VERSATILE SERPENTINE

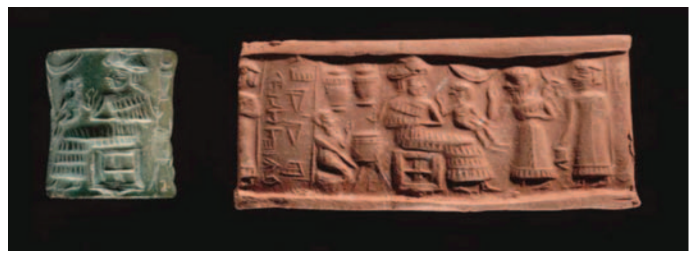
Georges Calas

It is always fascinating to see how much science has not only progressed but also diversified during the last few decades. Even focusing on a single mineral or rock allows us to visit many facets of the Earth and environmental sciences and related domains, such as materials science and cultural heritage. Indeed, I marvel how each time an issue of *Elements* is devoted to a single mineral, it reveals that specialization does not necessarily lead to a narrow vision but actually opens new doors. Here we see that research activity on one of the most classical minerals—used by man for millennia and investigated since the founding of geology and mineralogy—is now making a strong "comeback," with scientists tackling the role of serpentine in present-day hot topics such as alternative energies and the origin of life.

This issue of *Elements* demonstrates clearly that serpentine is a mineral group exhibiting many contrasts. As the dominant hydroxyl-bearing mineral in CM carbonaceous chondrites, serpentine is among the oldest witnesses of the formation of our Solar System. Serpentine is suspected to have formed as a direct nebular condensate or by aqueous alteration of anhydrous silicates during the cooling of the solar nebula. But present-day serpentinization is also a major geological process, as dramatically illustrated by the serpentinite-hosted Lost City hydrothermal field on the Mid-Atlantic Ridge, where hydration reactions are the driving force of the hydrothermal system. This issue also illustrates well the fact that there is an intimate interdependence between the fundamental and applied aspects of serpentine. At a time when funding for research and higher education is difficult and when science is sometimes questioned by officials about its relevance for opening new ways to benefit the economy and society, it is important to reiterate that a better understanding of our planet will provide robust answers to key questions about the future of our societies.

Serpentine is also well known in cultural heritage as an important historical material. For example, it was probably among the first materials to have been used in many different civilizations, in tool making, in decoration, or for its magic properties, such as protection from snakebites. A spectacular illustration is provided by cylinder seals—small items that may have been used as much as 5 millennia ago as administrative tools or amulets. The unique mechanical properties of serpentine may have been instrumental in helping develop such objects: serpentine is an easily worked material, but hard enough to keep the information engraved on it from becoming blunted over time. This may explain the high quality of these small masterpieces now displayed in museums (see figure).

The origin of serpentine has been discussed for more than two centuries because of its close association with a large diversity of rocks. In the late 1800s and early 1900s, there was a vigorous debate regarding the origin of serpentines: sedimentary or igneous? Alexandre Brongniart, who taught mineralogy with René-Just Haüy at the newly founded University of Paris during the early years of the 19th century, insisted that serpentines were more common than presumed, and he advocated an igneous origin for serpentine-bearing rocks. Later in the century, microscopic observations by Tschermak and others demonstrated that olivine alters to serpentine. Serpentinites also received the attention of many geologists in the second half of the 19th century, when they were recognized as being definitely derived from peridotites. And the quantification of the stability field of serpentine was the purpose of a pioneering hydrothermal study by Bowen and Tuttle in 1949, during their classical investigation of the $MgO–SiO_2–H_2O$ system. Current research on serpentine now encompasses many different fields in the Earth and environmental sciences, including geomicrobiology and energy science. For this reason, many countries hold scientific meetings to bring together this rapidly growing community. Such is the case for Serpentine Days (www.sfmc-fr.org/spip.php?article131), a series of meetings that began 6 years ago in France and now attracts an international audience.



Left: The serpentine cylinder seal of Shilishu, Mesopotamia (2.9 cm high; from about 2400 BC). The seal is carved in reverse in order to leave a positive image on clay (Right). Paris, musée du Louvre © RMN-Grand Palais (musée du Louvre) / Franck Raux

Looking ahead, nickel-bearing serpentinites, together with their weathering products, are exploited in many countries. As pointed out in this issue, serpentine-related mineral resources will become the world's main source of nickel and cobalt. However, in the fragile tropical environments where these deposits commonly occur, mining must be done in a sustainable, environmentally benign manner. New cooperative research is emerging to minimize the environmental and societal impacts of future mining operations, such as at the New Caledonian Center for Technological Research on Nickel and Its Environment (www.cnrt.nc), funded by the French government, regional authorities, and mining companies. From observing the early Solar System to caring about the future evolution of our environment, we have come a long way by following the serpentine track.

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