Superior Super Earths

November 30 2009, by Leslie Mullen

Astronomers are finding a variety of planets orbiting distant stars in the galaxy. Image credit: German Aerospace Center (DLR)

Super Earths are named for their size, but these planets - which range from about 2 to 10 Earth masses - could be superior to the Earth when it comes to sustaining life. They could also provide an answer to the 'Fermi Paradox': Why haven't we been visited by aliens?

Astronomers have discovered hundreds of Jupiter-like planets in our galaxy. However, a handful of the planets found orbiting distant stars are more Earth-sized. This gives hope to astrobiologists, who think we are more likely to find life on rocky planets with liquid water.

The rocky planets found so far are actually more massive than our own.

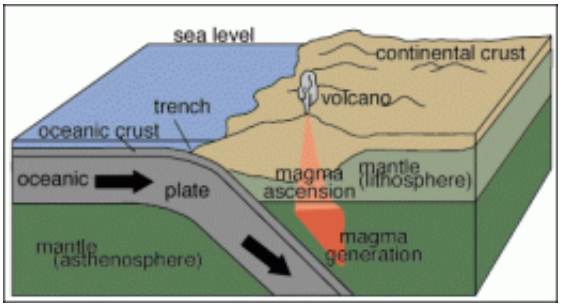
Dimitar Sasselov, professor of astronomy at Harvard University, coined the term “Super-Earths” to reflect their mass rather than any superior qualities. But Sasselov says that these planets - which range from about 2 to 10 Earth masses - could be superior to the Earth when it comes to sustaining life.

On Shaky Ground

It is said that 99 percent of all species that ever lived have gone extinct. Earth, it seems, is a tough place to call home. Our planet has gone through Ice Ages and global warming trends, it has been hit by comets and asteroids (leading, in one case, to a mass extinction that felled the mighty dinosaurs), and the amount of oxygen in the atmosphere has risen and fallen over time. Our planet is always in a state of flux, and life must adapt to these changes or die.

The shifting of tectonic plates is another example of Earth’s restless nature. Continents bang together, forming mountains, only to be later torn apart. Islands grow from underwater volcanoes, and elements are liberated from rocks when they are melted beneath the crust.

While all this geologic activity makes us literally stand on shaky ground, scientists have come to believe that tectonics is one of the key features of our planet which makes life possible. If not for tectonics, carbon needed by life would stay locked within rocks.



Tectonics have reshaped the surface of our planet and altered the atmosphere over time. Scientists now think tectonics may be necessary for life to emerge on a planet. Image credit: USGS

The fear today is that too much carbon dioxide in the atmosphere will lead to global warming. Yet too little carbon dioxide in the atmosphere would make Earth a much colder place, and the photosynthetic plants and algae that rely on CO2 would perish. The demise of these oxygen-producing organisms would leave us all gasping for breath.

According to Sasselov, Earth's mass helps keeps tectonics in action. The more massive a planet, the hotter its interior. Tectonic plates slide on a layer of molten rock beneath the crust called the mantle. Convective currents within the mantle push the plates around. For smaller planets like Mars, the interior is not hot enough to drive tectonics.

Super Earths, with a larger and hotter interior, would have a thinner planetary crust placed under more stress. This probably would result in faster tectonics, as well as more earthquakes, volcanism, and other geologic upheavals. In fact, Sasselov says the plate tectonics on Super Earths may be so rapid that mountains and ocean trenches wouldn't have much time to develop before the surface was again recycled.

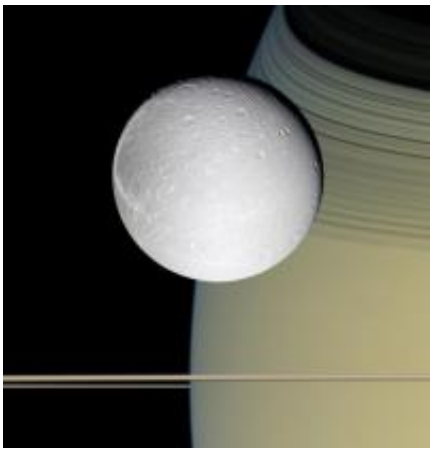
Venus, only slightly less massive than Earth, has had a great deal of volcanic activity, but it does not appear to have tectonics. This may be because low mass planets need water to lubricate the process, and Venus lost its water long ago through evaporation. Sasselov says Earth has just enough water for tectonics to work. Tectonics on Super Earths might be so efficient that water isn't even needed.

On the other hand, it's possible that a SuperEarth could be entirely covered by water. Sasselov says that in the case of such an ocean world, most of the water will be in an exotic state known as iceVII -- a very compressed, hard ice with a melting point above 212 degrees Fahrenheit (100 degrees Celsius).

Whether made of rock or ice, Sasselov says Super Earths will be only 1 or 2 times the actual size of Earth because they become densely compressed as they gain mass. This higher density will result in greater gravity. Sasselov says the most massive Super Earth would have about 3 times the gravity of Earth. Tests of human resistance to vertical G-force, where the blood is pulled down to the legs, have found the typical person can tolerate up to 5 Gs before losing consciousness. So while you might feel much heavier walking on a Super Earth, the extra gravity wouldn't be beyond what human explorers could endure. Of course, any life that evolved on a Super Earth would be adapted to the greater gravity, just as a human feels comfortable on the 1 G surface of Earth.

Habitable Hot Spots

This greater gravity means a Super Earth can easily hold onto an atmosphere, so it would not end up with a tenuous atmosphere like Mars. But the role of a planet's atmosphere in creating prime conditions for life can be tricky. Venus has a surface temperature of nearly 900 F (480 C) due to the thick greenhouse atmosphere that doesn't let heat escape.



Like Saturn's moon Dione, a Super-Earth could be entirely covered in water ice. Image Credit: NASA/JPL/Space Science Institute

One of the biggest influences on a planet's climate is the star it orbits. Earth has a circular orbit 150 million kilometers away from the Sun, a yellow dwarf star. This helps keep conditions warm enough so that our oceans don't freeze over, but cool enough so that we don't lose all our water through evaporation.

The Super Earths discovered so far orbit a variety of stars. The first Earth-like extrasolar planets ever found orbit a pulsar, a rotating neutron star that emits high energy radiation. The other Super Earths orbit stars that are smaller and cooler than our Sun.

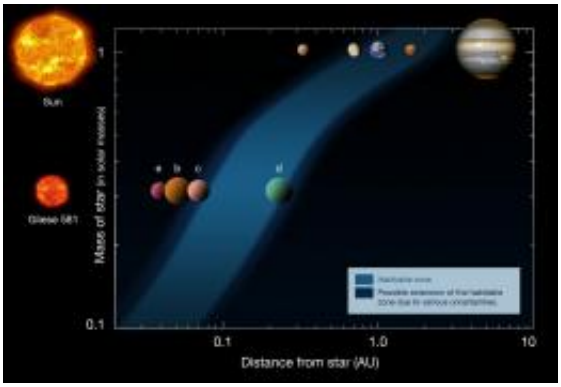
Most of the known Super Earths are very close to their stars, closer than the planet Mercury is to the Sun. Even though these stars don't burn as brightly as our Sun, the planets are so close they are like burnt cinders flickering close to a fire.

One such hot Super Earth is CoRoT 7-b (named for the CoRoT telescope that was used to locate the planet). CoRoT 7-b orbits the orange dwarf star TYC 4799-1733-1 once every 20 hours. This planet is

nearly 5 times the mass of Earth, but is less than twice as big. This solar system has another hot Super Earth, CoRoT-7c, which is 8 times as massive as Earth and circles the star in 3 days and 17 hours.

For astrobiologists hoping to find alien life, two Super Earths orbiting the star Gliese 581 have potential. Gliese 581, a red dwarf star, is cooler than our Sun. Based on their orbit around this star, planets Gliese 581-c and Gliese 581-d are thought to have habitable conditions, although some think planet "c" might have a runaway greenhouse atmosphere like Venus.

Another aspect affecting the potential for life is the presence of a companion moon. Earth's Moon helps balance our planet's rotation on its axis. Sasselov notes that a Super Earth's extra mass would give it a very stable rotation, so a moon would not be needed to help keep the planet in line.



This diagram shows the distances of the planets in our solar system (upper row) and in the Gliese 581 system (lower row), from their respective stars (left). The habitable zone is indicated as the blue area. Image Credit: ESO

Superior Alien Civilizations

Missions like the Kepler space telescope, launched just this year, could help astronomers find many Earth-like planets in the years to come. Sasselov estimates there could be a hundred million habitable Super Earth planets just in our Milky Way galaxy. He predicts we'll find 50 to 100 Super Earth planets in the next 5 years.

The existence of so many Super Earths could explain the "Fermi Paradox" of why aliens have not contacted us. If our lower mass planet does not have the ideal conditions for life, alien explorers would be less likely to look to us, choosing instead to target the many Super Earths in the galaxy.

"Earth is a marginal planet when it comes to conditions we would like to see for complex life to sustain itself," Sasselov notes. "In the family of Earth-like planets, the sweet spot for complex chemistry and biochemistry to emerge and sustain itself lies in planets larger than the Earth."

If aliens on Super Earths ever decided to investigate Earth to see if such a tiny world could harbor life, they would have a harder time sending rockets into space because of the higher gravity on their planet. "This could be another answer to the Fermi Paradox," says Sasselov, "but it's not an insurmountable problem." It could even be that because of their deeper gravity well, aliens living on Super Earths would have to develop a technology superior to our chemical rockets in order to explore the universe.

Sasselov's own suggestion for the Fermi paradox relates to the age and evolution of planets in the universe. When the universe was young, only hydrogen and helium were available. Generations of stellar evolution were needed to produce the heavier elements, such as silica and iron, which build rocky planets. Even though the universe is approximately 14 billion years old, our solar system only formed about 4.6 billion years

ago. (Astronomers did find a 12.7-billion-year-old Jupiter-mass object in our galaxy, but Sasselov thinks this so-called ancient planet could instead be the remnant of a red or brown dwarf star that was stripped of some of its mass.)

If other rocky worlds with life are about as young as we are, then perhaps the lack of visiting spaceships indicates there are no ancient, highly advanced alien civilizations out there.

“Most life emerges on Super-Earths with habitable potential, but Super-Earths started forming in the galaxy only relatively recently, and few technical civilizations have managed to emerge since,” Sasselov says.

Source: Astrobio.net, by Leslie Mullen