If I could just, very gently, correct Madsen here [1]

Written by **Tim Worstall** [2] | Saturday 27 October 2012

In his series of reasons to be cheerful (yes, he is indeed a Blockheads fan, why do you think he lets me hang around the place?) Madsen tells us this about copper and other mineral resources [3]:

> Famously in the case of copper we developed fibre optic cables to convey our signals as copper rose in price. We use plastic pipes instead of copper ones to convey liquids because they are cheaper. The falling demand for copper means that world reserves are now estimated at between 25 and 60 years (depending on assumptions about growth rates), whereas at the time Erlich wrote, it was much less.
>
> This is not to suggest copper will suddenly run out in 25 or 60 years. If it becomes scarce it will become more expensive, and people will use other things in its place. The reason the world is not running out of scarce resources is that the technology to locate and extract them is advancing year by year, and market prices motivate us to use it.

This is true, yes. But it's also not the whole story and I think that whole story is rather interesting. For the truth is we create resources, not discover them. And it is most certainly true that we create reserves of these minerals. We create them through the invention of new technologies.

On the specific point about copper, the great change in that metallurgical world was the early 80's introduction of SX EW technology. For the full gory details try here [4]. The important point is that before this new technology we got our Cu from copper sulfates and sulphides. When we found a mountain of copper oxides it was just a mountain of useless dirt. We didn't know what to do with it. Then we adapted the SX EW technique and all those mountains of dirt became mountains of copper ore. Hurrah!

And we can expand this point into a much larger lesson. To a useful level of accuracy the mining world divides the world up into dirt and ore. Your allotment patch contains gold, rare earths, uranium and all sorts of other lovely metals*. However, your allotment patch is dirt. For while we do know how to extract all of those metals the cost of doing so would be higher than any value that could be recovered.

Ore is simply dirt where we know how to extract the metals: and also the value of the metals is higher than the cost of extraction. Ore is an economic concept, not a natural world one. And as with so many other economic concepts what is dirt and what is ore is a constantly changing spectrum. For technology, including the technology of extraction, changes over time. As an example I'm about to embark on the extraction of tungsten from some left over rock. A century ago, when it was dug up, it was rock. Now it's ore. The extraction technology has changed over time.

We should also go one stage even further and talk about Donald Rumsfeld's known unknowns.

When you see an environmentalist complaining that we're going to run out of a mineral in a generation he'll actually be correct. That's also the number Madsen uses for copper, 40-60 years or so. For every generation runs out of mineral reserves, this has been true since we started mining. For what everyone is talking about is "reserves". These are the known knowns. These are the ore, we know where it is, we know

we can extract it at current prices, with current techniques, and make a profit doing so. Further, we have also tested and proven all of this to the satisfaction of the stock market listing rules where mining companies go to get traded.

You'll not be surprised to learn that drilling and sampling and sending odd hairy geologists over the hill with little hammers is expensive. So we only do this with the stuff we're likely to dig up in the next few decades. Thus, reserves of ore are, at any one time, good for only a few decades of use. Because they are a both legal and economic concept and as such we only define as reserves what we're likely to use in the next few decades. Or rather, only bother to do enough work to declare as reserves what we're likely to use in the next few decades. Thus every generation does indeed use up the available reserves of minerals.

But that isn't all there is of course: there's also the known unknowns. We've only bothered to stake out this side of the hill and in a couple of decades we'll do the same to the other side. We know it's there, we've just not bothered to prove it yet. These are more generally known as resources. They're there, we know that, we've just not gone through the expense of converting them to reserves yet.

Then there's our unknown knowns. We do know roughly what the geology of many places is. But we've sent very few hairy odd men with hammers over it. For example, we know that the geology of Madagascar is quite similar to that of the German/Czech border. Lots of lovely tungsten, tantalum, niobium, scandium up in them thar hills. Same sort of volcanic structure that's been folded in a similar manner and weathered much the same way. But why bother with the lemurs when you can go digging within reach of the Pilsener Urquel brewery? Well, quite. We're sure there's lots out there. Not sure quite where, in what quantities, quite how we'd get it out: an unknown known.

And then there's the unknown unknowns. The best way to approach this is from the other side. We think we know what the crustal abundance of all (OK, most) metals is. At the extreme we can imagine mining your allotment for them. Whether or when we'll get the technology to do so at economic cost we don't know. We do know that we can do it right now but only at exorbitant cost. Take, say, Tellurium, that we use to make a certain type of solar cell. Crustal abundance is, well, I can't remember how many zeroes there are after the decimal point to be honest. 0.1 parts per million? 0.0001 ppm? Somewhere in that range meaning that in the crust of the earth there's some 120 million tonnes of the stuff (I do recall that number from having done the calculation).

We use 125 tonnes of tellurium globally each year. Our known known is that we get it from copper slimes (no, real mining word, one of the wastes of making copper). We make enough to cover current demand from our known known. We're pretty sure about the known unknown as well: there's mountains just full of copper out there which contain that Te. Our unknown known is that there are other minerals that contain it in some quantity but we've just never bothered to check. And our unknown unknown is that, if it ever became expensive enough, I'd be around rootling through your veg patch to get it.

Do we, in the end, face resource constraints? Sure we do: absent asteroid mining we cannot use any more tellurium atoms than there are on the planet. Are these resource constraints meaningful in any manner at our current scale of activity? Nope.

For we continually create new reserves through the invention of new technologies. And we continually turn the various known/unknown combinations into those known known reserves by bothering to spend the time and money to do so. Or, as I say, we turn dirt into ore all the time. And so far at least no one has posited a shortage of dirt.

**I have a hankering to do a mad scientist TV show. In which we really do take a field, a pile of rock, and we break it down into its component elements. Here's the uranium, here's the iron, the aluminium and so on all*

scarcity is an economic, a cost, concept. Not some immutable law of our environment. Sadly I fear there are no TV producers quite as mad as me.

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