**SEISMIC ACTIVITY ESTIMATES FOR THE CERBERUS FOSSAE REGION OF MARS AND IMPLICATIONS FOR THE 2016 INSIGHT MISSION.** J. Taylor[1], N. A. Teanby[1] and J. Wookey[1], [1]School of Earth Sciences, University of Bristol (jennifer.taylor@bristol.ac.uk).

**Introduction:** The InSight geophysical lander mission to Mars is scheduled for launch in 2016. The instrument payload includes two seismometers - one broadband and one short period. It is important to characterize all possible seismic sources to optimize data return from these instruments. In the context of a seismic mission, recent studies have explored the use of meteoroid impacts as a potential source [1] and attempted to quantify the global distribution of seismic events due to cooling-related contraction on Mars' extensive fault population [2]. Here we consider the Cerberus Fossae graben systems and associated minor faults on the Elysium Planum, since this region is of particular importantance for the InSight mission. Firstly, it is widely accepted to be one of the youngest surfaces on Mars [3], meaning that fault graben systems in the region are more likely to be representative of current seismic activity. Secondly, the Cerberus Fossae are located approximately 1000km to the North-East of the proposed InSight landing site, making them the most likely sources of seismic signal for both the broadband and micro- seismometer.

The problem was approached by attempting to quantify the rate of fault motion for each of the graben systems. New crater-based ages were determined for the youngest geological units in the area to give a maximum age for the faults, since they must be younger than any surface they bisect. Total fault motion was then determined from the available topographic datasets. The age and throw estimates were then combined to give a minimum rate of motion for the faults, which we converted into an annual seismic momement release using appropriate scaling relations. This method should provide a much more direct measure of current fault activity than previous approaches.

**Surface dating:** Crater density studies are the most reliable remote sensing technique for dating planetary surfaces [4]. Three orbital imagery datasets were considered. The Mars Orbiter Laser Altimeter (MOLA) data, despite having the advantage of global coverage, was such low resolution that craters smaller than 1.0km could not be reliably resolved, which was too limited to date the extremely young surfaces in our study area. Instead, the Context Camera (CTX) and High Resolution Imaging Science Experiment (HiRISE) datasets were used, which have per pixel resoltions of 6 and 0.25 m respecitivly. These different resolution scales meant that a wider range of crater sizes could be recorded which provided an independent check on the surface age.

Surface ages were determined for units through which the faults cut (*Figure 1*) and where possible, secondary craters were ignored, since these artificially increase the count and introduce a bias towards older ages. Particularly elongate crater morphologies were assumed to be secondaries and were thus ignored, given that high velocity impacts tend to create circular craters, regardless of impact angle [5].

**Fault motion:** Estimating the detectability of seismic activity in the Cerberus Fossae region required accurate measurements of past fault motion. Digital Terrain Models (DTMs), constructed from images taken with the High Resolution Stereo Camera (HRSC) aboard Mars Express were processed using a custom filter to estimate fault throw. The faults were then picked manually and profiles drawn every 200meters.

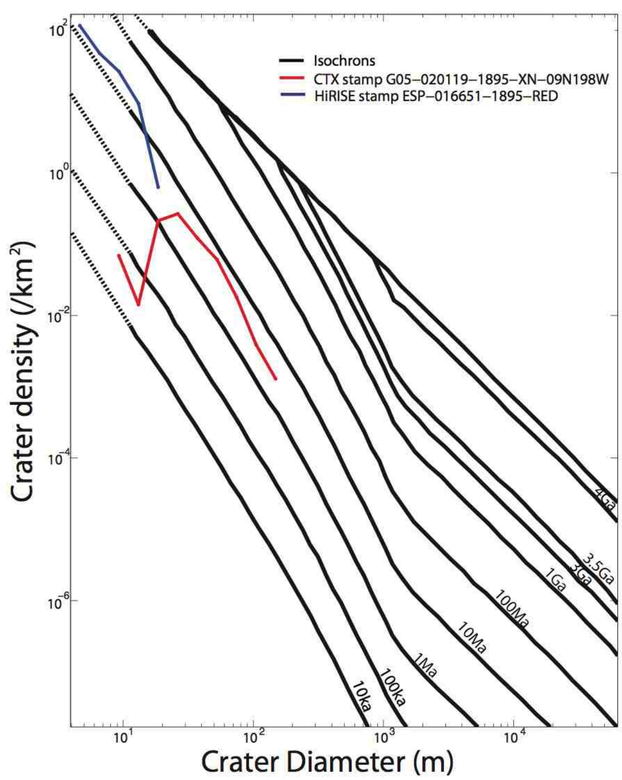
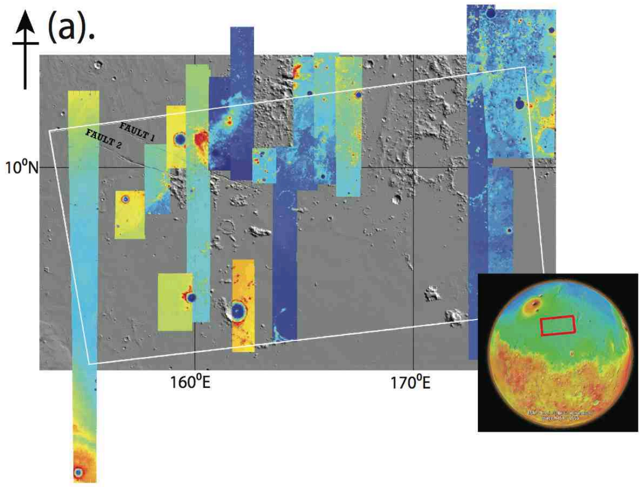



***Figure 1**: Isochron plot showing cratering density from one CTX and one HiRISE stamp. Age is approximately 10Ma. Isochrons are from [6].*



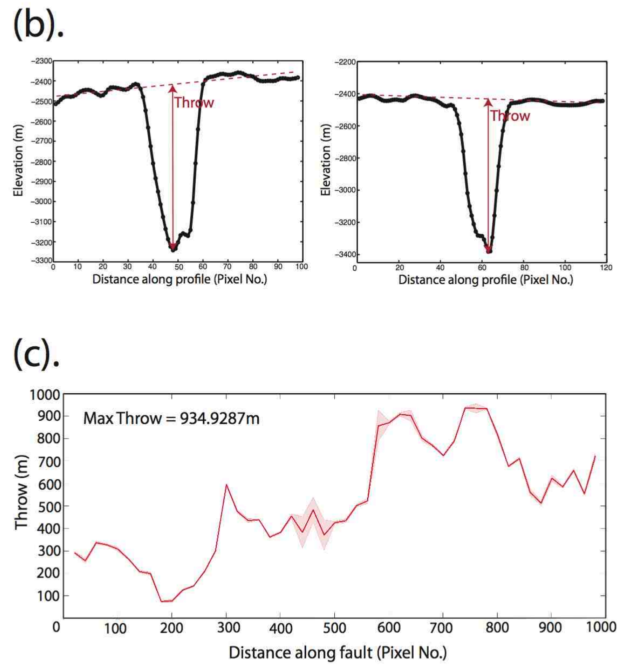




***Figure 2**: (a) All available HRSC data rendered onto context map of the Cerberus Fossae region. Map source JMARS online software (b) Examples of graben profiles from Fault 1 (see fig 2a). (c) Plot showing variation of throw along Fault 1.*

The topography either side of the fault was averaged and interpolated, so that the throw could be measured (*Figure 2b*). The throw on each profile was then plotted against distance along fault (*Figure 2c*). Errors in the throw measurements are caused by variation in topography surrounding the fault.

**Seismicity estimate:** By combining the new surface ages with the measurement of throw, the rate of fault motion has been calculated. This rate, along with assumptions of fault scaling relationships [7] gives us an annual seismic moment release budget. Using the Gutenberg-Richter relationship for earthquake size distribution [8], we than estimated the likely number of observable events at the InSight landing site. Based on waveform modeling by [1], a seismic event should be detectable at 1000km range under nominal noise conditions if it has a seismic moment over $M_0 = 10^{13}$Nm (equivalent to a moment magnitude of Mw > 2.6). From our calculated combined moment release budget for the four main graben systems of **$4.91\times10^{17}$Nm/yr** to **$2.09\times10^{18}$Nm/yr** (and with reference to [2], *Figure 10*), we found that the Cerberus Fossae region is likely to experience **$10^2$** to **$10^4$** events over magnitude 2.6 per year, all of which should be detectable with the InSight seismometers.

**Discussion:** Assuming these faults have remained active over the last 10Myr, we predict a significant number of detectable events for the Cerberus Fossae region alone, meaning that Mars is likely much more seismically active than has previously been thought. The assumption that these faults are still active is supported by a recent geomorphological study of the Cerberus Fossae [9], demonstrating evidence suggestive of recent activity. They found numerous boulder trails, which seem to indicate that energy release sufficient to dislodge such large rocks is common, and the fresh appearance of the trails also suggests that the activity was very recent, most likely between ten and one hundred years old.

The implications for InSight are extremely significant and encouraging. With so many detectable events, valuable information about the deep interior and crustal structure and properties can be determined. This will have far-reaching impact for planning future seismic surveys on Mars; knowledge of seismicity, seismic wave velocities, internal layering, and elastic properties will enable future arrays to be optimsed for greater internal resolution.

**References:** [1] Teanby N. A. and Wookey J. (2011) *Phys. Earth & Planet. Int, 186,* 70-80. [2] Knapmeyer M. et al. (2006) *JGR, 111,* E11006. [3] Jaeger W. L. et al. (2010) *Icarus, 205,* 230-243. [4] McGill G. E. (1977) *Bull. Geol. Soc. Am., 88,* 1102-1110. [5] McEwen A. S. et al. (2005) *Icarus, 176,* 351-381. [6] Hartmann W. K. (2005) *Icarus, 174,* 294-320. [7] Scholz C. H. et al. (1993) *JGR, 98,* B12, 21,951-21,961. [8] Gutenberg B. & Richter C. F. (1944) *Bull. Seis. Soc. Am., 34,* 185. [9] Roberts G. P. et al. (2012) *JGR, 117,* E02009.