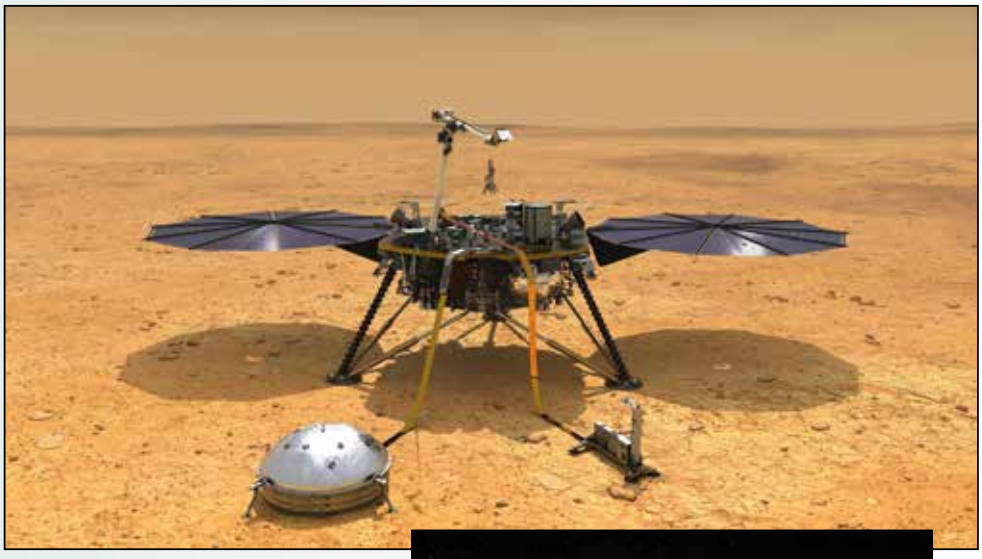
Discovering an Impact Crater after a Seismic Event

by F. Bernardini, FBIS

Looking for meteor impacts on Mars surface has been for years a major research activity performed by the Context Camera, CTX, instrument on-board Mars Reconnaissance Orbiter, MRO. Their detections provide important information on sub-surface structures, in cooperation also with other instruments. The detection of these impacts led recently also to a new important discovery, a real first in the field of planetary sciences. We interviewed dr. Liliya Posiolova (Sr. Staff Scientist at Malin Space Science Systems, Inc.) about this achievement that involved Mars Reconnaissance Orbiter, its lower resolution cameras (CTX and MARCI), and the InSight lander with its seismometer.

Liliya Posiolova, a senior scientist at Malin Space Science Systems, looks at photos of a huge crater that a meteoroid created on Mars last December. Credits: Adriana Heldiz / The San Diego Union-Tribune



Q. How did you discovered the crater and then associated it to the seismic event recorded by InSight?

A. The Amazonis Planitia impact was discovered by our MRO-CTX/MARCI science group on February 14, 2022 in a CTX image taken on February 11, 2022. The new crater and surrounding blast zone were a complete surprise to us because we had never come across a fresh crater or blast zone that big. We knew the impact had occurred sometime between June 2019 and February 2022.

The dust disturbance area was so large that we thought it might be visible in our lower resolution camera. We then started combing through MARCI data (our weather camera) to see if we could further constrain the timing. At first we constrained it to about 5 days in late December, but with further processing we managed to constrain it to a 25 hour time period centred roughly on December 24, 2021.

It was that date which triggered my memory about a large *marsquake* reported by InSight's MQS (Mars Quake Service) on Christmas Eve of last year. We quickly looked up the epicentre location estimate in the *marsquake* catalog and realized that our crater-to-lander distance matched almost perfectly the MQS event-to-lander distance. So, we had a match - that large seismic event was caused by this large crater! The largest crater we have found in 16 years of MRO mission! I was thrilled by this discovery when I realized that I was, in fact, looking at the source of a global seismic event.

Q. What additional science information the discovery provided?

Several features stand out in the surface dust disturbances. In particular there were some bright patches surrounding the crater. We were pretty sure there were large amounts of ice (which was later confirmed by the HiRISE team, which acquired higher resolution images).

Q. How big you think this event was?

We can piece together a lot of what happened during this event. If there had been observers at Amazonis Planitia, they would have seen, just after sunset, a fireball screaming through the sky from the southwest-to-northeast and then an explosion, followed by lots of debris (with ice) raining down up to 37km away from the impact site. They would have felt the ground shake and two shockwaves (from the "mach-cone" and the impact blast).

These impacts are not only the largest detected on Mars by MRO, but are also the largest impacts detected by seismometers. On Earth, seismometers have detected atmospheric explosions associated with impacts, such as Tungunska in 1908 or Tcheliabinsk in 2013. But they exploded at a height of about 20-30 km and left no crater. Since the advent of seismometers, both on Earth and Mars, these Mars craters are record events: the largest ever detected jointly by a seismometer and documented by cameras across all of the terrestrial planets.

Q. What is the outcome of the discovery?

When we shared our findings with the rest of the InSight team, there was much excitement, and it led people to re-examine other seismic events. In particular, there was an event from September of 2021 that had some similarities to the Amazonis event. This led us to examine MARCI data in the vicinity of the estimated epicentre, and we found a possible candidate event. We followed this up with a CTX image and that is how we discovered the Tempe Terra crater.

In my view, these craters provide a simple, straightforward test of the seismic models that the InSight team has developed over the years. On Earth we use networks of seismic stations along with known sources to verify and refine our models. But on Mars we only have InSight. These impacts are the first direct tests of Martian mantle velocity models. In the upper-mantle, the models did remarkably well. For the Tempe Terra impact, a seismic wave that travelled deep into the mantle (called P-diffracted) was observed. With this wave, the observation didn't match as well to our best guess for the model of the lower mantle, but that only shows that we still have some interesting things to figure out about Mars.

The impact crater imaged by HiRISE, the white traces is ice ejected from the subsurface layers.

PAROLE CHIAVE

Mars; lower resolution cameras; CTX; MARCI InSight lander; marsquake; seismic event;

ABSTRACT

The detection of a seismic event after a meteoric event happened on Mars. It is the first time in human history that such an event is recorded.

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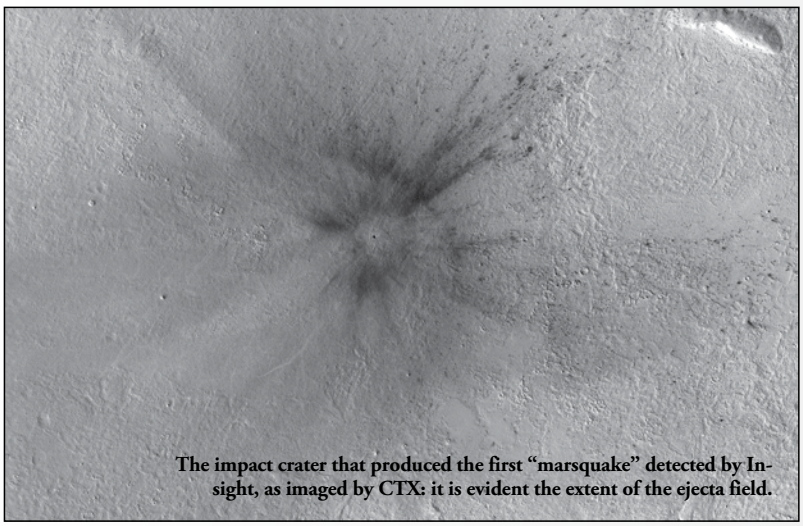
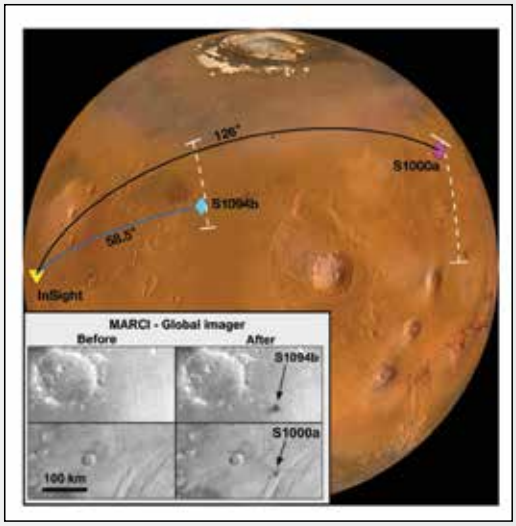


The impact crater that produced the first "marsquake" detected by Insight, as imaged by CTX: it is evident the extent of the ejecta field.



Both impact sites and InSight lander position as imaged by MARCI.