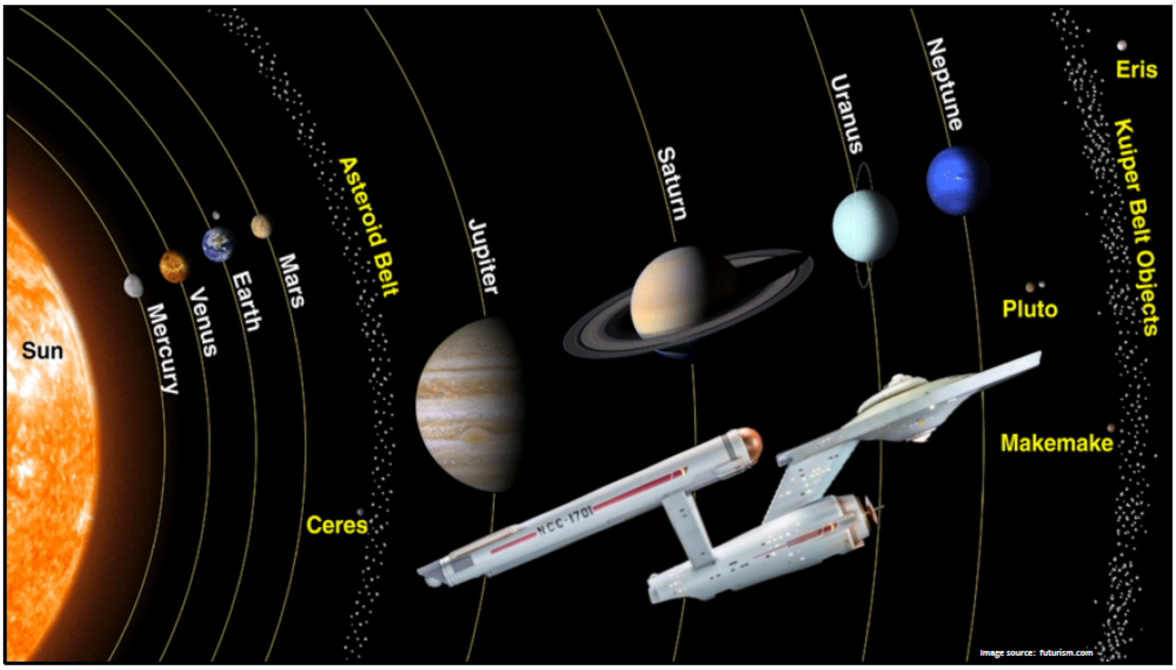


Space… isn't it the final frontier?

We probably can mine out there, but should we, are we that desperate for resources?

Legally, we apparently can mine in space. The Space Act came into force in the US only 2 years ago.

But I'm not going to bore you with all the politics and ethics about space mining because I'm a geologist and I like rocks, which actually aren't boring at all.

So I'm going to walk you through our solar system as best I can to assess the relative prospectivity of some of its planets, moons and asteroids, because that's what an exploration geologist does – decides where the best opportunities are to drill for resources.

Let's start with the **SUN**…. Or let's not. We're never going to get there. Its surface temperature is around 5 ½ thousand degrees Celsius and if you think, yep, that's way too hot well we wouldn't even make it through the corona which is actually around 2 million degrees Celsius.

Moving outwards, what about **Mercury?** Its sunny side is only 400 degrees Celsius and its dark side is -200. It has no atmosphere, no moons, its surface is covered in craters and it is completely dry. That's about as much as we know about it and without having any water there it's pretty unattractive.

VENUS – has a disgusting atmosphere made up of water vapour and sulfuric acid, so I don't know about you but I wouldn't be happy about breathing that in. Interestingly, Venus is actually hotter than Mercury by around 60 degrees, because of the carbon dioxide trapped by its atmosphere creating a perfect example of the greenhouse effect. NASA's Magellan Spacecraft used its radar to penetrate through the atmosphere of Venus and showed us pictures of the surface of the planet which actually looks very much like Earth. So potentially Venus has been 'geologically active' even up to the last 2.5-3 Ma, and so it should have scattered mineral deposits in its crust just like the Earth.

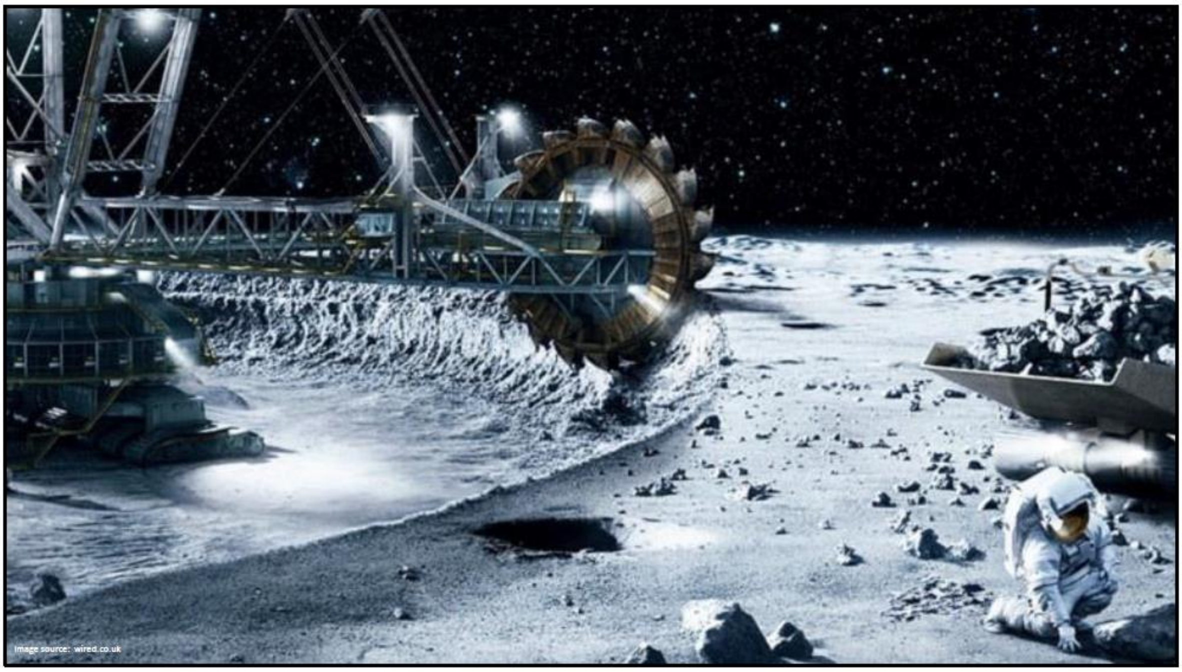
Moving right along as I don't think I want hang out anywhere so far... That brings us to the third rock from the sun, which we all should all be pretty familiar with... the **EARTH.** We're pretty good at exploring here but in many places the easy deposits have been found and so it's getting harder to find orebodies and very much more expensive.

Next up, for those who don't recognise it, this is our nearest neighbour, the **MOON.**

It's only 384.5 thousand km away, and 48 years ago the Apollo mission took about 3 days to get to it. So obviously this is celestial body we're most interested in, and we can send probes there in about 8 hours these days.

The moon has lots of craters which formed from meteorite impacts. This is quite exciting from a geologist's perspective as many asteroids are essentially chunks of metal.

Some metals, like Platinum, didn't originate naturally in the Earth's crust. They got there by meteorite impacts and the metals have been remobilized and scattered throughout the crust by tectonic processes. Because our Earth has an atmosphere, most of the asteroids that try to hit us just burnt up, so we haven't had as many impacts as our friend the moon, which therefore could have lots of chunks of metal stuck in it.



Some scientists are also keen to exploit the moon's helium-3 resources – yes, that's a gas, not a metal. Helium-3 is perceived by some to be a potential fuel for future nuclear FUSION reactors on Earth, as the reaction produces no radioactivity or carbon emissions, but a hell of a bang of around 13 million electron volts in a single reaction.

The Earth has much less He-3 than the moon, where the gas is implanted to the lunar soils by solar winds (from which we're shielded by our magnetic field).

The concentration of He-3 is still quite low on the moon (~10 pp billion by mass, 7 pp trillion for Earth) such that strip mining and processing of hundreds of square kilometres of the lunar surface would be required each year in order to make a significant contribution to the Earth's future energy needs.

And frankly, sustainable nuclear fusion using He-3 has yet to be shown to be practical. Sure, it may well be in the future, but the gas giants of our solar system, Jupiter and Saturn, and to a lesser extent Uranus and Neptune, would be more prospective for He-3 at around 10 pp million, than the moon.

However, if we were to harvest He-3 from way out there we would experience problems like getting back out of the huge gravity well of Jupiter. Basically there would be no mass budget left for cargo in a vehicle returning from Jupiter, as it's escape velocity is about 60 km/sec. Not to mention it would take us 6 years to get there anyway.

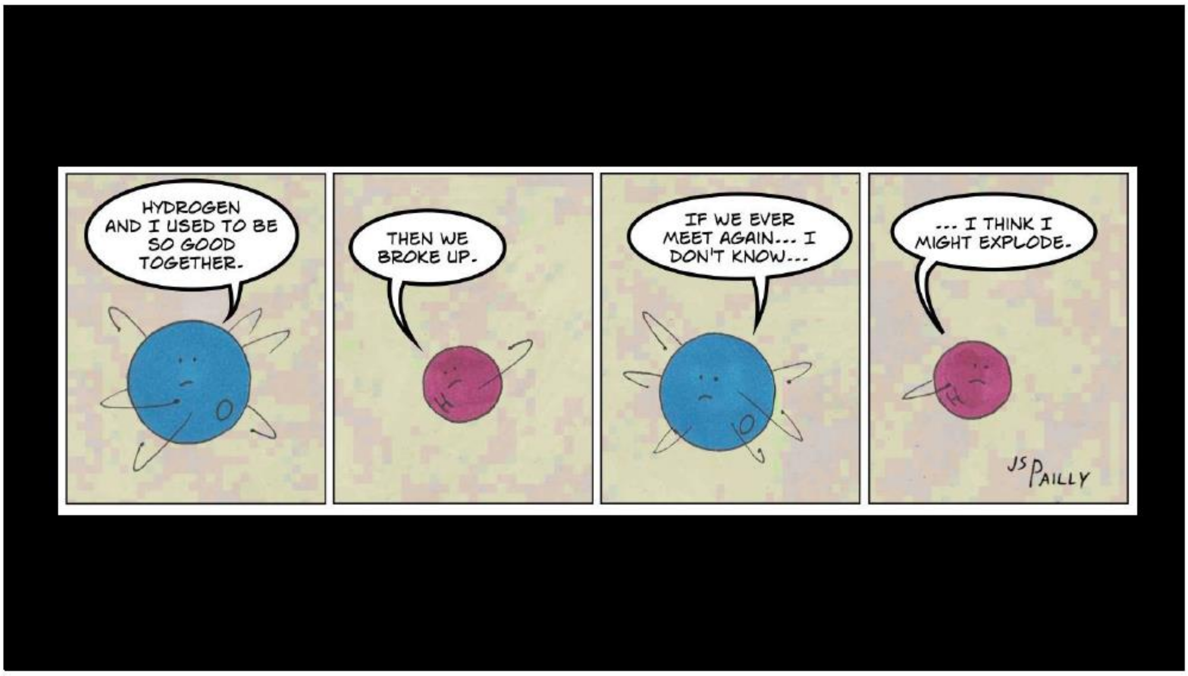
Escape velocity, what does that mean? I'm getting a bit technical here – but there is a point to discussing this.

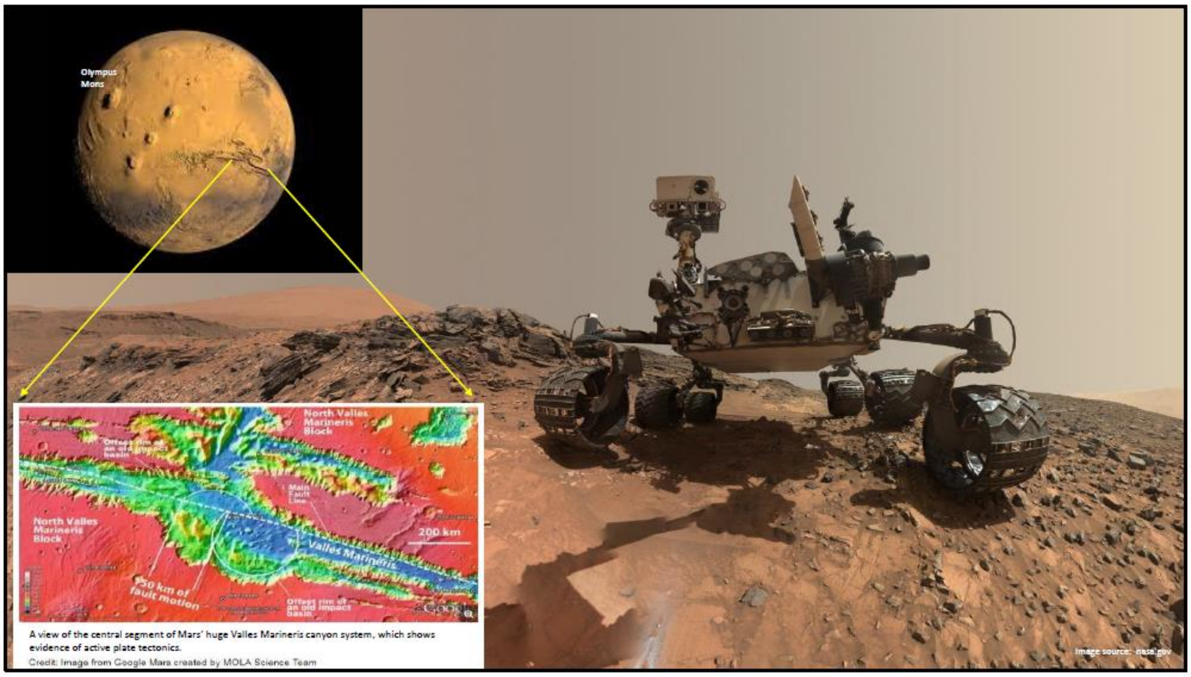
Let’s go back to that rare metal, Platinum, for a minute. Say we found a lovely 1 tonne chunk of platinum on the moon and we wanted to bring it back to Earth, where it would be worth around $30 million USD. We could shoot it out of a bloody big gun from the surface of the moon at 2.4 km/sec which is the moon’s escape velocity, but it may not survive re-entry to the earth’s atmosphere.

Ok, so how much fuel do we need to transport 1 tonne of platinum back to Earth? Using some back of the envelope calculations the figure is apparently around 750 kilos of liquid H and liquid O. Assuming we have to bring that fuel with us from Earth, it would cost about $30 million JUST TO GET THAT FUEL UP TO THE MOON.

So you can see that one of the most important resources we need to find out there is a source of fuel.

Hello water. We know the moon has water in it now and so it is the most valuable resource in space, not to bring back to Earth, or just for survival but so we can split it up for rocket fuel.





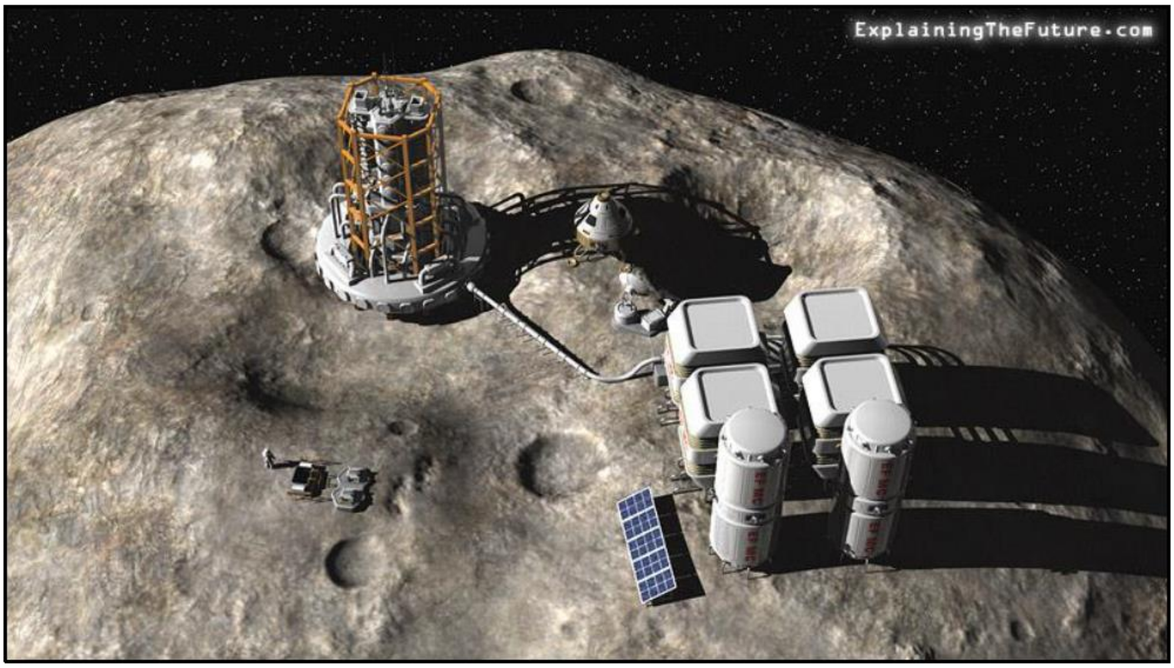
MARS – is not looking too bad either really, despite the fact we can't breathe the relatively thin atmosphere there, as it's around 96% CO2.

There is evidence to suggest that Mars may still be geologically active, with plate tectonic movement even as recently as 2 million years ago.

Mars has polar ice caps – useful for water.

Its soil is 15% by weight FeO and may be useful for radiation shielding, industrial and construction materials. Obviously, given it takes about 300 days to get there, we're unlikely to be bringing anything back in bulk, so when I talk about building materials it's really only for martian settlement.

Mars has the largest volcano in the solar system – Olympus Mons. 25km high (3 x Everest) – so that would be pretty cool to see.



To be honest, I don't see much point exploring any further, plus I'm running out of time.

So I'll finish up with the solar system's **MAIN ASTEROID BELT,** because that's actually what some of our start-up space mining companies are seriously aiming for.

There's 3 types of asteroid, of which we're really only interested in two. The C-type, or carbonaceous, as they can be up to 22% water. These are the most common type of asteroid and are made of clays and silicate minerals.

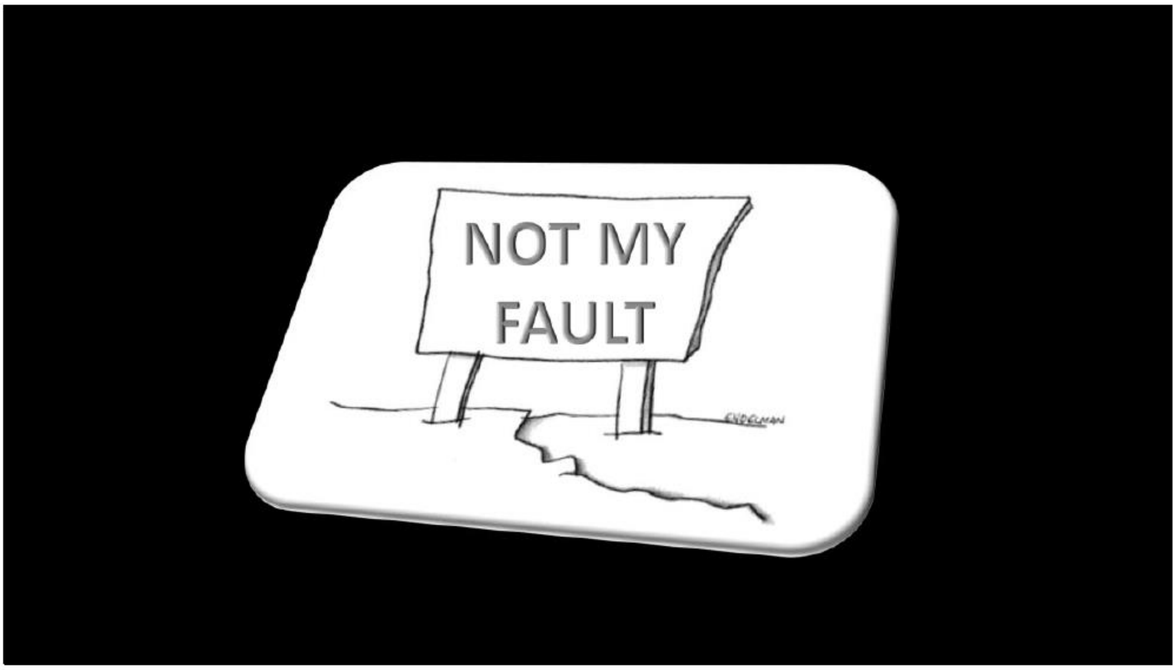
The other type of asteroid we're hankering to get our hands on are the M-type, or metallic asteroids. These guys are chunks of metal, mainly Ni and Fe.

The beauty of asteroids is that, unlike the Earth, heavier metals are distributed evenly throughout the object, rather than closer towards the core. Conveniently, the metals are also present in higher concentrations in asteroids than on Earth where they have been oxidized and scattered around the crust into mineral deposits.

Why is this? It comes down to the way in which the asteroids formed from the primordial solar nebula. Scientists believe that a tenth planet tried to form between Mars and Jupiter but Jupiter's gravitational forces (which we've already spoken about) were too strong to allow the 'bits' to accrete into a planet.

So this means we're left with a belt of rocks floating around basically unchanged in composition as when they formed 4.5 billion years ago.

So after all my arm-waving about things having been geologically active which is important for finding mineral deposits, the asteroids are, geologically speaking, completely “inactive.”



But thanks very much for listening and hopefully I can answer some questions for you later! Don’t make them too difficult though…