PLUTO

A NEW SCIENTIST SPECIAL

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Pluto: the world that's everything at once

Early images from the dwarf planet's surface are baffling and amazing

Jacob Aron and Joshua Sokol

PLANET, dwarf planet or the little world that could? One thing's for sure: it's the Frankenstein's monster of the outer solar system, because Pluto looks like bits of different worlds stitched together.

Mountains like Earth's, 3 kilometres high and made of frozen water. A comet's tail of escaping gas pulled back by the solar wind. Smooth surfaces like the icy veneer of Neptune's moon Triton next to cracked terrain that resembles the highlands of Mars.

This variation stunned researchers when NASA's New Horizons spacecraft beamed back the first close-ups of Pluto and its moons last week. The dwarf planet is unlike any other world we've ever visited. So is its largest moon, Charon.

That surprise has turned even the most seasoned Pluto experts into wide-eyed surveyors, cataloguing the dwarf planet's many mismatched oddities and trying to find the joins. The maps from New Horizons, which will be downloaded and analysed over the coming year, are already proving hard to interpret – and harder still to explain.

Smooth regions on the surface of both Pluto and Charon were the biggest shock in the data we got last week. Prior to the probe's arrival, researchers expected to see a pair of heavily cratered worlds, bombarded since their formation in the early days of the solar system. Counting craters provides a way to date a planet's surface because impacts build up at known rates over time. Now we see that while both Pluto and Charon have their share of asteroid scars, the existence of unmarked terrain means they must have been geologically active fairly recently, at least on planetary timescales.

"We now have an isolated small planet that is showing activity after four and a half billion years," said mission leader Alan Stern at a press conference last week, as he revealed that the first high-resolution image of Pluto's surface seemed to have no craters at all. "I think that's going to send a lot of geophysicists back to the drawing board," he said.

Terra incognita

Perhaps the most perplexing site of geologic activity is a region called Sputnik Planum, where surface ice is cut into polygonal chunks around 20 kilometres wide. "When I saw this image for the first time I decided I was going to call it 'not-easy-to-explain' terrain," says team geologist Jeff Moore of the NASA Ames Research Center in California. It might be that the surface is cracking like mud as it contracts, or that convection within Pluto is heating and melting the surface like a bubbling pot of porridge.

The hunt is on for the mechanism driving that activity, providing enough energy to smooth away craters after they form. These smooth surfaces are also seen on Neptune's moon Triton, another small icy body that until last week was thought to resemble Pluto. But Neptune's gravity warms and remoulds Triton through a process called tidal heating.

That same process can't still be active on Pluto and Charon, because they are tidally locked so always show the same face to each other. "We know that process is over now, but when was it over?" says Geoffrey Collins, a geologist at Wheaton College in Norton, Massachusetts. Pre-New Horizons, it was thought that a collision between 4.4 and 4.5 billion years ago between a proto-Pluto and a proto-Charon created the binary system we see today.

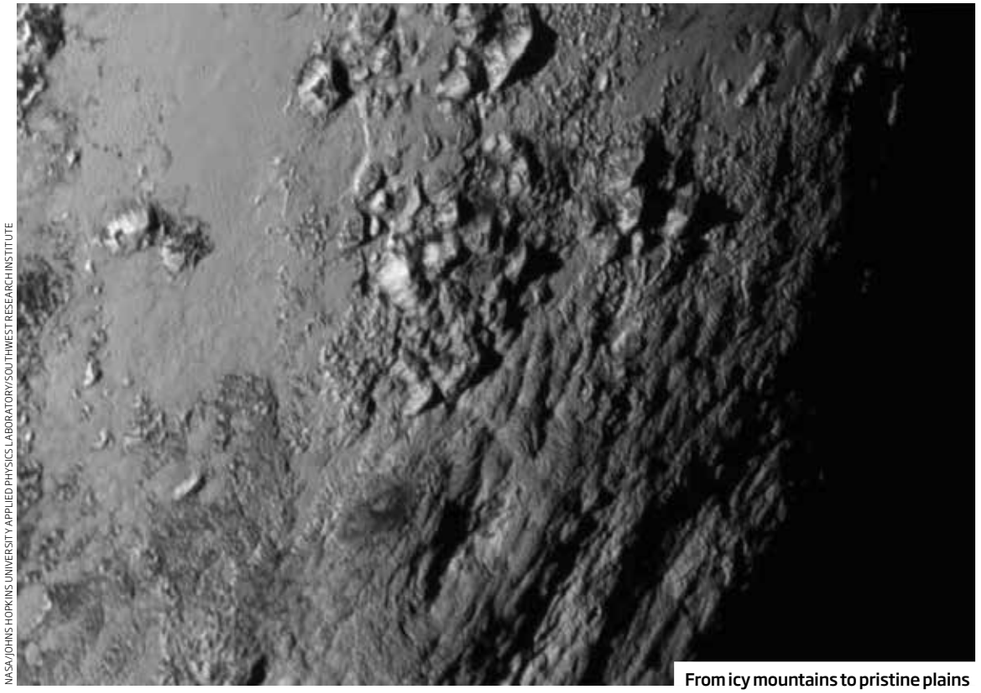
What if the smash-up was more recent, allowing the two worlds to retain energy later into the history of the solar system?

Pluto's insides could also be warmed by the slow breakdown of radioactive elements left over from the formation of our solar system, team geologists say. Alternatively, the gradual freezing of a buried ocean could be helping the dwarf planet hold on to the last glow of heat left over from its birth. More data is needed to draw any firm conclusions.

The jagged mountains dotted across the high-resolution image of Pluto's surface, thought to be made of frozen water, also hint at unexplained activity below. "The traditional way of growing a mountain is you smoosh stuff together and it pops up, or you pull them apart and you get a volcano. These things didn't look like any of that," says team member Will Grundy of the Lowell Observatory in Flagstaff, Arizona.

Collins thinks these mountains could rule out some kinds of activity. To him, they resemble nunataks, which on Earth are the tips of rocky mountains sticking out of glaciers. Nunataks on Pluto could be water ice sticking out of other ices, possibly frozen methane, which have snowed down from Pluto's atmosphere and smothered the craters. It's hard to tell because we don't know enough about how different ices interact at very low temperatures.

It isn't just Pluto's geology that hints at surprising vitality. When New Horizons was five days out from Pluto, it saw ionised nitrogen escaping from the atmosphere, a far stronger signal than the team expected. The latest results show that the gas seems to be forming a tail behind the Pluto system, blowing in the charged particles of the solar wind. That confirms a long-held suspicion that Pluto is undergoing a process also found in the distant past of other worlds, providing us with a window backwards in time.



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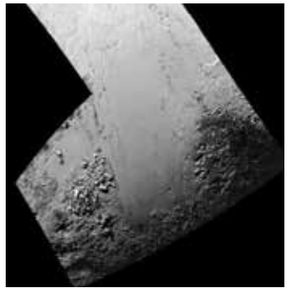
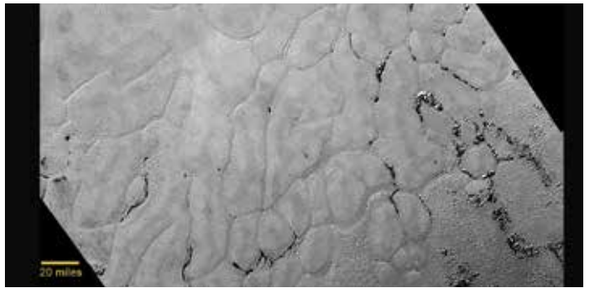
From icy mountains to pristine plains





We've never been able to study gas escaping on this scale before because the process is more or less complete on other planets. New Horizons saw it happening in real time, both spying the glow of ionised nitrogen and catching the particles directly with on-board sensors.

Earth's first atmosphere, a poisonous brew of hydrogen and helium, is thought to have escaped in much the same way. These lighter gas molecules were the only ones able to break away from our planet's stronger gravity. On Pluto, nitrogen, which is heavier and makes up most of both Earth and Pluto's present-day atmosphere, can also escape.

"The team is cataloguing the dwarf planet's many mismatched oddities and trying to find the joins"

The same thing probably also happened on early Mars, wicking water vapour out of the atmosphere and drying out the planet. "Exploring Pluto is testing our ideas about this very escape on Mars," says team member Fran Bagenal of the University of Colorado in Boulder.

So far, it looks as if about 500 tonnes of nitrogen gas leave Pluto's atmosphere every hour, Bagenal says. Nailing down the exact rate of escape is a priority for the mission – it will help the team make comparisons with theories of similar behaviour in the solar system's ancient past. And since New Horizons discovered that the atmosphere is thinner than expected, that gas is probably coming from another reservoir – within the dwarf planet itself.

That could mean plumes of nitrogen are erupting from the surface just as the Voyager probe saw on Triton, team geologists say. Smudges deposited near dark shapes could be indirect evidence of plumes, although the team thinks these features look more like streaks where winds as fast as a few metres per second have blown material around surface obstacles.

The images taken as New Horizons looked back on a rapidly shrinking Pluto could reveal such plumes, lit up in the distant sunlight. That explanation would invoke the same kind of underground heat thought to be driving Pluto's mountains and smoothing the surfaces. Alternatively, a thick layer of nitrogen ice over Pluto's surface could be turning to gas and floating up into the atmosphere.

And there's so much more to learn from the Pluto system. Its largest moon, Charon, is far more varied than the team expected, and hosts a mountain within a moat that has researchers baffled. Hydra, one of the four smaller moons, is lumpy like a peanut and probably covered in dirty water ice. We've also had a brief look at another, Nix, and will see the final two in the coming months (see "Where next for New Horizons?").

These worlds will slowly reveal themselves as data trickles down, and planetary scientists shape all these disparate parts into one cohesive whole. Researchers are as fascinated as they are confused by what they're seeing, and the findings at Pluto show it is every bit as complex as the other planets we've explored. "I think the solar system saved the best for last," said Stern. ■

WHERE NEXT FOR NEW HORIZONS?

The adventure isn't over yet. The New Horizons team is hoping that in 2018 or 2019 the spacecraft will be able to visit another Kuiper belt object (KBO), the family of icy worlds on the edge of the solar system of which Pluto is the largest.

A search with the Hubble telescope has identified two possibilities. New Horizons only has enough fuel to visit one, and the choice will be made later this year. The team also has to persuade NASA to stump up the cash to extend the mission.

One argument for visiting another member of the family is that it will help make sense of some of the data gathered this week. New Horizons only got a fleeting look at Pluto's four smaller moons, but they are all around the same size as the possible Kuiper belt targets.

One question is whether Pluto's moons resemble other small objects in the belt, pristine samples left over from the solar system's birth. But the moons are likely to be shrapnel from the collision we think created Pluto and its largest moon, Charon. If so, their surfaces would be completely remade, and be unlike the other objects. A New Horizons visit is the only way to know for sure. "We're going to look at them and go 'oh, this is what KBOs are like'," says William Grundy of the Lowell Observatory in Flagstaff, Arizona. "Then we'll see a KBO and go 'oops'."

Back where it all began

Four and a half hours. That's all the time it took for NASA's New Horizons probe to send a signal across the void on 14 July, sharing news of its successful rendezvous with Pluto. And that's not the only mind-boggling number.

New Horizons, seen here during a June 2005 spin test before its launch, crossed 5 billion kilometres of space with near-perfect aim, missing its ideal path past Pluto by just 70 kilometres. It is as big as a baby grand piano. It is fast enough to fly the equivalent of London to New York in 6 minutes. It runs on less power than two 100-watt incandescent light bulbs.

The probe travelled for almost a decade to reach the frozen tundra at the frontier of our solar system, and when it finally arrived, it looked down on Pluto and its moons. Then it beamed back images of ancient worlds that are very much alive, to the delight and confusion of everyone involved.

The mission team members, captained by Alan Stern, weathered threats of cancellation from NASA. After launch, with the target already in their sights, they learned that Pluto would no longer be counted as a planet. And they faced down a glitch just 10 days before reaching Pluto.

Photographer Michael Soluri (pictured below) was with the New Horizons team documenting the 10-year journey. His images, appearing on the following pages, capture the real people behind this historic mission. Joshua Sokol

JOHN GRUNSFELD

Photographer
Michael Soluri
MichaelSoluri.com

Photography by **Michael Soluri**

"I want to say to you just three words: we did it"
Mission leader Alan Stern

Opposite page (clockwise from top left): Flight controllers George Lawrence and Sarah Bucior celebrate as New Horizons wakes up from hibernation in December 2014; **mission chief Alan Stern leads the team cheer on the morning of the fly-by on 14 July**; up and away in January 2006; **Pluto-mapper Marc Buie awaits the launch**; mission operations manager Alice Bowman before the probe woke up, she was the first to hear from New Horizons after the fly-by

This page (clockwise from top left): Patricia Tombaugh, widow of Pluto-discoverer Clyde Tombaugh, points to Pluto; **mini New Horizons takes a break**; engineer Donald Clopein covers up to prep the probe; **Edward Stone, lead scientist on NASA's Voyager mission, holds a photo of Neptune and its moon Triton, along with Stern and a Hubble shot of Pluto**; mission scientist Fran Bagenal predicting Pluto's origins; **Andy Cheng points out his LORRI camera, which New Horizons used to snap Pluto**

CHARON

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