bowen (1947, p. 264) teased: "The difference between a pontiff [magmatist] and a soak [granitizer] is that the latter must have his liquor in lavish quantities on nearly all occasions, but the former handles his liquor like a gentleman." Magmatists had no problem with small-scale hydrothermal replacement, but they contended that the time and energy constraints for fluids to replace a body the size of the Sierra Nevada Batholith were unreasonable, as is the disposal problem for the generated wastes. Bowen likewise dismissed dry granitization, based on the slow rates of diffusion demonstrated by zoned phenocrysts, dryly noting that, as proposed, "the whole process of dry diffusion is nothing, if not versatile" (Bowen 1948, p. 84). The experimental verification that diffusion is too slow to form a batholith came after Bowen's death. Backed up, as they were, by comprehensive study, such quips of satire are welcome departures from the dry norms of scientific writing today, where the life-juices have been boiled off by diligent editing. The subsolidus formation of granite plutons didn't lose favor, however, until Tuttle and Bowen (1958) used a newly developed cold-seal hydrothermal apparatus, which allowed high-pressure hydrous melting experiments, to show that granites form magmatically both by fractional crystallization and by partial melting. Not all of Bowen's ideas have stood the test of time, but the number of times he was right, sometimes in conflict with general geological opinion, is remarkable, as is his legacy in establishing the importance of experimental petrology, synthesized with studies in the field and theory.

As for granitic pegmatites, their genesis continues to be debated. They are similar to granites in major element chemistry and quartzofeldspathic mineralogy, but in textures and in some trace elements or minor minerals they are very different. Pegmatites are clearly related to the crystallization of granitic magma, but are they late differentiates, and hence igneous rocks, or are they precipitated by subsolidus fluids, and hydrothermal? If magmatic, what are the temperature, composition, and role of fluids? What combination of intensive and extensive parameters controls the diversity of pegmatites? Some of the answers are provided in this issue of *Elements*.

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ABOUT THIS ISSUE

Since my MSc days, when I grappled with uraniferous pegmatites of the Grenville Province, pegmatites have been dear to my heart, so I am delighted that we have an issue on the topic. In my student days, we learned that pegmatites crystallized over a long time from a very liquid magma, hence the large size of their crystals. Well, current thinking, as outlined in this issue, is that pegmatites crystallized from an undercooled viscous magma in a matter of days. How about that for a 180 degree turn?

As David London argued in his proposal to *Elements*, pegmatites and their amazing textures and large crystals are an excellent way to attract students to the study of rocks and Earth science. That pegmatite formation has a bearing on the origin-of-granites debate will also be much appreciated.

Interestingly, four of the authors in this issue have had minerals named after them: David London, Skip Simmons, Petr Černý, and Federico Pezzotta. We have chosen to illustrate the minerals named after them—londonite, simmonsite, černýite, and pezzottaite—in the top right-hand corner of four of the articles. And, of course, all of these minerals were discovered in pegmatites.

FOLLOW-UP TO THE FUKUSHIMA ISSUE

The Story behind the Fukushima Issue

Shortly after the Fukushima Daiichi nuclear accident, the editors approached Rod Ewing to write a breaking-news piece, which was published in our June 2011 issue. While he was working on this piece, the idea of publishing an issue on the situation at Fukushima one year later germinated, and Rod Ewing and Takashi Murakami agreed to be the guest editors.

On a similar path, the organizers of Goldschmidt 2011 (Prague) reacted swiftly by adding a full-day special plenary session entitled "Fukushima Review." This was a remarkable feat considering the short lead time, and the European Association of Geochemistry is commended for its leadership. Rod Ewing was among the experts approached by the organizers to suggest potential contributors. This plenary session was a key factor in scouting authors for the thematic issue of *Elements*. In fact Guest Editor Takashi Murakami invited many of the authors right after the plenary session, and all lead authors in the Fukushima issue except one were presenters at that session. We therefore acknowledge with thanks the contribution of the EAG and the organizers and chairs of the plenary session, Mitsuru Ebihara, then president of the Geochemical Society of Japan, Bernard Bourdon, president of the European Association of Geochemistry, and Bernard Marty, chair of the Organizing Committee of the 2011 Goldschmidt Conference, to this thematic issue.

Investigation Commission Report Published

Shortly after we published the June issue, the Fukushima Nuclear Accident Investigation Commission published its official report. It makes for fascinating and sobering reading. The report can be downloaded at http://naiic.go.jp/wp-content/uploads/2012/07/NAIIC_report_lo_res2.pdf. This commission, made up of 10 members, was established by an act of the Japanese parliament and was given free rein and access to any document it requested. Members of the Commission conducted public hearings and interviewed hundreds of refugees. The hope of the Commission is that its findings, gathered in just 6 short months, will be useful to the Japanese people and to the rest of the world.

EDITORIAL MEETING AT GOLDSCHMIDT 2012

Elements' editors met on Sunday, June 24, and welcomed Trish Dove, incoming principal editor 2013–2015, who was able to attend part of the meeting.

Because we now receive more proposals that we can slate, we discussed altering the way we will deal with proposals in the future. From now on, when we receive a proposal (or an idea for a proposal), we will work with the proposers to ensure that their proposal is in a format acceptable for *Elements*. However, we will not slate proposals right away. Rather, at our annual meeting, we will choose the six top proposals from among all those we have on hand, of course keeping in mind the need to have a good mix of mineralogy, petrology, and geochemistry topics. Proposals not slated will, with the proposer's approval, be reconsidered the following year.

From left to right, Tim Drever, John Valley, Georges Calas, and Pierrette Tremblay. Photo: Barb Dutrow

Our lineup for 2013 is now complete, and a list of titles (provisional) and guest editors is shown below. You can download a preliminary version of our 2013 preview, which will be published in our December issue, at www.elementsmagazine.org.

- **February – 100 Years of Geochronology**
  Daniel J. Condon (British Geological Survey, UK) and Mark Schmitz (Boise State University, USA)
- **April – Serpentinites**
  Stéphane Guillot (Observatory of Earth Science Grenoble, France) and Keiko Hattori (University of Ottawa, Canada)
- **June – The Mineral–Water Interface: Where Minerals React with the Environment**
  Christine V. Putnis (University of Münster, Germany) and Encarnación Ruiz-Agudo (University of Granada, Spain)
- **August – Continental Crust at Mantle Depths**
  Jane A. Gilotti (University of Iowa, USA)
- **October – Nitrogen in the Geosphere**
  Gray Bebout (Lehigh University, USA), Marilyn Fogel (Geophysical Laboratory, USA), and Pierre Cartigny (Institut de Physique du Globe de Paris, France)
- **December – Garnet: Common Mineral, Uncommonly Useful**
  Ethan Baxter (Boston University, USA), Mark Caddick (Virginia Tech, USA), and Jay Ague (Yale University, USA)

On behalf of the editorial team
Pierrette Tremblay, Managing Editor

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