TOURMALINE RESEARCH: UNLOCKING ALI BABA'S CAVE


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Mineralogy is among the scientific fields most accessible to the general public. People dream about the beautiful crystals they see in museums, and they wonder about mineral diversity. Some become passionate about finding exceptional minerals, original colors, and crystal shapes. There is a broad range of mineral fans, from rockhounding teenagers who spend their weekends at old mines and former famous mineralogical sites, to the experienced—sometimes wealthy—collectors who often lead very different professional lives. All these amateurs are eager to share their passion and tell stories about their cherished samples, although their discretion about the place of origin of their specimens is legendary.

Researchers, too, may spend much time and energy in investigating a few single crystals, deciphering the information they bear like messages in a bottle. They now have access to small scales of observation, and they can investigate grains measuring a few micrometers or nanometers—they can even image minerals at the atomic scale. We now have a broad range of analytical equipment providing spatially resolved information, including electron microscopes, ion probes, synchrotron X-ray microprobes and microdiffractometers. Analytical information is also complemented by numerical modeling, constraining the structural and dynamical properties of minerals and their reactivity at mineral–fluid interfaces. All this information provides a continuum of knowledge on Earth materials by linking scientific fields that were once isolated, such as crystallography, crystal chemistry, experimental and field mineralogy and petrology, geochemistry (including isotope geochemistry), mineral physics, mineral deposit studies, etc. The list is long, and a distinction between mineralogy, petrology, and geochemistry is becoming less and less appropriate. Indeed, a forward–backward exchange approach progressively integrates all the information these fields provide, and the concept of disciplines is fading. A few years ago, an editorial by Ian Parsons in *Elements* (3: 3-4) recalled the importance of teaching "the whole wonderful world of imaging techniques that the 21st century provides," to make students understand the real nature of Earth materials. Spatially resolved methods are replacing former approaches that once considered minerals and rocks just as black boxes containing some pertinent parameters. Nowadays, the data obtained on the conditions of formation and evolution of minerals are interrelated, and novel information is arising from this cross-fertilization. And even if all quantitative scaling laws are not available for transferring information from the crystal scale to more global scales, minerals already provide major constraints on the physical and chemical evolution of the Earth.

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This issue of *Elements* tells the story of the tourmaline supergroup. Previous issues of the magazine devoted to a single mineral were on diamond, gold, bentonite, and zircon. The first two are minerals well known to the public; but, in addition to their high monetary value, these minerals also contain much information of interest to "serious science." Zircon and bentonite are more complex. Bentonite, well known for its industrial and environmental uses, also provides information on low-temperature alteration processes. And zircon, a "tiny but timely" mineral, has been a major witness to the evolution of our planet since the first cooling events 4.4 billion years ago, and is a superb vector of geochemical information due to its exceptional resistance. These minerals tell us how investigations of key minerals can provide amazing insights into the history of rocks and the evolution of our planet. Tourmaline is well in line with that philosophy. In many respects, tourmaline is even more complex than zircon. Tracking tourmaline is not a common pursuit, notably in the mineral's nonclassic contexts, such as sedimentary and metamorphic environments, and we are probably far from completing our knowledge about this group and from using all the potential information it bears.

As shown in this issue, tourmaline deserves more attention. Lively research activity on this mineral is providing unique information on various aspects of our evolving planet, including crustal evolution, the genesis of ore deposits, and fluid–rock interactions over a broad range of *P*–*T*–*X* conditions. A tourmaline grain is like Ali Baba's cave: you can open it to retrieve its treasures, provided you have the magic formula. Tourmaline's scientific wealth comes from the variety of information it contains. Tourmaline retains information about the formation and evolution of its complex crystals, and it marries mineralogy and geochemistry perfectly. Tourmaline's ability to retain information over time leads to the apt description of this mineral as a "geologic DVD," as shown in the Introduction. We can unravel the conditions of tourmaline crystal growth or the crustal residence time of the isotopes of a broad variety of elements. And now that boron and lithium—important tourmaline components—are becoming strategic elements, there is a need for improving our knowledge on Li- and B-bearing minerals. Tourmaline may be considered uncommon, but most mineralogists are actually familiar with it, from the black schorl tourmaline sampled in a field trip to the incredible specimens displayed in mineral fairs and mineralogical websites. This mineral also recalls stories from our past history, such as the centuries-old presence of tourmaline in our cultural heritage and its historical importance in various technological developments, for example, the tourmaline tongs used by 19th century mineralogists. This issue of *Elements* will help us take this "semiprecious" mineral more seriously, at its true scientific value.

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