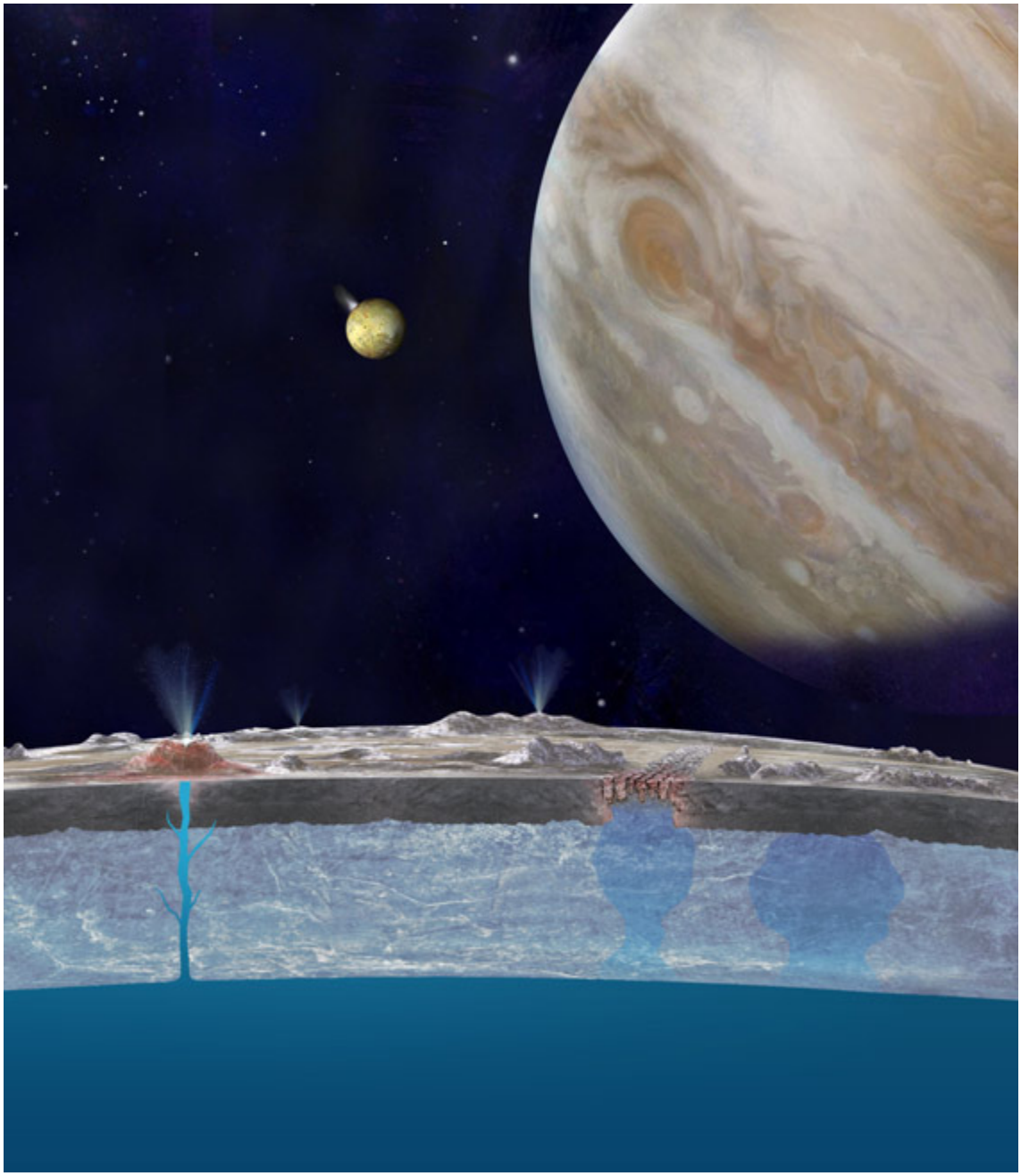
Astronomers Find Evidence of Ocean Salts on Europa's Surface.

By Phil Plait
Posted Wednesday, March 6, 2013, at 8:00 AM

Slate.com



Astronomers have found evidence of that Jupiter's moon Europa has an ocean leaking to the icy surface. Click to arthurcclarkenate. Image credit: NASA/JPL-Caltech

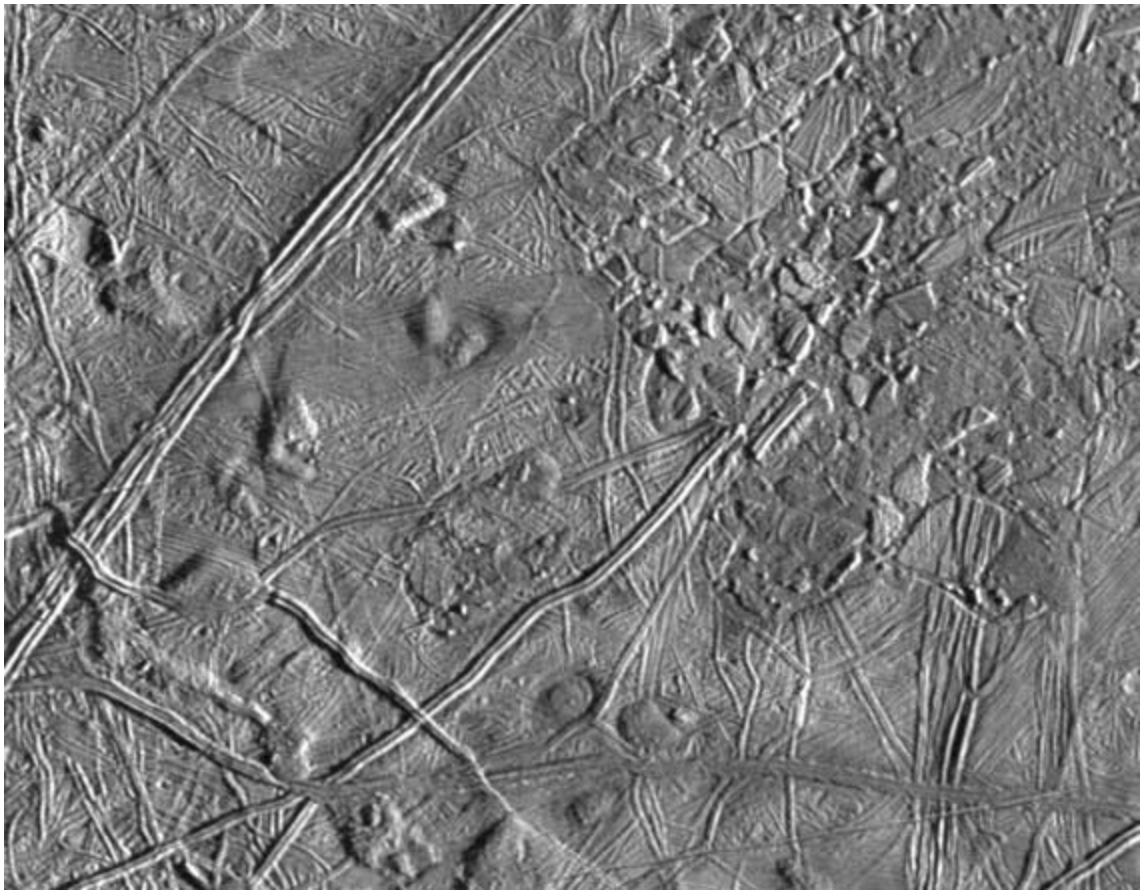
He killed Pluto, but he may have just breathed life into Europa exploration.

Astronomer Mike Brown* —discoverer of the giant outer-solar-system iceball Eris which is what started the machinery that kicked Pluto out of the planet club—has found some pretty strong evidence that Jupiter's moon Europa has sprung a leak. Its undersurface ocean may be mixing with the icy surface, making it possible to understand its composition without having to dig down through dozens of kilometers of solid ice.

Mind you, we've been eyeballing Europa's ocean as a potential habitat for life for decades. This news is not evidence of life, but it does add reason to look at Europa even more closely.

This evidence that the surface ice and undersurface ocean are in intimate contact comes in a series of steps, which I outline below. But first, you need to understand Europa. It's an iceball 3120 kilometers (1940 miles) across, about a quarter the size of Earth, roughly the same size as our Moon. There's a lot of evidence it has a global ocean about 100 kilometers deep under its icy surface: For one thing, pictures taken by probes show the surface is broken up like ice floes. There are also very few craters, meaning the surface is young, constantly resurfaced by some sort of erosion—probably shifting, grinding ice floes as they float on the ocean. There are more technical reasons to think that vast amounts of water exist under the surface as well, so most astronomers are pretty sure about this.

The water is kept liquid by heating via tidal forces, the



The Galileo spacecraft saw cracks and fissures in this "chaotic" region of Europa, evidence of a liquid ocean under the surface. Click to enfloenate. Image credit: NASA/JPL/Galileo

effects of the gravity of its massive parent planet. But what kind of water is it? Salty, acidic, pure? One hint is that Europa's density is more than that of rock, indicating it has a dense core (water is much less dense than rock, so to get such a high average density there must be a lot of rocks in its heart). When you put rocks in water they dissolve, giving up some chemicals. That makes it unlikely the ocean is fresh water.

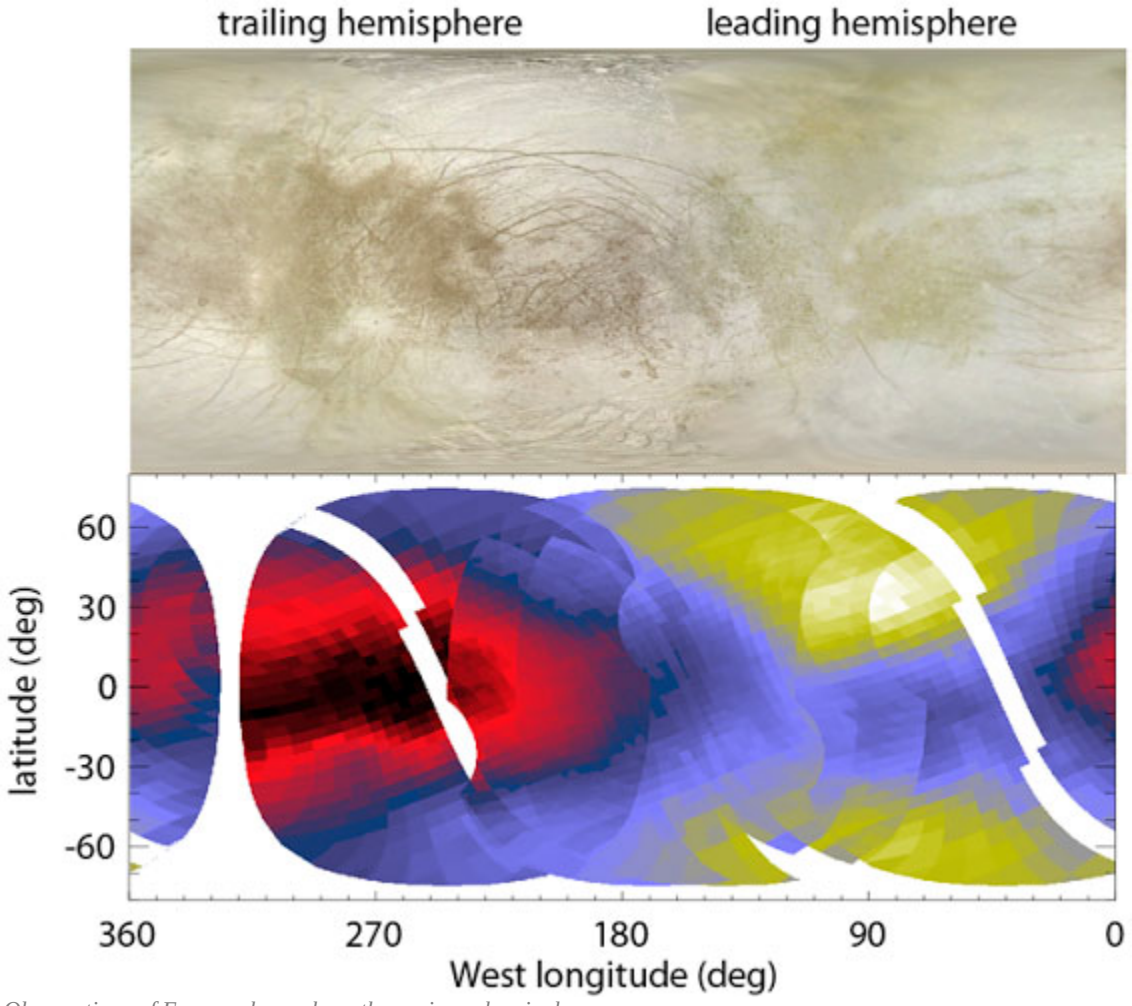
The new data taken by Brown and his colleague Kevin Hand indicate that ocean is much like Earth's: salty. Here's how they figured this out. [Note: You can skip down to the conclusion if you want, but you'll miss all the awesome Holmesian chemistry deduction. You can also read all this from Mike Brown himself on his blog.]

1. Europa orbits Jupiter in 3.5 days, and rotates at the same rate. That means, like our own Moon, one hemisphere always faces into the direction it orbits (the leading hemisphere, like the front windshield of a car) and one faces away (the trailing hemisphere, the car's back window). The chemical composition of the two halves are different: The trailing hemisphere has a lot of sulfur, while the leading half does not.
2. Io, another moon of Jupiter, has a lot of sulfur. It also has volcanoes. Those spew out sulfur, which is then swept up by Jupiter's ridiculously powerful magnetic field. Jupiter spins every 10 hours, much faster than Europa orbits. That means the magnetic field catches up with Europa, continuously slamming into it from behind, dropping sulfur there. That's why Europa's trailing hemisphere has more sulfur.
3. Brown and Hand, using the monster 10-meter Keck telescope, discovered the presence of magnesium sulfate—$MgSO_4$, a mineral called epsomite—on Europa's trailing hemisphere (but not the leading half). This has never been seen before, even by probes sent to look at the moon.
4. Magnesium? That's weird. You expect that to come from rocks, which are not present at all on the surface of Europa. The only place you find rocks is deep under the surface…where they sit in the water and dissolve out their minerals, like I said above. Huh.
5. So the magnesium started in the rocks, dissolved into the water in the undersurface ocean, somehow got to the surface, and then got slammed by all that sulfur pummeling Europa's surface by Jupiter's magnetic field. This creates the magnesium sulfate.
6. It seems unlikely that the magnesium only exists on the trailing hemisphere. Most likely it covers the whole surface, and we only see magnesium sulfate on the trailing hemisphere because that's where the sulfur is coming in from space with enough energy to make $MgSO_4$. It also wouldn't just exist as big piles of magnesium before getting hit by sulfur; more likely it would be as part of some other chemical. The ocean under the surface should have either lots of sulfur or lots of chlorine, due to the nature of the rocks in the core. Brown and Hand only saw sulfates on one side of Europa, which would be weird if sulfur's coming from under the surface—it'd be everywhere if that were the case. That means there must be more chlorine than sulfur in the water. That in turn makes it likely the magnesium comes up in the form of magnesium chloride—$MgCl_2$—what chemists call a salt (because it dissolves in water).

7. Not only that, but years earlier, Brown detected sodium and potassium in a very thin gas above the surface. An atmosphere, if you will, though very thin. That must get kicked up from the surface, maybe from radiation powered by Jupiter's magnetic field. And how do you get sodium and potassium on the surface? Most likely, again, from the undersurface ocean. Combine that with the surface being coated in MgCl2, and it's not hard to jump to the idea that the ocean is salty, with lots of sodium chloride (table salt!) and potassium chloride (convenient, if you're on a low sodium diet).
8. One more thing: Brown, along with his undergraduate research fellow at the time, Sarah Horst†, looked for magnesium in the Europan atmosphere and didn't find it. That means it must be a minor component of the surface. The reason you see it on the trailing side of the moon is because sodium sulfate and potassium sulfate are easier to blast away off the surface by radiation. There's more magnesium sulfate there because it tends to stick around better. It's like evolution. Also, as an aside, chlorides are hard to detect, which is why they aren't clearly seen anywhere on Europa. They're almost certainly there, just hard to actually see.

Got all that? No? OK, let me explain. No, there is too much. Let me sum up:

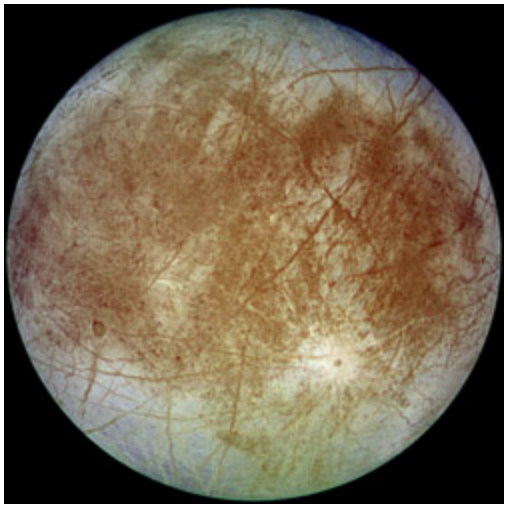
These new observations seem to indicate that there's an undersurface ocean on Europa, with salty water loaded with sodium-, potassium-, and magnesium chloride. It gets to the surface somehow, and on the trailing hemisphere gets whacked with high-speed sulfur from Io. These form sulfates. The sodium and potassium sulfates go away, leaving behind the magnesium sulfates. That's what Brown and Hand found.



Observations of Europa show where the various chemical compounds are. Yellow and white are relatively clean ice, red and black are where there is magnesium sulfate contaminating the ice, and blue is a mix of the two. Note that the sulfates are mostly in the trailing hemisphere. Image credit: Mike Brown

Also, that "gets to the surface somehow" part is intriguing. It means that the water under the surface, and the ice above it, can get mixed. Maybe it's from cracks in between the ice floes, or maybe it's from weak geysers, lazier versions of what we see from Saturn's moon Enceladus. The exact mechanism isn't known, and that will be the target for future work, no doubt. But the clear conclusion is that the liquid interior and solid exterior get mixed.

And why is this so very cool? Well, it means that if we want to find out what the ocean under Europa is made of, we don't have to punch a hole through kilometers of ice (some missions have been proposed to do just that). All we have to do is either aim better telescopes at the surface, or send more sophisticated probes to do the same. Digging would be better, of course, but may not be so urgent.



Europa's trailing hemisphere. Note how red it looks. Image credit: NASA/JPL/Galileo

And another thing. On Europa we have warm salty water, interesting chemicals (carbon-based molecules—called organic molecules—have been found on two of Jupiter's other moons, so presumably they are on Europa as well), and energy supplied both from tides and from Jupiter's crazy strong magnetic field. We have no direct evidence for life on or in Europa, but wow, the ingredients really do look like they're there, and this new observation indicates the surface and interior can mix. Between Europa and Enceladus (and maybe even Titan), the prospects for finding some sort of biological presence in our solar system outside of Earth are still very, very interesting.

* Full disclosure: Mike and I are friends. He has been to my house, and I have fed him experimental bacon and chocolate chip ice cream, which we mutually agreed was interesting but not all it could have been.

[† Correction: I originally wrote that Sara Horst was Mike's graduate student, but she was an undergraduate research fellow at the time, which, honestly, is even cooler.]