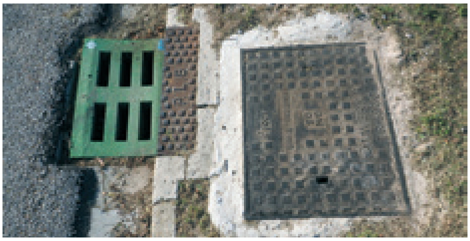

Figure 173. Iron and concrete (green) storm drain (above) and iron-stained garden wall (below).

Iron

When I was asked by the Astronomical Society of Southern Africa to give a talk on some aspect of Earth, iron came to mind. Iron is Earth's most abundant element, making up more than a third of its total mass. I waited until my run at the end of the day to mull over what I might say about iron. My first thought was about the many cars and buses that I had to cautiously weave through as I ran along the road. All those metal boxes on wheels powered by petrol- and diesel-burning cast-iron engines, literally tons of metal moving, in many cases, a single person about town. No wonder we find ourselves in the midst of a global warming crisis.

As I turned off the main road onto a quiet side street I noted the iron manhole covers, each with an embossed geometric pattern (Fig. 173, top). Up from a perforated cover I caught the scent of the sewer, not a nasty sewer smell but the smell I associate with iron, like the taste of blood sucked from a cut finger or of water from some rural taps. A few blocks on I saw garden walls stained a bright orange, a small sign 'Borehole Water' posted nearby. Passing an old Toyota Tazz parked on the side of the road I noticed the bright orange rust spots along the lower rear-window seal and I was reminded that ours is a green, photosynthesising and oxygenated world where silver and manganese tarnish black, copper green and iron orange. Below ground, where air cannot penetrate easily, iron is free to move about in the dark, oxygen-poor subsurface. But as soon as that subterranean iron hits the atmosphere – as borehole water is sent through sprinkler heads into the air, for example – it reacts with oxygen and precipitates out as orange iron oxide (rust), forming a highly insoluble coating (Fig. 173, bottom).

I joined a narrow path cutting through Rondebosch Common, one of the few plots of lowland fynbos left in the city. Just barely outcropping along the path are hard, nodular stones of orange ferricrete (koffieklip), which formed long ago by the concentration of iron oxide cements. I make my way down the path over grasses and flowering plants all busy growing by photosynthesis, a process which releases oxygen gas as a by-product. Odourless and invisible, the oxygen-enriched air wafts up from the green field for me to inhale into my lungs and be carried by iron-rich haemoglobin in my blood to cells

Extract from Compton, J.S., 2021. *West Coast, A Natural History*, Earthspun Books (johnscompton.com).

frantically burning up my lunch to power me forward. At the end of my run I realised that my suburban landscape is dominated by asphalt, bricks and concrete. Iron appears to be losing ground to lighter, non-corrosive plastics, with increasing amounts of plastic in cars, and even the iron street drains, stolen for scrap, are now replaced by plastic or concrete. But in terms of getting around – be it by bicycle, car or train – ours is still very much an iron world.

Along with the burning of fossil fuels, it was the production of steel that set off the Industrial Revolution. Most iron sank as molten blobs early in Earth's history to end up in its solid inner and liquid outer core. Although widely distributed at the surface, iron rarely makes up more than several per cent of rocks and soils. Even the relatively iron-rich ferricrete in Rondebosch Common contains too little iron to be economic. So, where does all the iron to make steel come from? Ancient iron-rich deposits known as banded iron formations, or BIFs for short, contain up to 60% iron by weight. The bands consist of jasper, an orange-to-red variety of finely crystalline quartz that alternates with grey-to-black bands made up mostly of the iron oxide minerals haematite and magnetite (Fig. 174). Individual bands, some only a millimetre thick, can be traced continuously for kilometres. The bands precipitated out of the sea when oxygen gas was just starting to build in our atmosphere between 2.7 and 1.9 billion years ago. Throughout Earth's early beginnings the atmosphere had essentially no oxygen and iron moved freely in waters both below and above ground. After the evolution of photosynthesis, oxygen started to be produced in earnest. However, before oxygen gas could build up in the atmosphere, all the iron in the sea had to be converted to iron oxide – much of it coming out as BIFs.

BIF iron ore may lack the allure of platinum and gold, but South Africa has an estimated 9 billion tons, most of it residing in the Northern Cape. The ore is shipped by a dedicated rail line to the Saldanha Bay loading jetty coated with red dust (Fig. 175). The rail track has a slight continuous downhill gradient that lowers the cost of transporting the ore. South Africa has the world's largest reserves of manganese ore, also shipped by rail to Saldanha Bay. Manganese is used to make stainless steel and an iron smelter was built in Saldanha to enhance value: rather than sell the ore, sell specialty stainless steel. However, only 1 of the 43 million tons of iron ore shipped each year is used to make Saldanha steel, which struggles to compete with huge producers on the global market.

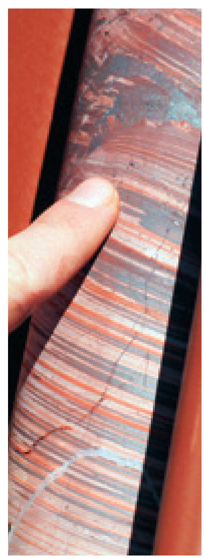

Figure 174. A drill core of banded iron formation reveals finely layered bands of jasper (red/orange) and the iron-rich minerals haematite and magnetite (grey/black).

Figure 175. Every day 9 electrical and 7 diesel engines carry 71,000 tons of ore in 660 cars, 7 km in length, over a 861 km distance – seen here passing by Eland's Bay. It was once the world's longest train carrying the heaviest load over the longest distance until the record was recently broken by our competitor we love to hate most – an Australian iron ore train.

Along with the recent artificial flow of iron by rail from the Northern Cape, there is a long-term, natural flow of iron from the continental interior to the West Coast. The iron is carried in windblown dust (Fig. 60) and in mud suspended in the Orange River (Fig. 73). In addition to fertilising the fynbos plants, dust plumes sent far out to sea play an important role in fertilising the ocean (Fig. 176). Among the trace elements required by living cells, iron stands out as one needed in surprisingly large amounts. This may reflect life's early beginnings in an originally iron-rich sea before oxygen had siphoned it all off into BIFs. The reason why iron can be so abundant on Earth and yet so unavailable to life at sea is that the surface ocean contains only trace amounts of iron. Ever since the rise of oxygen in the atmosphere, iron has been reduced to barely detectable amounts in the ocean – with only one iron atom in every hundred billion molecules of water.

Two pathways exist to deliver iron to the surface ocean: iron can come from above as windblown dust or it can come from below as deeper waters come to the surface.[48] Iron-rich muds eroded from the Drakensburg Mountains are carried by the Orange River to the sea, where the fine mud is transported offshore in submarine plumes. These plumes of suspended iron-rich clay particles flow with currents from the edge of the continent far out to sea and can be upwelled to the surface, where life extracts the iron that it needs to grow. Variations in the supply of iron from above and below may have contributed to the large glacial to interglacial climate swings of the past (Fig. 53). Increased delivery of iron from below, as lowered sea level suspended more mud off the margin, and from above, as more dust was generated under the colder, dryer and windier conditions, may have resulted in more iron-fertilised algal growth, lower levels of CO_2 and colder climate during glacial periods.

When we do not have enough iron in our diet we become anaemic and fatigue easily from the less efficient transfer of oxygen to our cells. Some have proposed we give iron-poor 'anaemic' marine life a supplementary dose of iron to help it grow. The idea is that the more algae grow, the more carbon dioxide they remove from the atmosphere into the deep ocean, thereby lowering the carbon dioxide content of air and lessening the threat of global warming. Similar to the notion of planting trees to become 'carbon neutral' and compensate for carbon dioxide emissions, several commercial enterprises have proposed artificially fertilising iron-deficient ocean areas to promote the growth of algae and the removal of carbon dioxide. As appealing as this notion of iron fertilisation may sound, most marine scientists argue against it: the dynamics of marine ecosystems are simply not well enough understood to know what knock-on effects iron fertilisation may have.[49] Ocean trials clearly show that adding iron increases algal growth in the surface ocean, but just how much of the organic carbon ends up in the deep sea – as opposed to being rapidly recycled back into the atmosphere – is unknown. The blooms of life after adding iron may also threaten fish in deeper waters from the loss of dissolved oxygen as the dead algae decomposes while settling through the water column. Plus, the added iron doesn't stick around for long at the surface where it is needed, necessitating frequent additions if highly productive waters are to be sustained. Rather plant more trees.

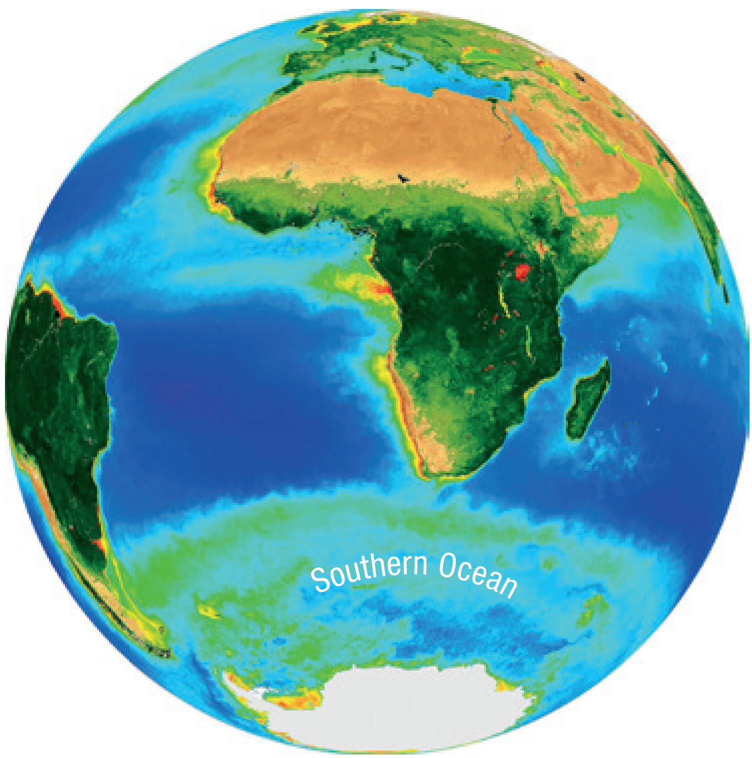

Figure 176. Productivity (shown here in shades of green, yellow and red) was greater in the Southern Ocean during cold, glacial periods than today because of the greater influx of iron delivered both from below by upwelling of ocean waters and from above as windblown mineral dust.

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