Cloudy with a chance of pebble showers: Simulation suggests rocky exoplanet has bizarre atmosphere

September 29 2009, By Diana Lutz

The exoplanet COROT-7b is close enough to its star that its "day-face" is hot enough to melt rock. Theoretical models suggest the planet has an atmosphere of the components of rock in gaseous form and lava or boiling oceans on its surface. Image by ESO/L. Calcada. The original file can be found at www.eso.org/gallery/v/ESOPIA/illustrations/phot-33a-09-fullres.tif.html

(PhysOrg.com) -- So accustomed are we to the sunshine, rain, fog and snow of our home planet that we find it next to impossible to imagine a different atmosphere and other forms of precipitation.

To be sure, Dr. Seuss came up with a green gluey substance called oobleck that fell from the skies and gummed up the Kingdom of Didd, but it had to be conjured up by wizards and was clearly a thing of magic.

Not so the atmosphere of COROT-7b, an exoplanet discovered last February by the COROT space telescope launched by the French and European space agencies.

According to models by scientists at Washington University in St. Louis, COROT-7b's atmosphere is made up of the ingredients of rocks and when "a front moves in," pebbles condense out of the air and rain into lakes of molten lava below.

The work, by Laura Schaefer, research assistant in the Planetary Chemistry Laboratory, and Bruce Fegley Jr., Ph.D., professor of earth and planetary sciences in Arts & Sciences, appears in the Oct. 1 issue of *The Astrophysical Journal*.

Astronomers have found nearly 400 extra-solar planets, or exoplanets, in the past 20 years. But because of the limitations of the indirect means by which they are discovered, most are Hot Jupiters, chubby gas giants orbiting close to their parent stars. (More than 1,300 Earths could be packed inside Jupiter, which has 300 times the mass of Earth.)

COROT-7b, on the other hand, is less than twice the size of Earth and only five times its mass.

It was the first planet found orbiting the star COROT-7, and orange dwarf in the constellation Monoceros, or the Unicorn. (This priority is designated by the letter b.)

Solid as a Rock

In August 2009 a consortium of European observatories led by the Swiss reported the discovery of COROT-7c, a second planet orbiting COROT-7.

Using the data from both planets, they were able to calculatethat COROT-7b has an average density about the same as Earth's. This means it is almost certainly a rocky planet made up of silicate rocks like those in Earth's crust, says Fegley.

Not that anyone would call it Earth-like, much less hospitable to life. The planet and its star are separated by only 1.6 million miles, 23 times less than the distance between the parboiled planet Mercury and our Sun.

Because the planet is so close to the star, it is gravitationally locked to it in the same way the Moon is locked to Earth. One side of the planet always faces its star, just as one side of the Moon always faces Earth.

This star-facing side has a temperature of about 2600 degrees Kelvin (4220 degrees Fahrenheit). That's infernally hot—hot enough to vaporize rocks. The global average temperature of Earth's surface, in contrast, is only about 288 degrees Kelvin (59 degrees Fahrenheit).

The side in perpetual shadow, on the other hand, is positively chilly at 50 degrees Kelvin (-369 degrees Fahrenheit).

Perhaps because they were cooked off, COROT-7b's atmosphere has none of the volatile elements or compounds that make up Earth's atmosphere, such as water, nitrogen and carbon dioxide.

"The only atmosphere this object has is produced from vapor arising from hot molten silicates in a lava lake or lava ocean," Fegley says.

What might that atmosphere be like? To find out Schaefer and Fegley have used thermochemical equilibrium calculations to model COROT-7b's atmosphere.

The calculations, which reveal which mineral assemblages are stable under different conditions, were carried out with MAGMA, a computer program Fegley developed in 1986 with the late A. G. W. Cameron, a professor of astrophysics at Harvard University.

Schaefer and Fegley modified the MAGMA program in 2004 in order to study high-temperature volcanism on Io, Jupiter's innermost Galilean satellite. This modified version was used in their present work.

Raining Rocks

Because the scientists didn't know the exact composition of the planet, they ran the program with four different starting compositions. "We got essentially the same result in all four cases," says Fegley.

"Sodium, potassium, silicon monoxide and then oxygen — either atomic or molecular oxygen — make up most of the atmosphere." But there are also smaller amounts of the other elements found in silicate rock, such as magnesium, aluminum, calcium and iron.

Why is there oxygen on a dead planet, when it didn't show up in Earth's atmosphere until 2.4 billion years ago, when plants started to produce it?

"Oxygen is the most abundant element in rock," says Fegley, "so when you vaporize rock what you end up doing is producing a lot of oxygen."

The peculiar atmosphere has its own singular weather. "As you go higher the atmosphere gets cooler and eventually you get saturated with different types of 'rock' the way you get saturated with water in the atmosphere of Earth," explains Fegley. "But instead of a water cloud forming and then raining water droplets, you get a 'rock cloud' forming and it starts raining out little pebbles of different types of rock."

Even more strangely, the kind of rock condensing out of the cloud depends on the altitude. The atmosphere works the same way as fractionating columns, the tall knobby columns that make petrochemical plants recognizable from afar. In a fractionating column, crude oil is boiled and its components condense out on a series of trays, with the heaviest one (with the highest boiling point) sulking at the bottom, and the lightest (and most volatile) rising to the top.

Instead of condensing out hydrocarbons such as asphalt, petroleum jelly, kerosene and gasoline, the exoplanet's atmosphere condenses out minerals such as enstatite, corundum, spinel, and wollastonite. In both cases the fractions fall out in order of boiling point.

Elemental sodium and potassium, which have very low boiling points in comparison with rocks, do not rain out but would instead stay in the atmosphere, where they would form high gas clouds buffeted by the stellar wind from COROT-7.

These large clouds may be detectable by Earth-based telescopes. The sodium, for example, should glow in the orange part of the spectrum, like a giant but very faint sodium vapor streetlamp.

Observers have recently spotted sodium in the atmospheres of two other exoplanets.

The atmosphere of COROT-7b may not be breathable, but it is certainly amusing.

Provided by Washington University in St. Louis (news : web)