It happens that my house in the West Highlands of Scotland is close to a railway line – the West Highland Line – on which an extremely famous preserved steam train runs twice a day in the summer months. Sometimes I pass the train when I’m driving to the shops and a wonderful, evocative smell enters the car, a smell that is a cocktail of hot oil, composed, no doubt, of a variety of hydrocarbons, sulfur compounds, soot, steam and hot metal. In the way of smells it brings back a host of memories, from my school days and from the earliest part of my research career.

Long ago, when I went to school in southeast London by electric commuter train, all the long-distance trains were pulled by steam locomotives. They would thunder through the stations with a splendid clanking of coupling rods, leaving behind that marvellous smell. When stationary they hissed and gurgled, the safety valve sometimes let off a fearsome jet of steam, and they gave off warmth, like a living thing. The school rugby field backed onto an embankment along which travelled the boat trains between London and Paris. The luxury Pullman express, the Golden Arrow – the Flèche d’Or – passed once a day. The locomotive was polished until it shone, the boiler bore a giant golden arrow and the crossed flags of Britain and France fluttered bravely above the buffer-beam. It was simply magnificent. The Second World War had ended only seven years before and the Golden Arrow marked the beginning of a return to a world of affluence and international travel that today we take for granted.

The steam train in the Highlands (Fig. 1) is officially called The Jacobite, after the unsuccessful Jacobite uprising in 1745, the last civil insurrection experienced by the United Kingdom, an insurrection supported, as it happens, by France. Supporters of the uprising gathered at Glenfinnan, near where the viaduct now stands. In recent years, however, both train and viaduct have become internationally famous for another reason. It is not any old train, and the viaduct in is no ordinary viaduct. It is the Harry Potter train on the Harry Potter viaduct! Fans come from all over the world to worship. It featured in three of the Harry Potter films, most notably in Harry Potter and the Chamber of Secrets, in which Ron Weasley flies a Ford Anglia through those graceful arches and eventually lands on the track. The film made US$900 million at the box office. The curved viaduct is a historic piece of engineering in its own right. It was constructed by Robert McAlpine & Sons, of Glasgow, between July 1987 and October 1898, for a mere £18,904 (US$32,137 at today’s exchange rate). Each of its 21 arches has a 15 m span and the highest stand 30 m above the valley floor. A cheap film prop, with hindsight.

The smell of hot, oily metal also reminds me of the early part of my career, which started with a post-doc position at Manchester University where W. S. MacKenzie was setting up a new experimental petrology (XP) laboratory. The research position was not strictly in XP but Mac soon had me learning the ropes, which got me a permanent job, after only one year, at Aberdeen University, where I was given the task of setting up a small XP lab of my own. We didn’t have much money, so a technician and I built a water-pressurized cold-seal system from scratch, including making all the valves and an intensifier. He did the machining and I did the electrical bits. The primary source of pressure was an ordinary car jack, and with a little help from Boyle’s Law we could get up to 4 kbar. It worked well; nobody was blown up or electrocuted. But XP labs, like steam engines, always have a sense of brooding threat. The rows of furnaces gave off a lot of heat and there was that hot-metal smell and sometimes the hiss of steam, only recently supercritical, from leaky joints. Mercury-filled rocker switches made a rhythmic, gentle plopping sound as they responded to the thermocouples, and the mechanical temperature recorder creaked as it obediently typed the temperature in each bomb onto a paper roll. As with locomotives, the lab felt as though it was a living thing.

The work of early experimentalists is always an interesting read. Day and Allen (1905) set out to study the thermal behavior of some of the simple rock-making minerals by a trustworthy method, then the conditions of equilibrium for simple combinations of these, and thus to reach a sound basis for the study of rock formation or differentiation from the magma. No small task! They aimed to study melting and crystallization by observing ‘absorption or release of heat...recorded as breaks in a smooth curve [of heating or cooling]’. They began with the feldspar microcline and found ‘not the slightest trace’ of a change in the rate of heating of the dry crystalline powder, which they ‘prodced from time to time with a stout platinum wire to ascertain its condition’. Somewhat unluckily (their words), they had, as we now know, started their epic research programme with a mineral that melts exceptionally slowly in the absence of water. They were also unaware that K-feldspar melts incongruently to leucite + liquid.

Once they got to 1300°C, their charge had become ‘a viscous liquid which could be drawn out in glassy, almost opaque threads by the wire’. So they cooled this ‘melted orthoclase’ and tried to get it to recrystallize. Nothing happened. They tried adding crushed feldspar; they ‘applied successive quick shocks to the cooling liquid for several hours with an electric hammer below the crucible’; they

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see-sawed the temperature; they circulated air, water vapor and CO₂ through the charge; and finally (in desperation?) they ‘introduced a rapid alternating current sent directly through the substance while cooling, but no trace of crystallization resulted’.

Wisely, Day and Allen changed direction and made a series of entirely synthetic plagioclases, in which context they discuss the melting interval of isomorphous series and illustrate how the compositions of liquids and crystals can be found by finding the common tangents to intersecting free energy curves, a construction proposed by van Alkemade in 1893. Day and Allen’s synthetic plagioclases were used by N. L. Bowen (1913) to produce what many of us would see as the foundation work of modern XP (Fig. 2). Bowen’s great leap forward was to introduce the ‘method of sudden quenching’, which he achieved by dropping the charge into a dish of mercury at room temperature. Don’t tell ‘elf and safety’!

A curious feature of Bowen’s famous diagram is that the solidus between end-member anorthite and the point at 67 mol% albite is, within errors, perfectly straight. This is hard to achieve using Alkemade’s construction. If you have an opinion about why this is so, please send me an ‘owl’!

Ian Parsons (ian.parsons@ed.ac.uk)
University of Edinburgh, UK

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2 Bowen NL (1913) The melting phenomena of the plagioclase feldspars. American Journal of Science 35: 577-599

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**Figure 2** Norman L. Bowen’s famous phase diagram (1913) for the plagioclase feldspars at atmospheric pressure. Reprinted by permission of the American Journal of Science.
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