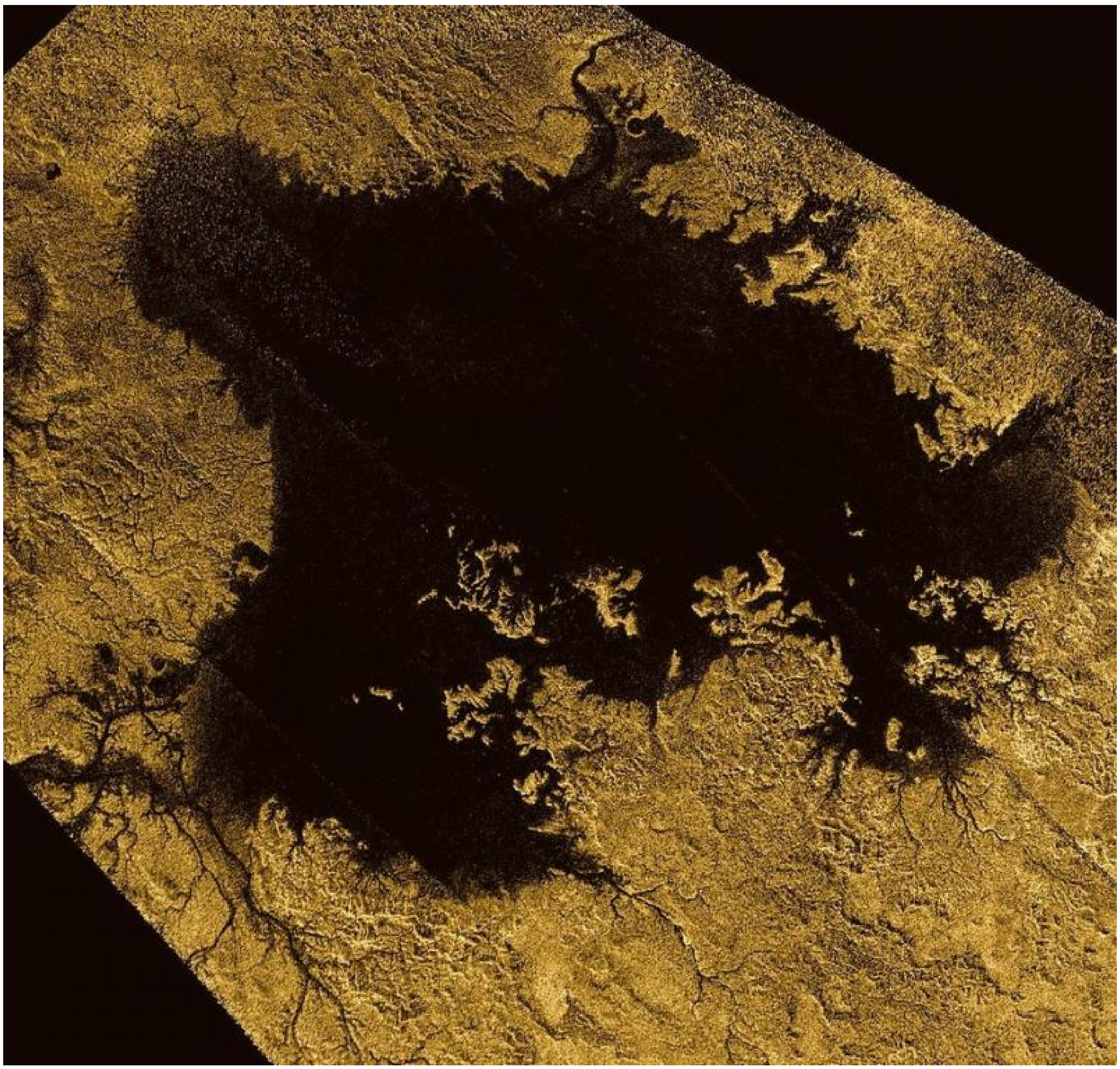
Discovering the bath scum on Titan

April 1 2016, by Helen Maynard-Casely



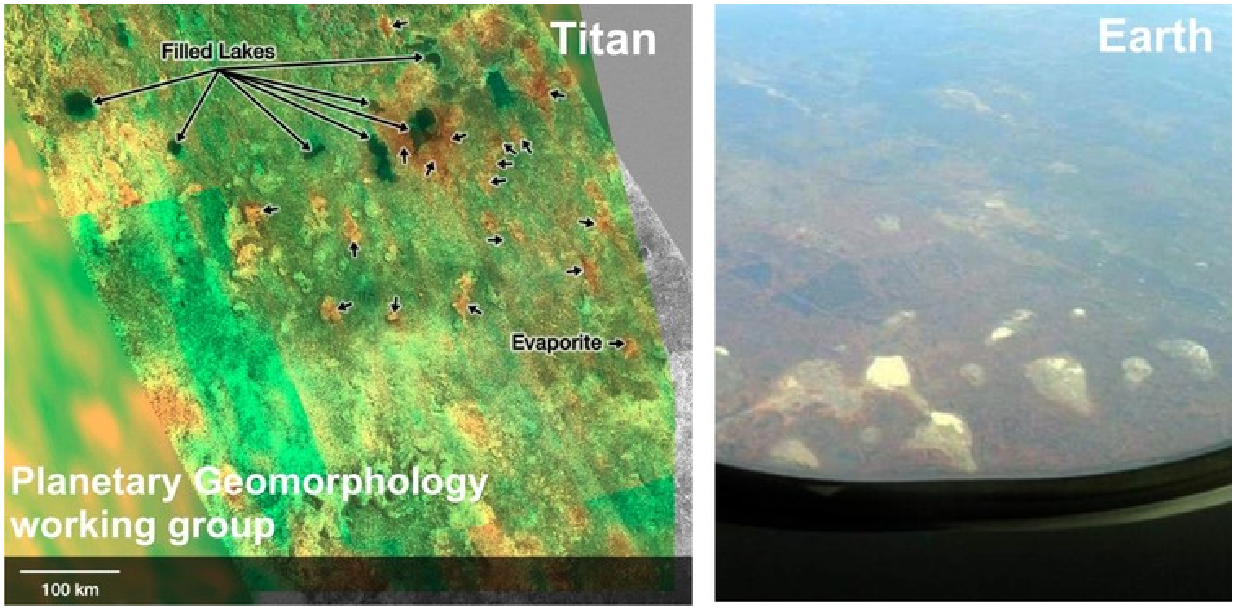
Titan's Ligeia Mare in false color. Credit: NASA/JPL-Caltech/ASI/Cornell

It's not everyday that you get to discover something new. But when you do it is a rather strange and quite brilliant feeling. You don't really cry out 'Eureka' (there's usually about a million things going about it your head pointing out how it could be wrong). When you finally conquer the 'wrong' demon and satisfy yourself that you have something new, well then you usually sit back in your chair and smile to yourself. Maybe at a push grab a cup of coffee and a celebratory chocolate bar from the vending machine. That's pretty much how I felt when I worked out the latest crystal structure I've just published, of the 'bath scum' of Titan.

The great thing about this column space is that I can use it to tell you all the back-story behind a paper, how it came about and why I think it's really exciting.

Titan, the largest moon of Saturn, is in many ways pretty similar to Earth. It's the only moon in the solar system with a substantial atmosphere, much thicker than our own. If you don't mind the cold and lack of oxygen, moving about the surface there will feel a bit like walking under water. It's pretty nice when you consider that the atmosphere most other planets and moons will barely shield you from the vacuum of space.

The other similarity with our own home is that Titan has liquid on the surface, vast lakes and seas. It's the only other place we know where you can watch the sun set into a sea (albeit very very slowly). But, where our seas are composed of water, the seas and lakes of Titan are filled with methane and ethane, which are liquid at the frigid temperatures on the surface (around -180°C). And in fact, the Cassini spacecraft and the team of scientists behind it, have gone further than just the discovery of standing liquid - they have shown that Titan has a kind of hydrological cycle.

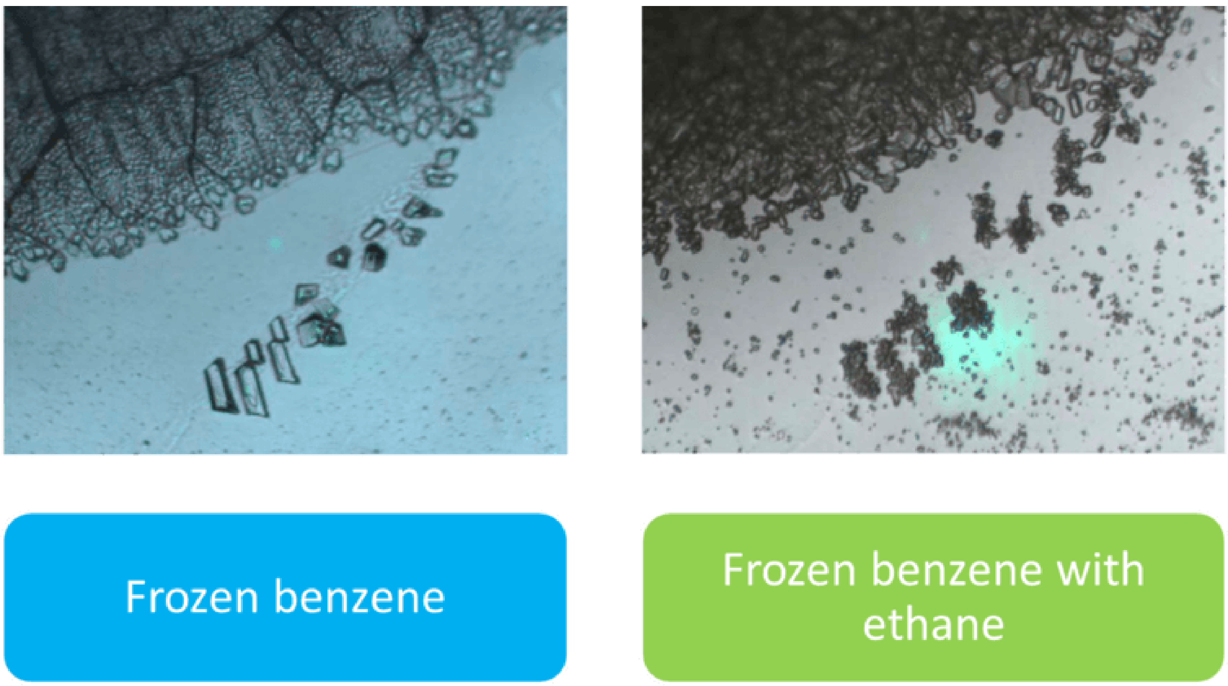


Titan surface. Credit: Left image: NASA/JPL/UA. Right Image, author.

Similar to our own on earth, with the liquid evaporating, then clouds forming and rain falling, except this liquid is methane. But there was a missing link in this cycle, there are features that look a lot like the scum left behind after a nice long hot bath - what is this stuff?

You see, Cassini has also spotted dried lakes - full of material that is different to the surrounding terrain. Again this is like something we see on Earth - you only have to look out the plane when you fly across the Australian red centre. On Earth we know what materials fill these lakes, they are salts and hydrates - materials with water trapped in their structure. But what are they on Titan? What scum gets left behind when the lakes of Titan evaporate?

The planetary ices group at NASA's Jet Propulsion laboratory were on the case. Along with liquid methane and ethane, there is a long list of solid materials that could be littering the surface of Titan. Evidence for these comes from three sources - models predicting the fallout from the atmosphere, the small windows of reflected light that make it through the thick Titan atmosphere and the was the radar from Cassini interacts with the surface.

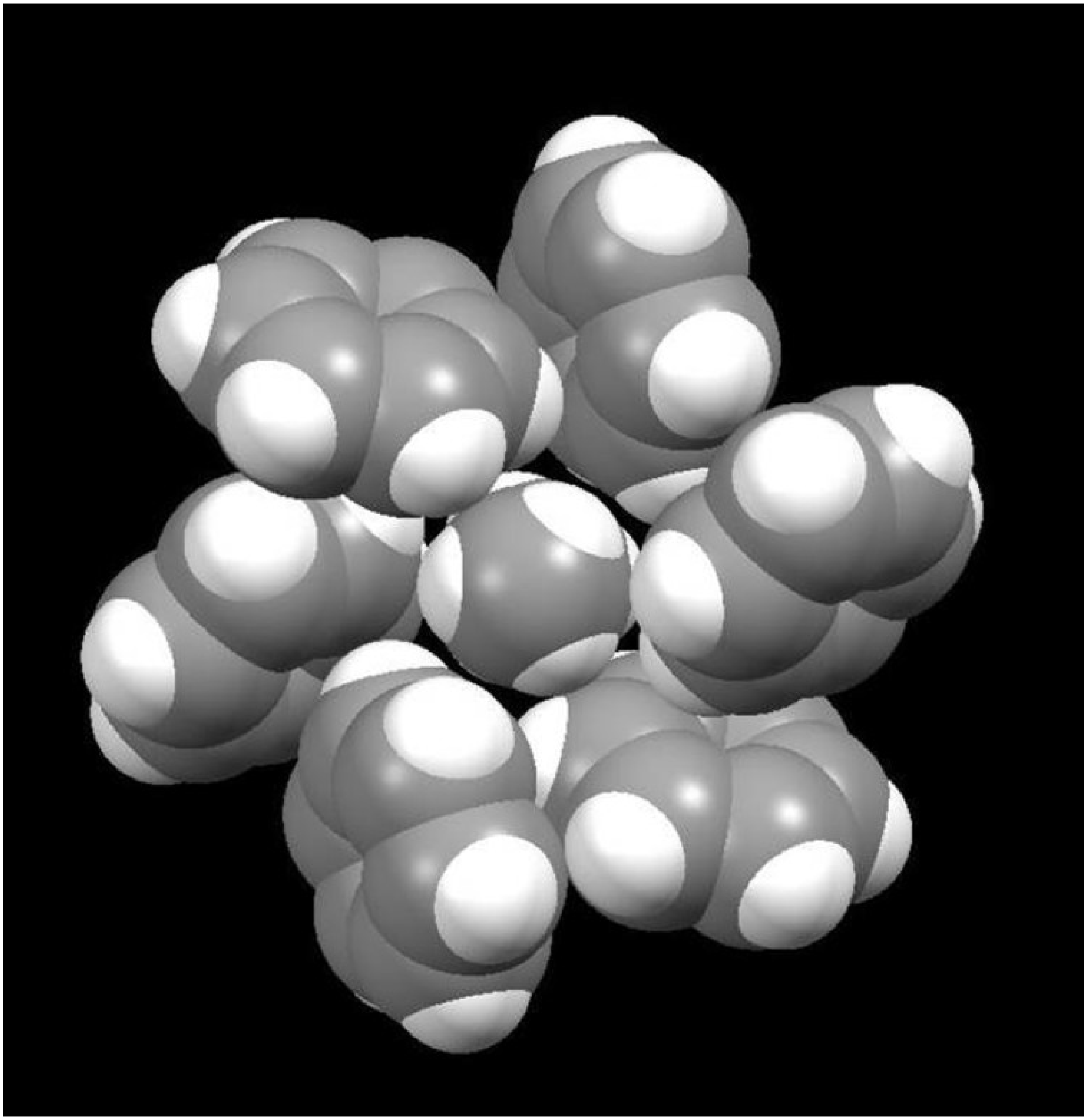


What happens when you mix benzene and ethane. Credit: JPL/Caltech

But we do also have one slightly more direct indication of surface composition, from the Huygens lander, which Cassini dispatched in 2005 to land. It sampled the atmosphere as it went down, showing peaks and troughs in concentrations of various small organic chemicals. On the surface it particularly noted a spike in benzene (a small ring organic material).

So, armed with this list of possible chemicals, the planetary ices group started picking pairs and mixing them up with methane and ethane at the chilly temperature of Titan. Any material that would form a solid with the two liquid materials in the seas would be a great candidate for the scum their colleagues had seen about the lakes. One particular result got them excited, they had evidence that ethane combined with benzene, at the chilly temperatures of Titan.

However, the evidence they had (from spectroscopy and from seeing it change under the microscope) wasn't enough to work out exactly what this new materials was - what was the proportion of benzene to ethane? How did the benzene and ethane molecules stick together to make a new material? What is the density of this new material? This last question was pretty key, as the 'magic island' had surfaced within one of Titan's lakes - could the island be made of this material?



Part of the crystal structure of the new material—a co-crystal between benzene and ethane. Credit: Helen Maynard-Casely

Now, to answer these questions the group were in search of a friendly crystallographer, who could help answer some of these questions.

Luckily for me, I happened to coincide at a conference with them - presenting my results on some structures of sulfuric acid hydrates I had worked out. They approached me after my talk and asked if I could help them with this material (and what idiot would turn down the opportunity to work with a group from NASA?).

The task then was to recreate the conditions of Titan for the benzene and ethane molecules, while firing a high-energy X-ray beam at them. Not particularly trivial, but after a lot of preparation we were about to undertake the experiment and collected some beautiful data at the Australian Synchrotron. So beautiful, I was able to tell straight away that this material was definitely new. And with a bit of help from a theorist, we were able to cement down the structure.

We found that the material, it's been named a benzene:ethane co-crystal, is too dense to be the reason that Titan's magic island pops up - but it is a remarkable structure. The benzene molecules form a channel, and the ethane molecules which are more elongated sit down these channels. You can read loads more about the structure in the paper published online today - it's open access. The structure is particularly interesting as you can see how the ethane might pop in and out of the structure. And this raises the thought, could other, similar shaped molecules, also sit in the channels?

So now we're on the hunt for more of Titan's materials, many of the chemicals spotted on the surface and in the atmosphere of this moon are gases and liquids to us on Earth - we generally haven't considered what they are like as solids. That's a shame, because Cassini has revealed the landscape of Titan to be very varied. Without knowing what all these materials are we won't be able to understand all the landforms we've spotted.

Well, I say a shame, but it should keep me furnished with interesting experiments for the next 20 years or so!

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