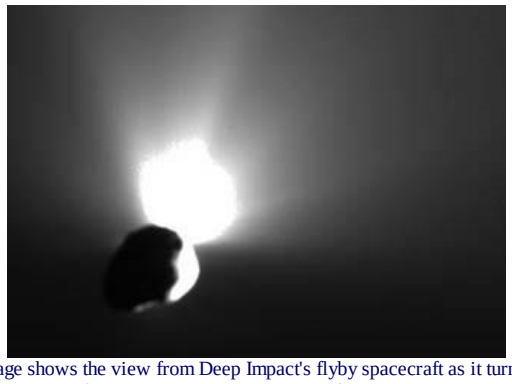
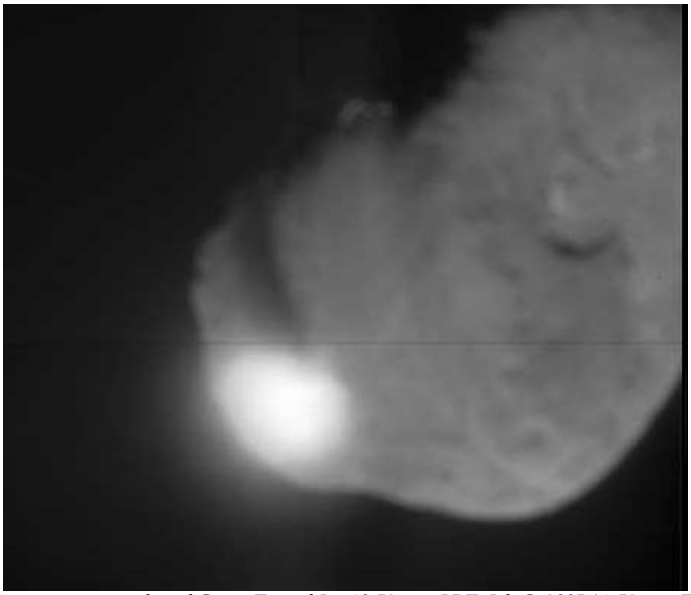
First Data from Deep Impact Crash Into Comet Tempel I



This image shows the view from Deep Impact's flyby spacecraft as it turned back to look at comet Tempel 1. Fifty minutes earlier, the spacecraft's probe had been run over by the comet. That collision kicked up plumes of ejected material, seen here streaming away from the back side of the comet. This image was taken by the flyby craft's high-resolution camera. Image credit: NASA/JPL-Caltech/UMD.

July 10, 2005 Austin, Texas - Astronomer Anita Cochran has been working at the University of Texas since 1982. Now she is a senior research scientist and Assistant Director of the McDonald Observatory in Austin. She and several hundred scientists around the world are helping to analyze the spectral data from the Deep Impact crash with Comet Tempel I on July 3 to 4, 2005. That night, Dr. Cochran was in Hawaii at the Kech I telescope, the largest in the world, watching to see if a light flare at the moment the impactor hit the very dim magnitude 11 comet could be seen.



Moment of impact on potato-shaped Comet Tempel I at 10:52 p.m. PDT, July 3, 2005 / 1:52 a.m. EDT, July 4, 2005.
Image by NASA, ESA, Johns Hopkins University Applied Physics Lab.

Interview:

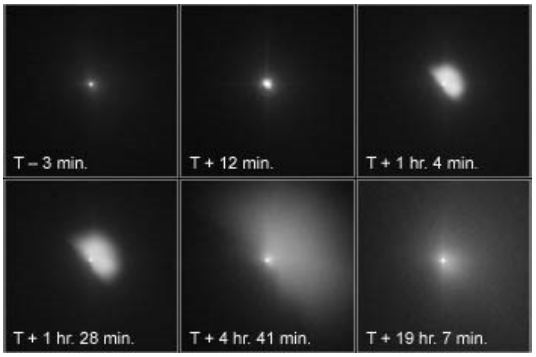
Anita Cochran, Ph.D., Asst. Director, McDonald Observatory and Senior Research Scientist, University of Texas, McDonald Observatory, Austin, Texas: "We didn't see a flash. We saw a more gradual brightening and increase in the size of the brightness in the region we were looking at.

BUT YOU WERE ACTUALLY ABLE TO SEE IN REAL TIME. THAT LITTLE IMPACTOR MACHINE WORKED. THE IDEA OF VELOCITY GIVING THE ENERGY, INSTEAD OF AN EXPLOSION, IS GREAT.

It is! It was a bold experiment, a very different approach than most astronomy, which is usually a passive science. We sit there to see what the universe hands us. This was different. We were being physicists. We were actually changing things (making a crater in Tempel I comet).

Virtually the whole astronomy community of the world (several hundred scientists) is involved with analyzing Comet Tempel I data at this point."

We did not know if Comet Tempel I was going to get extremely bright upon Deep Impact's hit or just a little bit brighter. At the Kech I post in Hawaii, what we saw was the comet brighten, not exactly at the time of impact, but a little bit later. What it looks like from the spectra is that the dust was the predominant trigger for the increase in brightness. This comes about because as you increase the amount of dust around, you get an increase in surface area so there is more reflection of solar light. It's kind of like in the old fashioned days when people would clap blackboard erasers together and get all this dust in the air. You would be able to see it because it reflected the light.



NASA's Hubble Space Telescope captured the Deep Impact collision with Comet Tempel I as the 820-pound impactor crashed into the comet at 23,000 mph. This image sequence shows the comet before impact at T-3 minutes. Then after impact at T+12 up to T + 19 hours and 7 minutes. Images credit: NASA, ESA, P. Feldman, Johns Hopkins University Applied Physics Lab.

Data Analysis - Some Unknowns Amid the Expected

So, what we saw was a large increase in the light because of the increase in the surface area of the dust. And in the spectrum, it was a lot more subtle. We did see a change in the amounts of various species (of dust and gases) that we were seeing and we saw some new lines that appeared the first night in our spectrum that are telling us about something that came short-term. But as far as the Keck spectra are concerned, we still haven't identified what feature it is we were seeing. We did see it go away the next night. So we are seeing a very short-lived something that came about because of the impact. But I can't give you any more definitive answer of what it is because WE haven't figured it out yet! (laughs)

WHAT COULD BE TRANSIENT?

It could be all sorts of things. It could be a heated bit of rock. It could be a fragment of a molecular species that did not live very long. Or it could be something that's reacting with the Impactor and that's something we haven't eliminated yet as a possibility.

CAN YOU GIVE A BREAK DOWN OF WHAT YOU'VE SEEN SO FAR IN SPECTRA?

The comet before the impact was not very active and in some senses, it made it a little harder for us because it wasn't very bright (only 11 magnitude). The spectra we've seen so far is an increase in the normal species, but we've also seen an increase in:

- formaldehyde
- a little bit of acetylene
- methyl alcohol
- maybe carbon monoxide (difficult to observe accurately because the Earth's atmosphere gets in the way)
- water, since the comet is probably 80% water ice

So, we see things we sort of expected to see, but there were transient species that we don't know yet what they were.

4.5 Billion Years Ago

WHAT DOES THAT TEACH US ABOUT THE SOLAR SYSTEM'S EVOLUTION?

So far we haven't figured out what we're looking at. But once we know what we're looking at, we can quantify how much of the material and get a much better picture of what the comet's composition is. And the reason that we care is that the comet is made up of the building blocks of the outer solar system. Comets ARE the building blocks of the outer solar system and they have not undergone a lot of change. So, what Comet Tempel I will tell us when we make sense of the data is what the conditions were like temperature, pressure, types of gases that existed when the planets formed.

THAT IS GOING BACK 4.5 BILLION YEARS AGO?

Right.

DO WE NOT ALREADY KNOW THAT?

We do *not* know that already. When we look at planets, they've undergone so much change that we would have to be incredibly good modelers to understand what they looked like in the beginning. Most people are aware of things like earthquakes, volcanoes, wind and rain and things like that life on Earth has profound influence on the chemistry of the Earth. So, with any planet today, it looks very different that probably it looked when it formed, which is why we want to look at the small things that don't have a lot of changes on them (such as comets) because they are too small to have volcanoes, earthquakes and things like that. Then we'll be able to understand the temperature and pressure conditions.

Some of the big questions in our understanding of the early solar system is: how much of the material that formed the solar system was unchanged from when the stars first produced it? And how much of the material came from the original molecular cloud that formed the sun? Because of the violent nature of forming the solar system, the original molecular cloud was actually changed quite a bit. Those are the kinds of questions we are still asking.

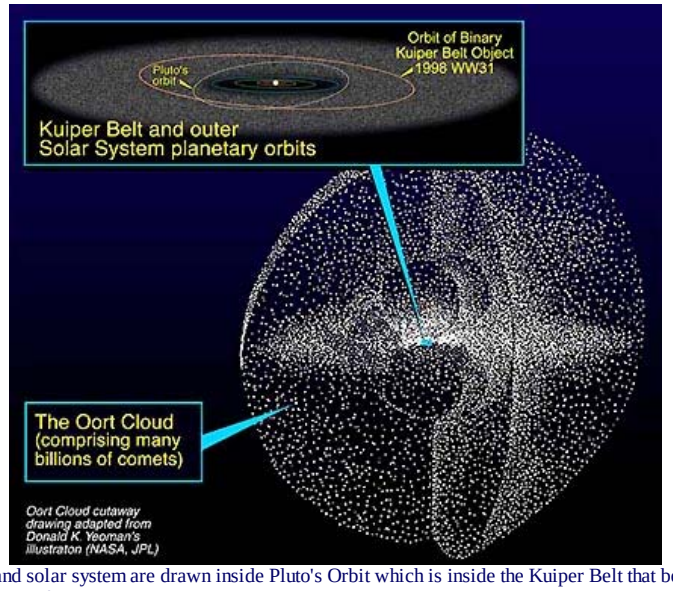
WHY IS THAT IMPORTANT TO KNOW?

It's a curiosity-driven thing. We want to know where we came from and how we came about and where we fit into the whole universe picture. It's not like it's going to change how we live day to day, but it's just man's quest to understand his origins.

THE ISSUE OF HOW MUCH CHANGE THERE HAS BEEN OVER 4.5 BILLION YEARS, HOW CAN THE TEMPEL I COMET GIVE INSIGHTS INTO THAT IF IT HASN'T CHANGED AT ALL?

It gives us a starting view. Then as we look at other objects, we'll know how they started. And it's easier go from knowing both ends and try to figure out the middle than if you only know one side. Instead of looking at the tail of the elephant and trying to figure out what it is, we'll have more pieces of the elephant.

Comet Tempel I from Kuiper Belt



Sun and solar system are drawn inside Pluto's Orbit which is inside the Kuiper Belt that begins around the orbit of Neptune and extends outward more than a billion miles toward the Oort Cloud made up of billions of icy comets. One of astronomy's great mysteries is why there is a defined boundary for the Kuiper Belt,
a clear separation from the more distant Oort Cloud. Illustration courtesy NASA and JPL.

DO YOU KNOW IF TEMPEL I CAME FROM THE OORT CLOUD OR KUIPER BELT?

It is most likely to have come from the Kuiper Belt.

THAT'S SUPPOSED TO BE THE MOST IMMEDIATE MATERIAL FROM WHICH THE SOLAR SYSTEM FORMED AND CONSOLIDATED FROM THE ORIGINAL GASES?

Yes, the Kuiper Belt is a region that basically was formed from Neptune on outward and has not moved from that region, whereas the Oort Cloud objects actually formed slightly closer to the Sun. But because of all the stirring up of the orbits by the large planets, they were thrown out to the Oort Cloud.
Thus, the Kuiper Belt is actually the reservoir that's been pretty much where it is today for the last 4.5 billion years. So, we understand much better where the Kuiper Belt objects have been than the Oort cloud comets.

On the other hand, Comet Tempel I has been in the inner solar system for many, many orbits. That means the outer parts of Tempel I have been changed by heating from the Sun, which is exactly why the Deep Impact mission was trying to bash a big hole so we could see deeper down inside and go back to the fresher (older untouched) material.

Earth Water Not from Comet Ice?

DO YOU THINK THAT COMETS LIKE TEMPEL I AND OTHERS ARE RESPONSIBLE FOR ALL OF THE OCEAN WATER ON OUR PLANET?

No, and I think the vast majority of astronomers do not think that comets were the bringers of the vast majority of the water on Earth. We believe only 10% to 15% of the water on the Earth could have come from comets.

WHERE WOULD ALL THE REST HAVE COME FROM?

That's still very much a debate. One possibility is that it came from objects in the outer part of the asteroid belt. The other part is that it was probably formed into the Earth early on and actually is original material.

WOULD THAT MEAN THAT MARS MIGHT HAVE FORMED OUT OF THE SAME MATERIAL AND THAT MIGHT EXPLAIN ITS EARLY WATER, TOO?

That's a possibility, yes.

I'VE ALWAYS ASSUMED OUR OCEANS WERE FROM COMETARY ICE.

So have many astronomers, but that comets don't explain the Earth's water is new thinking that has come about in the last ten or fifteen years.

WHY?

Because of our spectral studies. Instead of looking at just the big dominant features, we've looked at some of the very fine details and we've learned that the Earth's water has a very different signature of the isotope deuterium, which is essentially a heavy form of hydrogen. That ratio of deuterium to hydrogen indicates that it is not likely that the comets were the bringer of the water. Ten to fifteen percent might be linked to comets, but not much more.

WHAT IS THE PROCESS OUT OF GAS TO SOLID BODIES THAT H2O COULD MAINTAIN SO MUCH WATER ON EARTH WITHOUT BOILING OFF OR DISAPPEARING?

We think it was tied up in the rocks originally. We know that the universe is predominantly hydrogen and then everything else after that is about 25% of the universe and most of that is helium. But if you bring together oxygen with the hydrogen, they don't have to come and form into the rocks as water. They can come as other species, but as the material was heated in the inner part of the planet (below the crust) because of radioactive decay, you can get various species into the gas form. Then water is a logical thing to form at the right temperatures.

IT JUST SEEMS LIKE THERE IS SO MUCH WATER ON THIS PLANET.

There is indeed.

More About Deep Impact Data Upcoming

WHEN WILL YOU HAVE MORE DEFINITIVE ANALYSIS ON THE UNKNOWNS?

The data we collected at the Kech Observatory are as complicated as any data set in the world because we were at extremely high resolution so we could see very, very fine detail. But as a result, the data are much harder to reduce than lower resolution data. So, my goal is to have it reduced enough to talk about it at the end of the summer in the Division of Planetary Sciences (AAAS) meeting in Cambridge, England beginning September 3, 2005.4
We've got a preliminary reduction that I don't trust yet from the night of the impact. but hopefully over the next couple of weeks from now, I'll be able to say more.

IS THE CAMBRIDGE MEETING GOING TO BE THE FIRST PUBLIC PRESENTATION ABOUT THE DEEP IMPACT DATA?

No, actually there is a meeting on Asteroids, Comets and Meteors in Brazil beginning August 8, 2005."

More Information:

Deep Impact mission background: See **062905Earthfiles**

Websites:

NASA Deep Impact

Comet Tempel 1: **http://deepimpact.jpl.nasa.gov/science/tempel1.html**

http://deepimpact.umd.edu/amateur/where_is.shtml

http://spaceplace.jpl.nasa.gov/en/kids/deepimpact/deepimpact.shtml

Credits