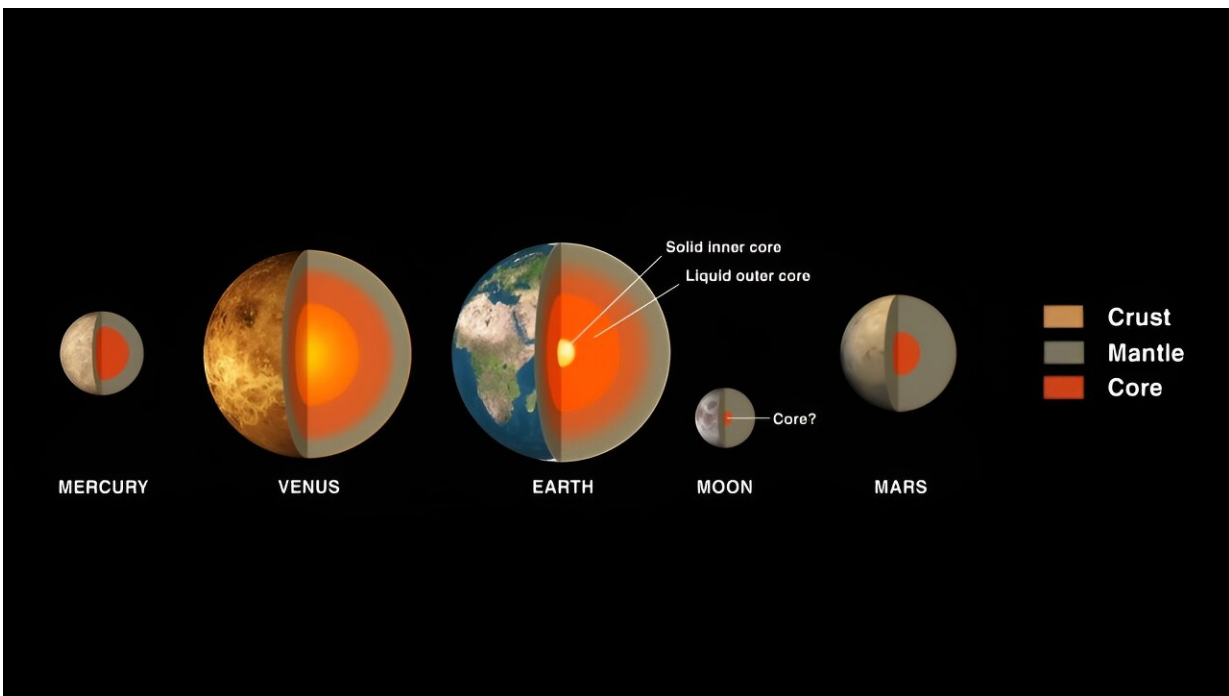


Planetary geophysics: What is it? What can it teach us about finding life beyond Earth?

March 19 2024, by Laurence Tognetti



Artist's illustration of terrestrial (rocky) planet interiors. Credit: NASA

Universe Today has examined the importance of studying impact craters, planetary surfaces, exoplanets, astrobiology, solar physics, comets, and planetary atmospheres, and how these intriguing scientific disciplines can help scientists and the public better understand how we are pursuing life beyond Earth.

Here, we will look inward and examine the role that planetary geophysics plays in helping scientists gain greater insight into our solar system and beyond, including the benefits and challenges, finding life beyond Earth, and how upcoming students can pursue studying planetary geophysics. So, what is planetary geophysics and why is it so important to study it?

"Planetary geophysics is the study of how planets and their contents behave and evolve over time," Dr. Marshall Styczinski, who is an Affiliate Research Scientist at the Blue Marble Space Institute of Science, tells Universe Today. "It is essentially the study of What Lies Below, focusing on what we can't see and how it relates to what we can see and measure. Most of the planets (including Earth!) are hidden from view—geophysics is how we know everything about the Earth below the deepest we have dug down!"

As its name implies, geophysics is the study of understanding the physics behind [geological processes](#), both on Earth and other planetary bodies, with an emphasis on interior geologic processes. This is specifically useful for planetary bodies that are differentiated, meaning they have several interior layers resulting from heavier elements sinking to the center while the lighter elements remain closer to the surface.

The planet Earth, for example, is separated into the crust, mantle, and core, with each having its own sub-layers, and understanding these interior processes help scientists piece together what the Earth was like billions of years ago and even make predictions regarding the planet's environment in the far future.

These interior processes drive the surface processes, including volcanism and plate tectonics, both of which are responsible for maintaining the Earth's temperature and recycling materials, respectively. So, what are some of the benefits and challenges of studying planetary geophysics?

Dr. Styczinski tells Universe Today, "Geophysics gives us the tools to determine what exists beneath the visible surface of planetary bodies (planets, moons, asteroids, etc.). It's our only way to learn about what we can't see! Finding out what is inside a planet, and under what conditions, like how much pressure and heat for each layer, helps us build a history for the planet and know how it will continue to change over time."

In contrast, Dr. Styczinski also emphasizes to Universe Today the challenges, noting the difficulty in reproducing geologic conditions that occur over millions of years, even with the most sophisticated laboratories in the world, due to their slow movements over vast amounts of time. Additionally, he notes that [particle accelerators](#) are sometimes required to reproduce the extreme conditions within gas giants, which are also differentiated, though with gas and liquid layers, as opposed to rock.

But Earth is not the only rocky world in our solar system that exhibits differentiation, as all four rocky planets (Mercury, Venus, Earth, and Mars) exhibit some form of interior layering that has occurred over billions of years, though at smaller scales due to their sizes. In addition to the planets, many rocky moons throughout the solar system also exhibit differentiation, including Jupiter's Galilean moons, Io, Europa, Ganymede, and Callisto, and several of Saturn's moons, including Titan, Enceladus, and Mimas.

Of those moons, Europa, Titan, and Enceladus are currently targets for astrobiologists, as Europa and Enceladus have been confirmed to possess interior liquid water oceans, with Titan presenting strong evidence, as well. Additionally, Titan is the only moon with a dense atmosphere, and like Earth, it likely has interior geophysics driving it. But what can planetary geophysics teach us about finding life beyond Earth?

"We've learned from studying Mars that the surfaces of planets can be

quite hostile to life as we know it," Dr. Styczinski tells Universe Today. "If and when we are able to find life elsewhere in the solar system that we didn't bring there ourselves, it will probably be found beneath the surface, where it can be protected from the harsh environment at the surface. Geophysics gives us the means to plan for expeditions into the subsurface, and the only method of finding liquid water that's hidden from view on icy moons. These are the best places we know of to look for life beyond Earth."

The reason why the surface of Mars is inhospitable to life as we know it is due to its lack of a thick atmosphere, which is responsible for preventing the sun's charged particles in the solar wind from reaching the planetary surface. While Mars once had a powerful [magnetic field](#), Dr. Styczinski notes to Universe Today that "Some researchers think magnetic fields can actually strip away the atmosphere", while quickly noting this "is a topic of fierce debate." Mars once had a thicker atmosphere, which was lost along with its magnetic field over billions of years as the Red Planet's interior cooled.

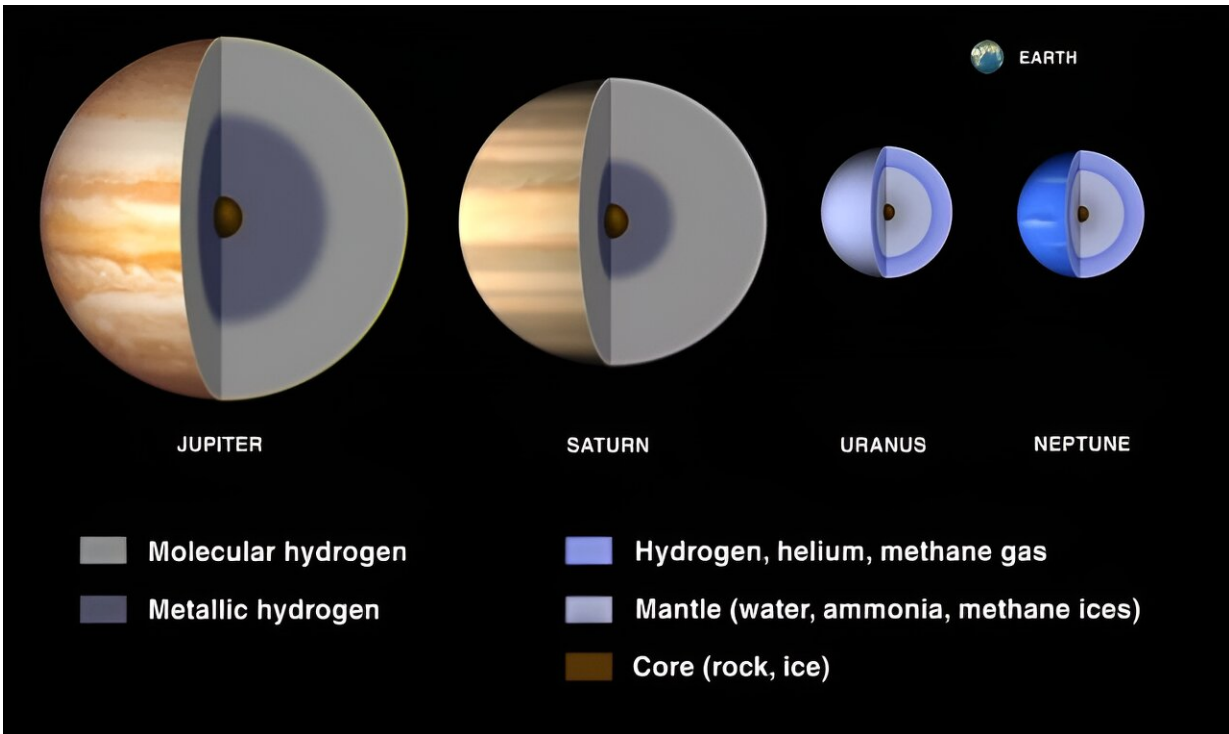
In addition to our solar system, Dr. Styczinski tells Universe Today that planetary geophysics also does an excellent job of helping scientists better understand exoplanets, specifically multi-planet systems like our own. While no exoplanet surface has yet been imaged, better understanding the geophysical processes of planetary bodies within our solar system helps scientists gain insights into how these same processes could occur on planets throughout the cosmos, including the magnetic field, as well.

A planet's magnetic field is driven by the internal processes occurring in its outer core, which for Earth is comprised of churning, liquid metal fluid, whereas the inner core is a solid ball of compressed metal. As this [outer core](#)'s fluid churns and circulates, it creates electrical currents that produce the massive magnetic field that envelopes our small, blue world

in a bubble of protection from harmful space weather.

The Earth's magnetic field traps charged particles in radiation belts in space nearby. The way the magnetic field protects our planet can be seen during magnetic storms from the sun, when the magnetosphere bends and flexes in response, sending particles from these radiation belts close to the surface in the high northern and southern latitude regions. There, they interact with the Earth's atmosphere to produce the breathtaking auroras often observed in Alaska, the Nordic countries, and Antarctica.

However, while the Earth's magnetic field is impressive, it's only fitting that the largest planet in the solar system, Jupiter, equally has the largest magnetic field, whose "tail" extends as far as Saturn's orbit, or approximately 400 million miles. Additionally, the internal processes responsible for generating magnetic fields on gaseous planets like Jupiter, Saturn, Uranus, and Neptune could be starkly different than on Earth. Therefore, given all of these variables and processes, what is the most exciting aspect of planetary geophysics that Dr. Styczinski has studied during his career?



Artist's illustration of gas giant interiors. Credit: NASA/Lunar And Planetary Institute

"The part of planetary geophysics that I find the most exciting is using the invisible magnetic field to sense subsurface oceans," Dr. Styczinski tells Universe Today. "I continue to be blown away by how it all works when I really think about it. Salty ocean waters partially reflect the fields they are exposed to from their parent planet, as in Jupiter and its moon Europa. We use these measurements along with laboratory studies here on Earth and geophysics to understand the material layers inside Europa to work out the properties of the ocean. It still blows my mind that this process works as well as it does."

Like most scientific fields, planetary geophysics encompasses a myriad of scientific disciplines and backgrounds with the goal of answering the

universe's toughest questions through constant collaboration and innovation. Geophysics is a combination of geology and physics but also incorporates mathematics, chemistry, [atmospheric science](#), seismology, mineralogy, and many others with the goal of better understanding the interior processes of the Earth and other planetary bodies throughout the [solar system](#) and beyond. Therefore, what advice can Dr. Styczinski offer upcoming students who wish to pursue studying planetary geophysics?

"There are many paths into geophysics, and many different things to study and ways to study them," Dr. Styczinski tells Universe Today. "Your past studies don't have to be specific to geophysics or even involve geology at all. Perhaps the most productive move you can make is to ask for help, especially from someone studying a topic that interests you. Computer programming skills are invaluable. I recommend learning Python—it's free and widely used all across science. There are many tutorials available, also for free. While not all geophysics will require a lot of programming, I think all geophysicists will benefit from having those skills."

Provided by Universe Today

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