

# Earth's natural wealth: an audit

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"I get excited every time I see a street cleaner," says Hazel Prichard. It's what they collect in their sacks that gets her juices flowing, because the grime and litter they sweep up off the streets is laced with traces of platinum, one of the world's rarest and most expensive metals. The catalytic converters that keep exhaust pollutants from cars, trucks and buses down to an acceptable level all use platinum, and over the years it is slowly but steadily lost through these vehicles' exhaust pipes. Prichard, a geologist at the University of Cardiff in the UK, reckons that tonnes of the stuff is being sprayed out onto the world's streets and highways every year, and she is hunting for places where it is concentrated enough to be worth recovering. One of her prime targets is the waste containers in road-sweeping machines.

This could prove lucrative, but Prichard is motivated by something far more significant than the chance of a quick buck. Platinum is a vital component not only of catalytic converters but also of fuel cells – and supplies are running out. It has been estimated that if all the 500 million vehicles in use today were re-equipped with fuel cells, operating losses would mean that all the world's sources of platinum would be exhausted within 15 years. Unlike with oil or diamonds, there is no synthetic alternative: platinum is a chemical element, and once we have used it all there is no way on earth of getting any more. What price then pollution-free cities?

It's not just the world's platinum that is being used up at an alarming rate. The same goes for many other rare metals such as indium, which is being consumed in unprecedented quantities for making LCDs for flat-screen TVs, and the tantalum needed to make compact electronic devices like cellphones. How long will global reserves of uranium last in a new nuclear age? Even reserves of such commonplace elements as zinc, copper, nickel and the phosphorus used in fertiliser will run out in the not-too-distant future. So just what proportion of these materials have we used up so far, and how much is there left to go round?

Perhaps surprisingly, given how much we rely on these elements, we can't be sure. For a start, the annual global consumption of most precious metals is not known with any certainty. Estimating the extractable reserves of many metals is also difficult. For rare metals such as indium and gallium, these figures are kept a closely guarded secret by mining companies. Governments and academics are only just starting to realise that there could be a problem looming, so studies of the issue are few and far between.

Armin Reller, a materials chemist at the University of Augsburg in Germany, and his colleagues are among the few groups who have been investigating the problem. He estimates that we have, at best, 10 years before we run out of indium. Its impending scarcity could already be reflected in its price: in January 2003 the metal sold for around \$60 per kilogram; by August 2006 the price had shot up to over \$1000 per kilogram.

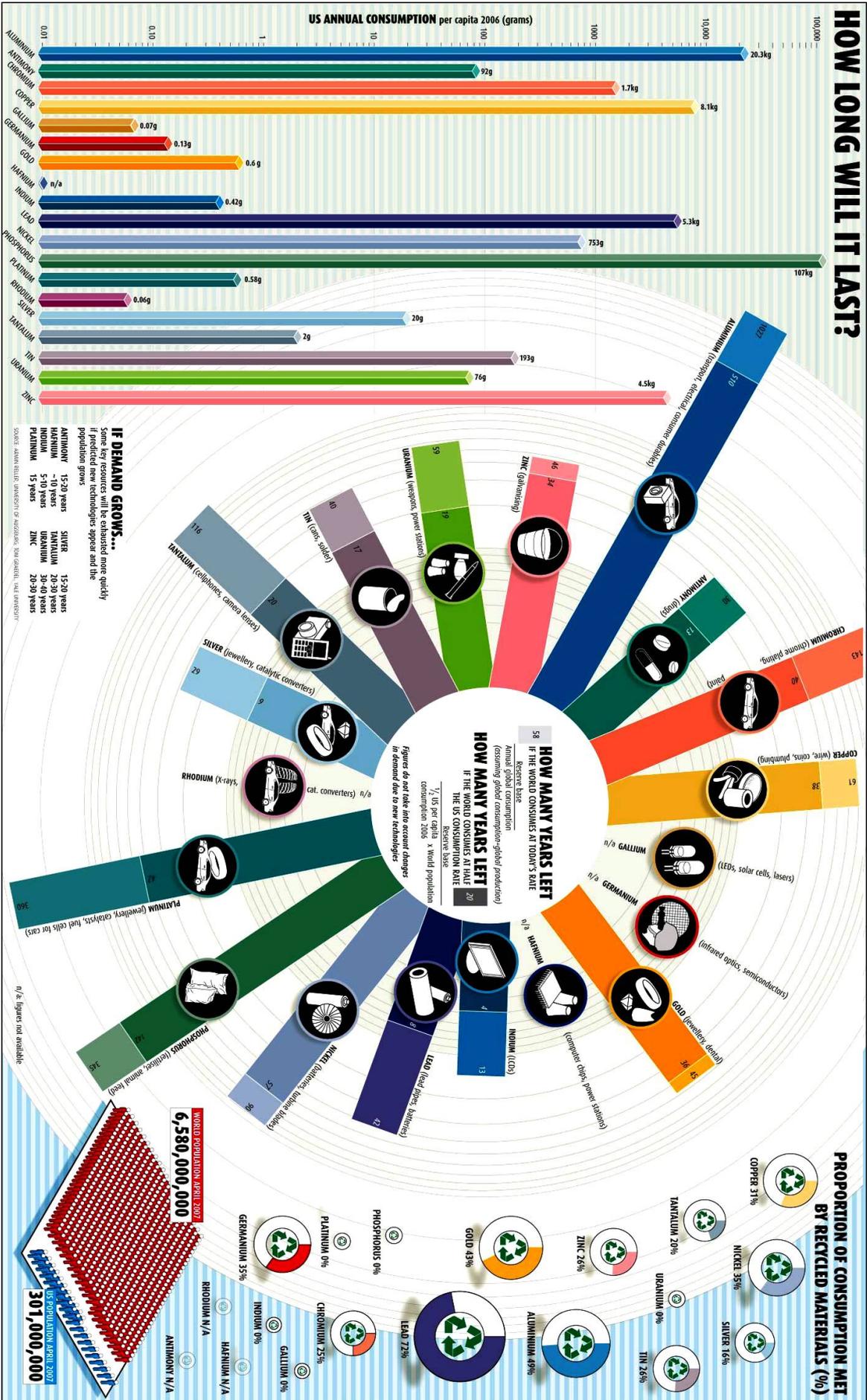
Uncertainties like this pose far-reaching questions. In particular, they call into doubt dreams that the planet might one day provide all its citizens with the sort of lifestyle now enjoyed in the west. A handful of geologists around the world have calculated the costs of new technologies in terms of the materials they use and the implications of their spreading to the developing world. All agree that the planet's booming population and rising standards of living are set to put unprecedented demands on the materials that only Earth itself can provide. Limitations on how much of these materials is available could even mean that some technologies are not worth pursuing long term.

Take the metal gallium, which along with indium is used to make indium gallium arsenide. This is the semiconducting material at the heart of a new generation of solar cells that promise to be up to twice as efficient as conventional designs. Reserves of both metals are disputed, but in a recent report René Kleijn, a chemist at Leiden University in the Netherlands, concludes that current reserves "would not allow a substantial contribution of these cells" to the future supply of solar electricity. He estimates gallium and indium will probably contribute to less than 1 per cent of all future solar cells – a limitation imposed purely by a lack of raw material.

To get a feel for the scale of the problem, we have turned to data from the US Geological Survey's annual reports and UN statistics on global population. This has allowed us to estimate the effect that increases in living standards will have on the time it will take for key minerals to run out (see Graphs).

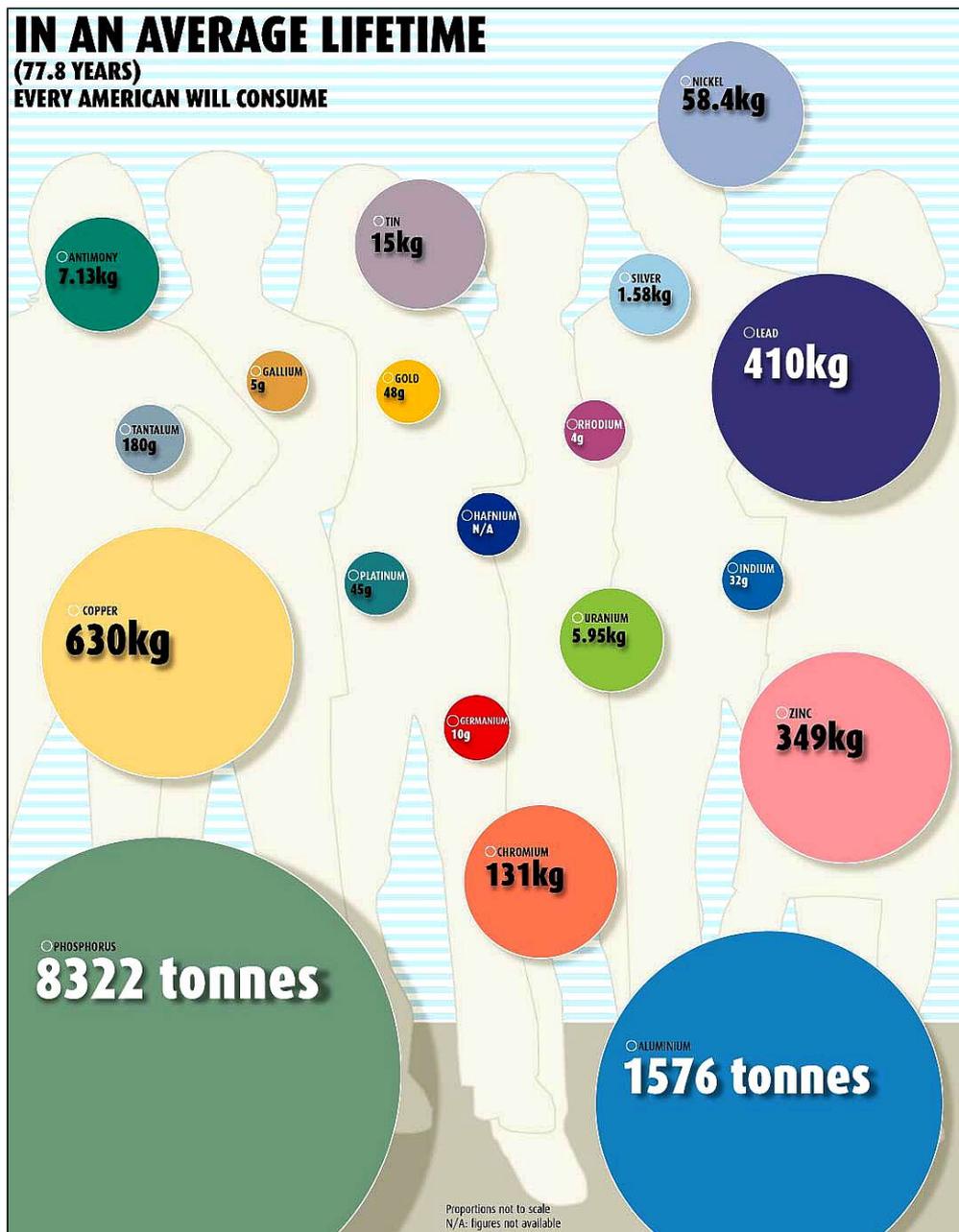


# HOW LONG WILL IT LAST?



How many years, for instance, would these minerals last if every human on the planet were to consume them at just half the rate of an average US resident today?

The calculations are crude – they don't take into account any increase in demand due to new technologies, and also assume that current production equals consumption. Yet even based on these assumptions, they point to some alarming conclusions. Without more recycling, antimony, which is used to make flame retardant materials, will run out in 15 years, silver in 10 and indium in under five. In a more sophisticated analysis, Reller has included the effects of new technologies, and projects how many years we have left for some key metals. He estimates that zinc could be used up by 2037, both indium and hafnium – which is increasingly important in computer chips – could be gone by 2017, and terbium – used to make the green phosphors in fluorescent light bulbs – could run out before 2012. It all puts our present rate of consumption into frightening perspective (see Diagram).



Our hunger for metals and minerals may not grow indefinitely, however. When Tom Graedel and colleagues at Yale University looked at figures for the consumption of iron – one of our planet's most plentiful metals – they found that per capita consumption in the US levelled off around 1980. "This suggests there might be only so many iron bridges, buildings and cars a member of a technologically advanced society needs," Graedel says. He is now studying whether this plateau is a universal phenomenon, in which case it might be possible to predict the future iron requirements of developing nations. Whether consumption of other metals is also set to plateau seems more questionable. Demand for copper, the only other metal Graedel has studied, shows no sign of levelling off, and based on 2006 figures for per capita consumption he calculates that by 2100 global demand for copper will outstrip the amount extractable from the ground.

So what can be done? Reller is unequivocal: "We need to minimise waste, find substitutes where possible, and recycle the rest." Prichard, working with Lynne Macaskie at the University of Birmingham in the UK, has found that platinum makes up as much as 1.5 parts per million of roadside dust. They are

now seeking out the largest of these urban platinum deposits, and Macaskie is developing a bacterial process that will efficiently extract the platinum from the dust.

Other metals could be obtained in equally unorthodox places. Cities are huge stores of metals that could be repurposed, Kleijn points out. Replacing copper water pipes with plastic, say, would free up large quantities of copper for other uses. Tailings from worked-out mines contain small amounts of minerals that may become economic to extract. Some metals could be taken from seawater. "It's all a matter of energy cost," he says. "You could go to the moon to mine precious materials. The question is: could you afford it?"

These may sound like drastic solutions, but as Graedel points out in a paper published last year (Proceedings of the National Academy of Sciences, vol 103, p 1209), "Virgin stocks of several metals appear inadequate to sustain the modern 'developed world' quality of life for all of Earth's people under contemporary technology." And when resources run short, conflict is often not far behind. It is widely acknowledged that one of the key motives for civil war in the Democratic Republic of the Congo between 1998 and 2002 was the riches to be had from the country's mineral resources, including tantalum mines – the biggest in Africa. The war coincided with a surge in the price of the metal caused by the increasing popularity of mobile phones (New Scientist, 7 April 2001, p 46).

Similar tensions over supplies of other rare metals are not hard to imagine. The Chinese government is supplementing its natural deposits of rare metals by investing in mineral mines in Africa and buying up high-tech scrap to extract metals that are key to its developing industries. The US now imports over 90 per cent of its so-called "rare earth" metals from China, according to the US Geological Survey. If China decided to cut off the supply, that would create a big risk of conflict, says Reller.

Reller and Graedel say urgent action is required. Firstly, we need accurate estimates of global reserves and precise figures for consumption. Then we need to set up an accelerated programme to recycle, reuse and, where possible, replace rare elements with more abundant ones. Without all this, any dream of a more equitable future for humanity will come to nothing.

Governments seem, at last, to be taking the issue seriously, and next month an OECD working group will be convened to come up with some of the answers. If that goes to plan, we will soon at least have a clearer idea of the problem. Whether any solution to looming global shortages can then be found remains to be seen.