CELEBRATING THE CREATIVE CONTRIBUTIONS OF JAPANESE EARTH SCIENTISTS & ENGINEERS

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Becky Lange

The first car I bought was a used 1978 Honda Accord hatchback. I don't recall what I paid, but the car served me well, with no repairs required, for the five years I owned it as a graduate student. The only other make and model I considered was a used Toyota Corolla. At the time in the mid-1980s, I would not have touched a used American-made car with a 10-foot pole because of their gas-guzzling thirst and frequent need of repair, which stood in marked contrast to the fuel efficiency and reliability of available Japanese cars. The reasons for this contrast, in this era, are well explained in Ralph Nader's 1965 book, *Unsafe at Any Speed: The Designed-In Dangers of the American Automobile,* and in David Halberstam's 1986 book, *The Reckoning.* In the latter, Halberstam compares two auto companies, Nissan in Japan and Ford in the United States, during the four decades following World War II. He describes how in Japan, the industrial culture was to appoint engineers and scientists for top management roles, leading to a focus on product design and quality. In contrast, in the post-World War II era of bountiful profits, leaders of the Detroit auto industry found little reason to heavily invest in quality control. The results led to the Chevrolet Corvair (aka "dangerous at any speed") featured in Nader's book, and a growing appreciation among many Americans by the early 1980s that the quality of Japanese cars was far superior to those made by Ford, General Motors, and Chrysler. As sales dropped, the Detroit automakers learned from their Japanese competitors, and the quality and reliability of American cars significantly improved over the ensuing decades. Nevertheless, my impression of Japanese excellence at the time of my first car purchase was lasting (and yes, 40 years later, I currently own a Toyota).

This impression was reinforced in 1989, when the Loma Prieto earthquake affected the San Francisco Bay Area in California (where I was raised), and I became aware of how far ahead Japanese architects and engineers were in "earthquake-proofing" their buildings. At the time, I was a post-doc in New Jersey, and my father (a civil engineer), in an effort to bond with his geologist daughter, mailed me countless articles from his professional journals extolling the virtues of Japanese designs for seismically resistant structures. He was all too aware of the lack of preparedness in California for the large earthquakes that were expected, but not planned for. Of course, Japanese ingenuity in seismic design stems from necessity, and they had learned the hard lesson of the Great Kanto earthquake of 1923, which devastated Tokyo and surrounding regions, leading to >140,000 deaths and disturbing civic unrest. What most surprised me several years later, immediately after the 1995 Kobe earthquake, was an article my father sent me describing the remarkable survival of one of Japan's tallest pagodas (~55 m tall), a five-storied structure built in 1643 near Kyoto, which experienced strong seismic shaking during the 6.9 M earthquake. The durability of this nearly 400-year-old building was attributed to the ingenious use of central pillars made from tree trunks. These supple pillars, which bend and flex during an earthquake, allow each of the five stories to shimmy back and forth, moving with the shaking rather than against it. Apparently, this Japanese design feature can be traced back more than 1400 years, illustrating the ability of Japanese architects to design earthquake-resistant buildings well before the cause of these recurring, devasting events was understood. Thus, the Japanese have a track record of being out front in engineering novel improvements, whether in the automobile or architectural realms.

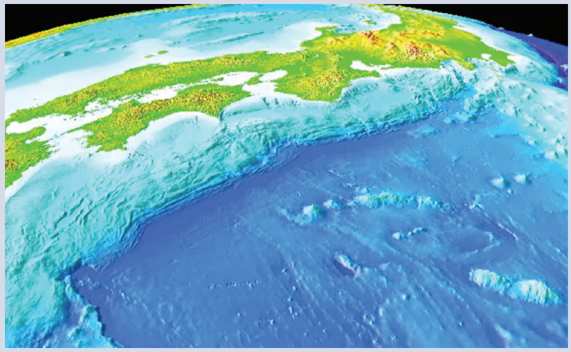
The five-story 17th century pagoda at Kyoto's Toji temple. PHOTO: IVAN MARCHUCK/ALAMY.

This record of Japanese innovation extends to the earth sciences, as it was Kiyoo Wadati, a Japanese seismologist, who made the first major contribution to understanding the underlying cause of Japan's recurring earthquakes. His initial fundamental discovery (Wadati 1928) was of the occurrence of deep (>300 km depth) earthquakes, distinct from the shallower events that cause the most destruction. Several years later, Wadati (1935) presented the first evidence of a dipping plane of earthquake foci, which marks the descent of subducting lithosphere. This plane is now more commonly known as the Wadati-Benioff zone, in recognition of Hugo Benioff's similar finding in 1949.

Cont'd on page 68

ABOUT THIS ISSUE

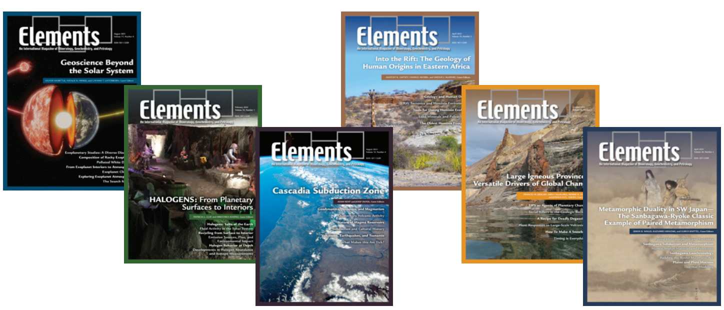
Subduction, where one plate dives beneath another, controls long-term whole-Earth cycling of rocks, fluids, and energy. Plates subduct faster than they heat up, making them the coldest parts of the Earth's interior. Fluids released from these cold plates rise into hotter overlying rocks, forming magma that feeds surface volcanism. Cold deep conditions associated with subduction complemented by hot shallow conditions under volcanic arcs are reflected in the presence of pairs of metamorphic belts, representing sites of ancient subduction.



This issue of *Elements* guides readers through a premier example of paired metamorphism: the Cretaceous Sanbagawa-Ryoke metamorphic pair of Japan. Estimates of pressure, temperature, the age and duration of metamorphism, and the tectonic framework in which metamorphism took place help us to develop quantitative models—both for the evolution of SW Japan and subduction systems in general.

FAREWELL BECKY LANGE

This issue of *Elements* marks the sixth and final theme published under the editorial leadership of Becky Lange (University of Michigan, USA). Becky has served *Elements* as the Principal Editor of Petrology since 2021, and will be replaced this year by Tom Sisson (United States Geological Survey). In addition to this issue on "Metamorphic Duality in SW Japan—The Sanbagawa-Ryoke Classic Example of Paired Metamorphism," Becky also handled "Geoscience Beyond the Solar System" (August 2021, v17n4); "Halogens: From Planetary Surfaces to Interiors" (February 2022, v18n1); "Cascadia Subduction Zone" (August 2022, v18n4); "Into the Rift: The Geology of Human Origins in Eastern Africa" (April 2023, v19n2); and "Large Igneous Provinces: Versatile Drivers of Global Change" (October 2023, v19n5). Please join us in thanking Becky and wishing her well in all of her future endeavors.



NEW INTERACTIVE EVENTS CALENDAR

Dozens of geoscience events are organized each year—conferences, short courses, workshops, field trips, and more. In an effort to promote event participation, facilitate widespread event announcements, and minimize double-bookings, *Elements* has launched an interactive events calendar on its website in cooperation with its 18 professional member societies.

Geoscience events can be found on the calendar pages—or by using a search filter to narrow down your preferences, such as professional society or country. Most importantly, **you can easily add your own events** to the calendar for the world to see. Once approved by the site administrator, your event will have its own landing page with your event's details, logo, site map, and more. Visit **https://www.elementsmagazine.org/events** to learn more or contact the Editorial Team at editor@elementsmagazine.org.

Conferences are an excellent venue for brainstorming how you and your colleagues can design your own thematic Elements issue on your favorite geoscience topic. To learn more, visit www.elementsmagazine.org/publish-in-elements/. We look forward to connecting with you, both virtually and at upcoming events!

Janne Blichert-Toft, **Sumit Chakraborty**, **Tom Sisson**, and **Esther Posner**

Cont'd from page 67

It is no surprise, therefore, that as an undergraduate student of geology in the early 1980s, I was frequently introduced to the contributions of Japanese earth scientists, whether the topic was seismology (the Wadati-Benioff zone), igneous petrology (MacDonald and Katsura 1964; cited >2000 times, distinguishing alkaline versus tholeiitic basalts), or metamorphic petrology (Miyashiro 1961; cited >1400 times, identifying paired metamorphic belts). I also learned about Miyashiro's insights into the origins of ophiolites, which are slices of oceanic crust that have been uplifted and thrust onto the margins of continental crust. Miyashiro (1973) was the first to demonstrate that most ophiolites were examples of oceanic crust that had been modified by subduction (i.e., island arcs). This trend continued into my graduate studies when I began to immerse myself in the experimental petrology and mineral physics literature. I soon became aware of the pioneering advantages of the Kawai-type multi-anvil press (Kawai and Endo 1970), later improved by Ohtani et al. (1989) through the use of sintered diamond anvils.

But it is the contribution made by Miyashiro (1961) that is most relevant to this current issue of *Elements* on the Sanbagawa-Ryoke paired metamorphic belts of Japan. It was Miyashiro's early recognition of two completely different T–P gradients preserved in side-by-side metamorphic belts, together with the seismic Wadati-Benioff zone, that played an outsized role in validating the emerging theory of plate tectonics in the late 1960s. In this issue of *Elements*, we continue to learn surprising and significant details regarding this most famous of paired metamorphic belts, including evidence of remarkably rapid rates at which material is subducted and then returned to the surface. This issue is yet another reminder of how much the earth science community has benefitted from Japanese ingenuity and innovation.

Becky Lange
Principal Editor

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