SOMETHING OLD IS SOMETHING NEW

1811-5209/16/0227-$0.00 DOI: 10.2113/gselements.12.6.379

Patricia Dove

Dear friends. This final issue of *Elements* for 2016 marks the end of my term as a Principal Editor.

Looking back, my tenure finishes near to where it began—with a focus on mineral–water interfaces (*Elements*, "Mineral–Water Interactions," v9n3, 2013). A recurring theme throughout the current issue is that chemical reactions at mineral surfaces likely had a role in sparking what we now experience as complex living systems. Indeed, mineral–water interfaces may reside at the heart of the ultimate scientific question—"What is the origin of life on Earth?"

We may never fully know the answer. However, advances in our knowledge of crystalline and amorphous solid–water interfaces and the molecular properties of solutions give reasons to be optimistic that we can gain a much deeper understanding.

Why make such a claim? High-resolution imaging techniques, such as in situ TEM, high-energy X-rays, and PEEM are producing an explosion of novel insights into mineral and solution structures and reactions that occur at their interface. Of particular interest is the prevalence of diverse small particles. From molecules to oligomers and nanocrystals, particles are present ... well ... *everywhere*. Our colleagues, Jillian Banfield (University of California, Berkeley, USA), Michael Hochella Jr. (Virginia Tech, USA), Lia Addadi (Weizmann Institute of Science, Israel), and many others, have demonstrated the abundance of small particles in every environmental compartment on Earth. Their ubiquity raises the question, touched upon in this issue, of whether the surface energy contributions of these smallest particles were a driver in the onset of prebiotic organization. Given the nonequilibrium interactions of particles with water, ions, and organic molecules, the answer could be a game-changer.

Other fields are showing that insights from high-resolution methods are already providing a broader understanding of mineral–water interfaces and low-temperature crystal growth. To put this into context, a crowning achievement of the mineralogical community over the past century was to establish a deep understanding of crystalline material structures and *properties* through detailed characterizations of "finished products." This expertise is why the synthetic materials disciplines continue to rely upon crystallographers and crystal chemists. Indeed, the connections between the mineralogical and materials disciplines are seen in the original vision statement of *Elements* magazine.

Lagging behind these advances in crystallography was an understanding of the *processes* by which minerals form, particularly from solutions. This knowledge required experimental and theoretical capabilities that were previously unavailable. The late Robert Berner (1935–2015) is often credited with attempting to bridge this chasm by introducing the concepts of classical crystal growth physics to the geochemical community. The classical theories are rooted in studies by Burton, Cabrera, and Frank and refer to the attachment of individual ions or atoms to the terraces, ledges, or kinks of mineral surfaces (Burton et al. 1951). This thermodynamic model provided a process-based framework for understanding crystal growth in natural and synthetic systems but was based upon assumptions that apply to a relatively narrow range of conditions. It was never intended to describe all types of mineralization.

In the meantime, nonclassical crystal growth processes were recognized but remained unappreciated beyond the domain of colloid chemistry. Amorphous and crystalline particles were known to interact by a multistep pathway to form crystals, but a mechanistic understanding was limited by inferences from measurements of indirect properties, such as solution composition and turbidity.

We have now come full circle. With the advent of the high-resolution experimental and theoretical methods mentioned previously, the field of colloid chemistry was transformed seemingly overnight into the nanomaterial and biomaterial disciplines that we know today. At first glance, it would also seem that these disciplines had uncovered a novel idea: diverse materials and minerals can form by particle assembly. It captures the imagination to consider that crystals, including those with faceted habits, can grow by the aggregation and sometimes-oriented assembly of nanoparticles to form synthetic and biological minerals.

But not so fast. We should pause and be humbled by the fact that crystal growth by particle attachment was first proposed during the 18th and 19th centuries. Unbeknownst to much of the world, Russian crystallographers were publishing penciled illustrations of crystal growth by the coalignment of submicron particles into macroscopic crystalline structures (see Ivanov et al. 2014). Moreover, these pioneering Russians understood, at least conceptually, that the surface charge distribution on particle faces must play a role in driving oriented particle–particle interactions.

With the secret life of particles finally being revealed, one might ask, "Are new insights into mineral–water interfaces almost finished?" I would argue, "No!" Right before us, something old is giving rise to something very new. We may be witnessing an advance in our understanding of how the Earth works that will rival the way history now views plate tectonics.

As the molecular details of particle interactions emerge—with solutes, organics, and each other—I expect that we will see these concepts explain some of the long-standing enigmas in the Earth and planetary sciences. The origin of

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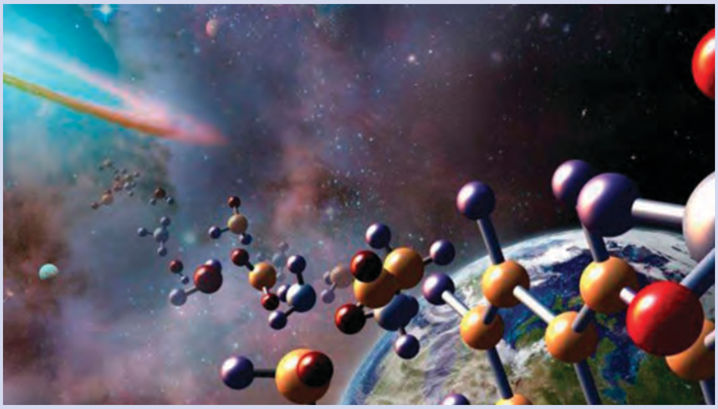
ABOUT THIS ISSUE



How did life arise from inorganic molecules? Did it develop in an early Earth primordial soup or was there an extraterrestrial source? Although the answer to the origin of sentient life has yet to be discovered by scientists, the origins of the genetic blueprints for life (e.g. RNA), the workhorses of life (e.g. proteins), and the protective membranes for life (e.g. lipids) are rapidly being uncovered. But, making the basic building blocks is only the first step. The next steps involve converting those molecules into viable cells. Believe it or not, geoscientists are needed to help uncover the answers to these questions because abiogenesis requires chemical, biological, and geological considerations. We hope the articles in this issue help introduce you to this exciting field of research.

2017 PREVIEW AND FUTURE ISSUES

Our lineup is complete through 2017 (see our preview for 2017 on pages 382 and 383), but there is so much more to cover. If you have ideas for a thematic issue, contact one of our principal editors and submit a proposal for our consideration at our mid-April 2017 editorial meeting. At that time, we will be setting our lineup for the first half of 2019. More information about publishing in *Elements* can be found at elementsmagazine.org/publish-in-elements/.

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life? Possibly. You will see connections as you read this issue. The early Earth? Likely. For example, we may finally resolve enigmas of the Proterozoic—that somewhat unusual interval of Earth history characterized by massive deposits of carbonate, sulfate, and iron sediments having textures and compositions that are rarely, if ever, found again in the geological record. And the modern Earth? Definitely. A mechanistic picture of particle-based processes will improve our ability to interpret and manage urgent environmental challenges.

The coming decade promises to be ever more exciting as scientific discovery marches forward. I wish you godspeed in being part of all that lies ahead.

Patricia M. Dove, Principal Editor

Burton WK, Cabrera N, Frank FC (1951) The growth of crystals and the equilibrium structure of their surfaces. Philosophical Transactions of the Royal Society of London Series A 243: 299-358

Ivanov VK, Fedorov PP, Baranchikov AY, Osiko VV (2014) Oriented attachment of particles: 100 years of investigations of non-classical crystal growth. Russian Chemical Reviews, 83: 1204-1222.

In our final issue of 2016, we like to take a moment to extend our appreciation to the guest editors and authors who contributed to the six issues of volume 12. These men and women succeeded at writing compelling articles for *Elements*' scientifically diverse audience and in adhering to the journal's deadlines and guidelines. We also thank our feature editors (Ian Parsons, Penelope King, Michael Wiedenbeck, Cari Corrigan, David Vaughan, and Andrea Koziol) who volunteer their valuable time to produce the Parting Shots, A Life in Science, The *Elements* Toolkit, Cosmo*Elements*, Mineralogy Matters, the Calendar, and People in the News. We also acknowledge the reviewers, our copy-editor Patrick Roycroft, and our graphic artist, who diligently work in the background to bring *Elements* to life.

In addition, we thank our advertisers for their continued support. In the day and age of digital media, these advertisers have invested in a print publication to reach you! Please take the time to speak with their representatives about their products and services. Those that advertised in 2016 were Analab, Australian Scientific Instruments, Cambridge University Press, CAMECA, Crystal Maker, Elemental Scientific, Excalibur Minerals Corporation, Geological Society of London, Gemological Institute of America (GIA), The Geochemist's Workbench, International Center for Diffraction Data, International Kimberlite Conference, International Mineralogical Association, IsotopX, National Electrostatics Corporation, Overburden Drilling Management, PanAnlytical, *Periodicio Mineralogia*, ProtoXRD, Rigaku, Savillex, Selfrag, Society for Geology Applied to Mineral Deposits, TofWerk, and Wiley. Special mention goes to **Australian Scientific Instruments**, **CAMECA**, **Excalibur Minerals Corporation**, **The Geochemist's Workbench**, ***Periodicio Mineralogia***, **ProtoXRD**, **Savillex**, and **Selfrag** who advertised in each issue during 2016.

We also want to thank the 17 participating societies who faithfully support this magazine. Without them, *Elements* wouldn't exist.

THANKS TRISH!

With this issue, Trish Dove retires as a principal editor of *Elements*. During her tenure, she was in charge of the following issues: The Mineral-Water Interface (v9n3), Unconventional Hydrocarbons (v10n4), Cosmogenic Nuclides (v10n5), Apatite: A Mineral for All Seasons (v11n3), Geomicrobiology and Microbial Geochemistry (v11n6), and Origins of Life: The Transition from Geochemistry to Biogeochemistry (v12n6). Trish has been a vital part of our editorial team since 2013. Not only did we value her editorial handling of articles, her expertise and experience were invaluable assets during the Executive Editor transition in 2015. Thank you, Trish, for all you have done to help *Elements* continue to be the most readable and authoritative magazine in mineralogy, petrology, and geochemistry.

Best wishes to everyone for the coming year.

Gordon Brown Jr., **Bernard Wood**, **Friedhelm von Blanckenburg**, and **Jodi Rosso**