Matthew Johnson's Terraforming Method
written by Matthew Johnson on January 24, 2004

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The terraforming of Mars has been a subject of interest for many years now, and it has given birth to a great many theories, methods and opinions. I have studied terraforming for over 4 years now, reading up on the subject in books and on the Internet. I have seen a great many good ideas, but have also seen a number of ideas that could use improvement. I now have an eclectic terraforming method I feel will guarantee success, be fairly swift and utilize all the best ideas out there.

Today, Mars is a hostile planet. It is colder than Antarctica, dustier than an ancient tomb and dry as a bone. The air is void of oxygen, barely has nitrogen, is mostly carbon dioxide and too thin for any terran organism to breath or effectively photosynthesize. All of these can be dealt with, given enough time and ingenuity. But before terraforming can begin, we must first study the planet onsite for 20 or 30 years to make sure we understand what we're going to be changing. This will also allow us to find sources of water, minerals, elements and other things that will be necessary.

To start terraforming, the thin and stormy air must be dealt with. The Martian air is only 10 millibars and the eccentric orbit makes the temperature in the south drop enough in the winter to freeze CO2, which then causes great storms when it sublimates again in the spring. The CO2 Deposition-Sublimation Cycle will keep Mars in its global dust storms every year, preventing effective terraforming by starving plants of precious sunlight. So, factories that generate PFCs must be built to give Mars several parts per million of these powerful, yet otherwise environmentally friendly, insulating gases. Once this is done, the planet will no longer have seasonal variations that result in global dust storms, allowing the possibility for plants to survive.

Once the dust storms are no more, other benefits will also exist. Currently, the southern ice cap is mostly dry ice, which is CO2. When the planet is warmed, all the dry ice will sublimate and thicken the atmosphere. Exactly how much, I am not sure, but it is certain to be at least a few dozen millibars considering the size of the ice cap. This will be enough for efficient photosynthesis and if the air is heavy enough, standing water will also be possible.

Even if algae, moss and lichen can survive in a few dozen millibars of CO2, they will still eventually need standing water, rain, ice and snow to survive and spread and animals will need thicker air. Because Mars' gravity is less than 0.66 Gs, it lost its old atmosphere over billions of years, so we cannot create a suitable planet with Mars' own supply of gases. Asteroids and comets (preferably the latter) rich in ammonia and ice must be brought to Mars to supplement its supply of nitrogen and oxygen. A single comet could add 50 millibars or so, so only a dozen or so will be necessary. And since comets are made of hydrogen-rich compounds, they are made of the fuel necessary to move them. They can either be grazed against the atmosphere and boil away, or be directed at Mars and blown into very tiny and harmless pieces. Either way is good, it doesn't matter.

This method will also be good for supplementing Mars' supply of water. Right now, Mars' local supply will not make for expansive coverage and will leave most of the planet rather dry. This is problematic because The Tharsis Bulge, taking up some 30% of the surface, will remain unchanged due to sheer height. Adding vast deserts to this will leave Mars very little habitable land. The northern plains, Mariner Valley, Hellas and Argyre should all be filled to their rims, which will give Mars much higher water coverage. Also, Borealis, Hellas and Argyre should be connected by wide and deep canals to allow water to flow freely between them. This would prevent possible fluctuations in the depths of Hellas and Argyre, which would cause fluctuations in the already extreme southern hemisphere.

Once the air is thick enough to hold a decent amount of heat and standing water exists, terraforming can progress much easier. Rain and snowfall will wash the dust out of the air and the salt into the growing water bodies. Wet soil will allow rapid growth of bacteria, algae, moss, lichen and fungi, making the soil richer in organic nutrients. This will open the way for more advanced plants, such as grass, shrubs and trees, which will anchor the soil and stop the planet-wide frequent mudslides.

Once the more advanced plants are introduced, Mars will be nearing an Earthlike status. The oxygen levels at this time should allow for various kinds of insects and bugs and quite possibly, small birds. The addition of animals will bring stability to O_2-CO_2 levels and further increase productivity. As oxygen levels rise, more advanced animals can be introduced, finally ending with humans.

This entire process could easily take less than 200 years. The initial PFC production could take only a couple decades. The comets will probably take over 50 years. The remaining century or so is up to biology and the little tweaks we give it. This timetable could even be shaved in half with an aggressive space program to get those comets and advanced bioengineering to create good initial organisms.

Mars’ Low Gravity: Paraterraforming Better?

Mars is 52% the diameter of the Earth and 10% as massive, giving it a surface gravity of 0.38 Gs, nearly two-fifths. At the temperatures we hope to make Mars, the gravity necessary to hold the necessary gases is about 0.66 Gs, so we have a problem. Mars lost much of its atmosphere over the last 4 billion years and nontrivial losses may occur within a timeline quite relevant to the planet. So what do we do?

One option would be to top off the air once in a while, but this has a number of issues. Constantly adding small amounts to counteract the loss would likely be rather expensive, as it would require lots of shuttles or something similar, so that’s out. Adding a large quantity, i.e. a new comet every few centuries or thousand years, would cause severe disruptions to the weather, possibly cataclysmic to a living world, so this too is risky.

All we know is that Mars won’t retain its atmosphere in the long run, so we must take this into consideration. But if topping off the air is so troublesome, what can we do? Paraterraforming may be the answer, putting a roof over the planet to contain the air. We’ve had the materials technology to do this with support towers spaced every few kilometers for several decades now, so we certainly could do it. More advanced materials like nanotubes could do the job with only a few larger towers, possibly by the end of the century.

If we were to put a roof over Mars, most of the above information is still valid, but a few changes must be made. First, the sun on Mars must be blocked out so as to totally freeze its current air and all the air imported from comets. This could be done with a large mirror that instead of directing more sunlight onto Mars, it reflected it away. Once Mars is an airless world coated with frozen gases, the towers must be built and the transparent roof constructed. To create an Earthlike meteorology, the roof should be at least 10 miles high, higher is possible. Once the ceiling is built, the sun is allowed to shine again and warm the frozen gases, creating an atmosphere and standing. Local biology does the same stuff as in terraforming, so everything progresses from here the same way.

Not only would this method stop slow escape of gases, but it would also decrease the amount of gases needed to get the job done. The only risk here is meteor punctures, but it would take a very large tear or impact to pose a significant threat. All that is needed to keep everything safe is a repair system constantly poised to fix holes, just as though Mars were an giant orbital habitat. Paraterraforming will fix the long-term problems of terraforming, but will likely add a century or two to total project time. And if the atmosphere is to be kept at bay by freezing it, a modular progression will not be possible. If we go this path, we will have to stick with the moon and orbital habitats until it is finished.

Mars’ Lack of a Major Moon

Unlike Earth, but quite like the other rocky planets, Mars has no major moon. Since large moons act as stabilizers for their planet, Earth enjoys relatively slight changes in axial tilt over the years, providing a stable climate. Without a moon, Mars has and always will experience extreme changes in tilt, making for a chaotic climate in the long run. There is however, nothing we can do about this.

There aren’t enough asteroids to build even the smallest possible moon, and we need those asteroids to build orbital habitats. As for moving another moon or large asteroid like Ceres, it is out of the question. The energy it would take to accurately move such things is beyond us at this time and the possible consequences too risky. We shall either have to give up on Mars and live exclusively on Earth and orbital habitats, or choose to risk Mars’ inevitable climate swings.