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EDITORIAL OFFICE
Washington State University Tri-Cities
2710 Crimson Way, Floyd 263
Richland, WA 99354-1671, USA
Tel/Fax: (509) 420-5331 (UTC-8)
Layout: POULIOT GUAY GRAPHISTES
Copy editor: PATRICK ROYCROFT
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CARBON – BEAUTIFUL, ESSENTIAL, DEADLY

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Jon Blundy

The unique physical chemistry of carbon confers an extraordinary ability to form molecules that are variously beautiful (think diamond), essential (think living cells), and toxic (think greenhouse gas). Nowhere is this split personality more evident than in the enigmatic igneous clan of kimberlites, the topic for this issue of *Elements*. No one who has set eyes on a cut diamond, especially the delicate pink stones from soon-to-close Argyle Mine in Western Australia (see photo to the right), can fail to be awestruck at Nature's capacity for beauty. Kimberlite magmas that bring diamonds to the surface are carbon-fuelled, whether by methane through a complex series of redox melting reactions (see Foley et al. 2019 this issue p. 393), or by carbon dioxide exsolving from kimberlite melt at sub-crustal depths and propelling it explosively to the surface (see Russell et al. 2019 this issue p. 405). We have yet to witness a kimberlite erupt – the last known eruption, in Tanzania, was ten thousand years ago – but we can be fairly sure that the greenhouse gas delivery of a single kimberlite pipe in full flow was pretty substantial. For kimberlites, carbon is both passenger and propellant.

Cut pink diamond from Argyle (Australia)

Carbon is just as essential for life itself; it is almost impossible to conceive of living without carbon. Paradoxically, however, living *with* carbon, in the form of carbon dioxide and its sinister sibling, methane, is increasingly problematic. As I write this editorial, travelling (by train) to a school reunion in the north of England, my newspaper is awash with news of political manoeuvring ahead of a United Kingdom general election in which CO_2 and CH_4 co-star (alongside Brexit) in the battle for voters' hearts and minds. At long last, it seems Planet Earth is on the political agenda. This, we are told, is the "climate election", with politicians clamouring to tell us what they will do to reduce greenhouse gas emissions, if only we would vote for them.

And what, indeed, might they do? If the solution were simple, we would have set about it immediately after the first Framework Convention on Climate Change, in Rio de Janeiro (Brazil) back in 1992. But potential solutions are complex, and the many pronouncements of media and activists are quite confusing, even to a scientist. Give up air travel? Go vegan? Eschew the motor car? Skip the odd avocado or other imported food items? Boycott industries that produce fossil fuel? Cut out concrete? It is hard to choose how most effectively to do our bit for the climate; certainly, there is no one-size-fits-all remedy. (To this globe-trotting academic, flying to a lot fewer international meetings would be a good start. See editorial by Friedhelm von Blanckenburg in the December 2017 issue of *Elements*.) What shines through all the rhetoric, though, is that doing our bit, whether at home or at the ballot box, will not be enough to avert a full-blown climate emergency. Ultimately, we need to reconfigure our existence, our custodianship of the planet.

Climate scientists have been telling us for some time, and in ever more gory detail, that the patient is unwell, very sick, at death's door. We recognise the symptoms and understand the prognosis. We now need to urgently move from diagnosis to medication. And in this sense, Earth scientists are physician and pharmacist rolled into one. The transition to a low-carbon world of wind, water, and sun (± nuclear and geothermal), will require a bewildering diversity and quantity of natural resources. Some of these, like copper, are already well known to us – we will just need an awful lot more, perhaps as much as ten times current known reserves. Others, like lithium, are set to acquire a global economy of their own as we strive to meet the battery needs of a billion electric cars. There are still other resources that we don't yet know we'll need – a glance at the periodic table gives a sense of the myriad possibilities. As engineers of the future develop the technologies needed to sustain the planet's growing and developing population, so pressure on Earth scientists to find the requisite elements will grow. Innovative ways to locate and sustainably extract nature's bounty will become essential. And no one innovates quite like an Earth scientist. At a recent meeting of the Society of Economic Geologists, I met a Canadian mining geologist whose company is developing a method of extracting battery-grade lithium from powdered, peraluminous obsidian in southern Peru. The nearby tuffs host supergene uranium minerals that were formed by reaction of volcanic glass with glacial melt water. Here is a single mineral deposit simultaneously providing the lightest and heaviest naturally occurring metals. And extraction is all powered by local hydroelectricity. Innovative indeed!

As global citizens, we have a collective responsibility to modify our lifestyles for the benefit of a sustainable planet. How we do this is chiefly up to us, at least until politicians really seize the initiative. As Earth scientists, we have a unique responsibility (and ability) to enable the transition to a sustainable global economy by finding the necessary natural resources. These are dark days for humankind, perhaps, but step-up-to-the-plate times for the Earth sciences.

Jon Blundy, Principal Editor