Using meteorite impacts to study seismic waves on Mars

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The solar arrays on NASA's InSight lander are deployed in this test inside a clean room at Lockheed Martin Space Systems, Denver. This configuration is how the spacecraft will look on the surface of Mars. Credit: NASA/JPL-Caltech/Lockheed Martin

(Phys.org)—Earth scientist Nick Teanby with the University of Bristol in the U.K. has come up with a novel way to measure seismic waves traveling through the under-surface of Mars—use data from meteorite impacts. In his paper published in the journal *Icarus*, he describes his idea and why it might help reveal the inner nature of the red planet.

Despite years of research, space scientists still do not know what lies beneath the surface of Mars—currently it is believed the planet once had a global magnetic field, along with volcanoes, but beyond, that the rest is pure conjecture, we do not even know if its core is molten. Some have suggested that like our own planet, Mars might have tectonic plates, which would of course cause tremors or marsquakes to occur.

To learn more, NASA is going to send a new probe to the planet—launch is scheduled for March of next year, called the InSight Lander—its purpose is to listen for tremors. If tremors are recorded, that would offer more insight into the inner structure, but because it is just a single probe, it would not be able to trace the source—three seismometers are required for triangulation. In his paper, Teanby suggests NASA also look for and measure seismic activity caused by meteorite impacts. He believes that if orbital probes were used to physically locate craters made by new meteorite impacts, scientists could figure out (by comparing time stamps) which seismic recording reflected the seismic activity that occurred as a result of the impact, and then use that information to learn more about what lies beneath the surface, because they would know where the source was, without having to triangulate.

Teanby acknowledges that most meteorite impacts would be barely perceptible, seismically speaking, but notes that Mars is really quiet (no noise made by vegetation, or from human sources)—enough so that it should be possible to not only detect the tiny tremors that occur, but to use that information to learn more about the material that the tremors are passing through beneath the surface as they move from impact zone to the InSight Lander.

More information: Teanby, N. A. (2015). Predicted detection rates of regional-scale meteorite impacts on Mars with the InSight short-period seismometer. *Icarus*, 256, 49-62. DOI: 10.1016/j.icarus.2015.04.012

Abstract
In 2016 NASA will launch the InSight discovery-class mission, which aims to study the detailed internal structure of Mars for the first time. Short- and long-period seismometers form a major component of InSight's payload and have the potential to detect seismic waves generated by meteorite impacts. Large globally detectable impact events producing craters with diameters of ~ 100m have been investigated previously and are likely to be rare (Teanby, N.A., Wookey, J. [2011]. Phys. Earth Planet. Int. 186, 70–80), but smaller impacts producing craters in the 0.5–20m range are more numerous and potentially occur sufficiently often to be detectable on regional scales (≲1000km). At these distances, seismic waves will have significant high frequency content and will be suited to detection with InSight's short-period seismometer SEIS-SP. In this paper I estimate the current martian crater production function from observations of new craters (Malin, M.C. et al. [2006]. *Science* 314, 1573–1577; Daubar, I.J. et al. [2013]. Icarus 225, 506–516), model results (Williams, J.P., Pathare, A.V., Aharonson, O. [2014]. *Icarus* 235, 23–36), and standard isochrons (Hartmann, W.K. [2005]. *Icarus* 174, 294–320). These impact rates are combined with an empirical relation between impact energy, source-receiver distance, and peak seismogram amplitude, derived from a compilation of seismic recordings of terrestrial and lunar impacts, chemical explosions, and nuclear tests. The resulting peak seismogram amplitude scaling law contains significant uncertainty, but can be used to predict impact detection rates. I estimate that for a short-period instrument, with a noise spectral density of 10^{-8} ms^{-2} Hz$^{-1/2}$ in the 1–16Hz frequency band, approximately 0.1–30 regional impacts per year should be detectable

with a nominal value of 1–3 impacts per year. Therefore, small regional impacts are likely to be a viable source of seismic energy for probing Mars' crustal and upper mantle structure. This is particularly appealing as such impacts should be easily located with orbital imagery, increasing their scientific value compared to other types of events with unknown origins. Finally, comparison of the empirical results presented here with the modelling study of Teanby and Wookey (Teanby, N.A., Wookey, J. [2011]. *Phys. Earth Planet. Int.* 186, 70–80) provides constraints on the seismic efficiency, suggesting that values of $\sim 5 \times 10^{-4}$ may be appropriate for impact generated seismic waves. Comparing explosion and impact datasets indicate that buried explosions are $\sim$ 10 times more efficient at generating seismic waves than impacts.

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