Question 1:

Dear Cheap Astronomy – So what can you do with lunar regolith?

Lunar regolith is readily available for use by space explorers, but just being available doesn't mean it's going to be useful. Nonetheless, there have been some interesting suggestions about what to do with it over the years since Apollo and now that we are in the Artemis era, this seems a good time to blow the moon-dust off some of those suggestions.

Assuming regular Moon landings ever become a thing, lunar regolith is problematic insofar as retrorocket fire blows the dust around at high velocity and over long distances since there's no atmosphere to slow it down. So the surfaces of any existing infrastructure around your landing site risks being blasted by regolith materially equivalent to tiny but sharp shards of glass. We can avoid that by building landing pads, built from fused regolith. Building methods range from adding a binding agent to your rocket exhaust so you literally create the landing pad as you land. Or you could prepare a landing pad beforehand by sweeping out a flat plane of regolith and then use microwaves to bake it into a solid surface. Or if those options sound a bit radical, you could just build a pad out of regolith-derived pavers.

It's widely anticipated that future lunar bases are likely to be built with regolith pavers and regolith bricks, as well as regolith mortar and concrete. It's sometimes also said that such bases will be built from the blood, sweat and tears of astronauts, literally. Blood albumin is apparently a good binding agent, where animal blood was commonly used in early cements on Earth. Urea, from sweat and tears and also another salty fluid, yep urine, can apparently enhance the tensile strength of regolith-based concrete. Mind you, there are just as many proposed chemical pathways to regolith masonry that don't involve human by-products. What is common to all such procedures is the need for lots of water, certainly more than could be derived from astronauts, so use of in-situ water ice may well be mandatory.

Something that could cut Earth-Moon transport costs significantly is regolith-based heat shields – which would be carefully shaped blocks of regolith masonry. If the Moon did become a base for mining and refining, you could send and soft-land a range of products back on Earth using robotic craft with regolith heatshields. This would save millions if not billions, since you wouldn't have to launch heat shields from Earth, plus they would achieve the usual role of heat shields, where Earth's atmosphere is used to aerobrake returning spacecraft rather than wasting fuel on retro rocket burns.

Lastly, there are various products we can extract from regolith. Its most abundant element is oxygen, around 40% by mass, another 20% is silicon, then there's around 5% each of iron, aluminium, calcium and magnesium followed by a range of trace elements at less than 1% each. These trace elements include titanium and also the isotope Helium3, which has a much-touted, though completely hypothetical, role in yet-to-be-invented nuclear fusion generators, but also a genuine role in medicine where it's currently used in some MRI scanning procedures.

Extracting any of these products from raw regolith requires some sophisticated infrastructure, where furnace-level heating and steam-injection under high pressure seem to be common requirements. Whatever has been achieved in a laboratory on Earth would need to be scaled up to factory-level production to produce meaningful amounts of the various products. And once again you'd need a lot of water to make it all happen. Whether doing any of this makes economic sense largely depends on how and why we want to have a sustained presence on the Moon. If it's just going to be some small bases for scientific research then a few bricks and pavers might suffice, but if the Moon is to become a major hub for Solar System resource exploitation and colonization then all the other stuff really could be worth doing as well. Stay tuned.

Question 2:

Dear Cheap Astronomy – Are we really not going to Mars in the 2030s?

Well, probably not. NASA's moving target is now 2037, it was previously running with 2033 until an independent review looked at their current plan and said no way and also said no way to the next launch window in 2035, so it's 2037 now – which Cheap Astronomy guesses will be pushed into 2040 in about three years. China is still talking about launching astronauts to Mars in the 2033 launch window, but without a lot of details on how, excepting some hints that they might use nuclear technologies, at least for power if not propulsion.

NASA's 2037 plan is to launch astronauts from Earth in the Space Launch System/Orion capsule combo and then dock with the planned lunar gateway space station, where the crew will then transfer over to the DST, the Deep Space Transport vehicle which will take them to Mars and back The independent reviews main concern was that prototype testing of the DST needed start next year to make a 2033 launch. For China's proposed 2033 launch, it's possible their less-transparent space agency is already building lots of exciting new spacecraft behind closed doors, but that's just possible, not likely.

At this point in history, it's highly unlikely that any government or private company is going to invest the hundreds of billions of dollars required to get astronauts to Mars and back, when the chances of failure and crew mortality are as high as they currently are. Current propulsion technologies means a crewed Mars mission will take at least two years – and if you wanted to stay at Mars for more than a quick flag plant, it will be more like three years. Either way, two or three years is ample opportunity for all sorts of things to go wrong, on a mission where you have to take everything you need with you.

And apart from the mission infrastructure deteriorating over time, the astronauts health will also deteriorate under prolonged zero G and exposure to cosmic rays. There are theoretical solutions to these issues, but such solutions are barely on the drawing board, let alone flight-tested, and would require a radical departure from any spacecraft designs that are currently in production. Details are sketchy on NASA's Deep Space Transport vehicle, but it certainly won't have rotation-induced gravity. At the moment it's looking like an Orion capsule with a larger inflatable habitat module attached. It's assumed that the Mars-bound astronauts will get by much as ISS astronauts do, doing lots of exercise to counter the musculoskeletal and cardiovascular effects of zero-G, though that may not help with other effects of zero-G, for example its effect on vision.

The Cheap Astronomy research department couldn't find any details on enhanced-shielding options for the mission either. The standard Orion capsule has a radiation sensor, intended to detect a burst of increased radiation say from a solar flare. The crew are meant to then huddle together, surrounding themselves with stowage bags to create a makeshift shelter. There's talk of a more permanent emergency retreat compartment planned for the DST, but none of this thinking deals with the constant background flow of the generally-more-harmful galactic cosmic rays.

So, you have to wonder whether the agencies saying they will go to Mars in the 2030s really believe it themselves. NASA has a number of webpages covering a range of issues needed for a mission Mars that aren't obviously part of the 2037 mission plan. For example, using nuclear thermal propulsion and using nuclear fission generators to maintain power on the global dust-storm-prone Martian surface. These are good ideas that the Chinese may be considering also. Other even less talked about mission components are a Martian lander and the key issue of how it will carry sufficient fuel to manage both the landing and subsequent launch. Landing with its launch fuel on board looks like too much mass so sourcing fuel from Mars itself is being talked about as the best option available. So sure, we could go to Mars in the 2030s and maybe even land, whether we could take off again is an open question – as is what kind of shape the astronauts might be in at the end of such a mission. Of course, a lot of development can be achieved in 16 years, but only so much