CHANGE DETECTION IN CERBERUS FOSSAE, MARS: SEARCHING FOR EVIDENCE OF MARSQUAKE PROXIES. E. Harris and P.M. Grindrod. 1The Natural History Museum, Cromwell Road, London, SW7 5BD (emma.harris1@nhm.ac.uk).

Introduction: Cerberus Fossae (~10° N, 158° E) is a series of sub-parallel fractures trending towards the south-east away from the Elysium volcanic complex (Fig. 1). These fractures were likely formed by normal faulting due to the emplacement of a dike system radiating from Elysium Mons [1-3].

On Earth, mass wastage events can act as evidence for paleo-seismicity [4, 5]. On Mars, none of the observed active surface processes have yet been attributed to seismic activity. The InSight lander detected 174 Marsquakes as of 30th September 2019, at least 2 of which originate in the Cerberus Fossae region of Mars [6]. In this study we carry out an analysis of possible mass wastage events within Cerberus Fossae, in order to search for evidence of past and present seismic activity.

Methods: Our study area spans ~1000 km² (154° E, 12° N – 175° E, 6°N). Here, 197 HiRISE [7] images, as well as overlapping CTX [8] footprints, were used in a GIS environment to identify evidence of possible mass wastage events, including: single boulders, boulder groups, boulder tracks, colluvium fans, aeolian deposits, slope streaks, and Recurring Slope Lineae (RSL).

Further analysis introduced a temporal element to the study. By eliminating images taken before February 2019, we controlled the temporal aspect of the study to within the collection of seismic data by the SEIS instrument on the InSight lander [9]. A comparison was then made to images collected earlier in order to detect surface change that could be correlated to seismic events identified by InSight.

To accurately analyse surface change, CTX and HiRISE Digital Terrain Models (DTMs) were created using SOCET SET and standard methods [e.g. 10].

Results: All features (boulders, boulder tracks, colluvium fans, aeolian features, slope streaks and RSL) were shown to be prevalent throughout the fossae with a dense number of features ~156-158°. However, the density could be a factor of the number of images available longitudinally, with areas of interest targeted for repeat imagery. Within this study, recent features have been identified within DTMs. A selection of these can be seen in Figures 2-5.

Discussion: Surface change has been identified within the DTMs including slope streaks, RSLs, and boulder tracks.

Slope streaks (Fig. 2) are globally extensive on Mars, with estimates of up to 800,000 individual streaks [11]. There are two theories regarding the formation of slope streaks: dry dust transportation [12] and wet debris flow [13]. In this study slope streaks ranged in length from <10 m to >800 m and appeared largely to be determined by the length of the slope on which they occurred. As there are no conclusive remarks regarding the formation of slope streaks it is difficult to establish a co-seismic relationship here.

Figure 2. Recent slope streaks identified within HiRISE images PSP_010638_1890 and ESP_017218_1890.

RSL require multiple observations to confirm their occurrence, needing annual recurrence and incremental growth [14]. Multiple possible new RSLs have been
observed, however repeat imagery will be needed to confirm their presence.

**Boulder tracks** (Fig. 3 and 4) identify the presence of a boulder that was once mobile; this is the only surface change feature within this study whose cause could be linked to seismic activity. However, the cause of this movement could also include erosion, thermal stresses, and nearby impacts [15].

Previous studies of boulder tracks on the Moon have shown they can be preserved for ~300 Ma [16]. Boulder tracks within Jezero crater, Mars showed no sign of degradation in 12 years [17] but Mars rover tracks have been eroded from view within weeks to months [18] suggesting the local wind regime is an important factor within the preservation of boulder tracks.

![Figure 3](image3.png)

**Figure 3.** A recent rockfall identified by comparison of HiRISE images ESP_030378_1900 and ESP_059349_1900.

**Recent boulder falls:** A new rockfall identified via repeat HiRISE imagery can be seen in Fig. 3. These HiRISE images were taken on 18th January 2013 (ESP_030378_1900) and 25th March 2019 (ESP_059349_1900), during which timeframe the rockfall occurred. Analysis of CTX imagery of the same area has narrowed down this time to between 15 August 2016 and 25 March 2019 using the images J06_047125_1900 and K15_059349_1901.

A second recent boulder fall (Fig. 4) was identified within HiRISE images ESP_016862_1895 and ESP_060272_1895 meaning that the surface change took place between 2 March 2010 and 5 June 2019.

**Marsquakes identified by InSight:** The two largest seismic events identified by InSight at the time of study have epicentral ellipses overlapping Cerberus Fossae and are estimated to be MW 3-4 [8]. The two largest events occurred on sols 173 and 235 of the InSight mission and have been named S0173a and S0235b accordingly. Seismic event S0173a occurred on 22 May 2019; this could, therefore, be correlated to the mass wastage event seen in Fig. 4.

![Figure 4](image4.png)

**Figure 4.** Recent rockfall identified between HiRISE images ESP_016862_1895 and ESP_060272_1895.

**Conclusion:** Analysis of features related to mass wastage events (single boulders, boulder groups, boulder tracks, colluvium fans, aeolian deposits, slope streaks, and RSL) were found in the highest densities at longitudes ~156-158° in Cerberus Fossae, correlating with previous studies suggesting a concentration of seismic activity in this area [e.g. 2, 18].

The analysis of boulder falls is an important factor in the analysis of both paleo and present seismic activity. Our identification of one new boulder fall event can be correlated to within the time frame of marsquake event number S0173a from NASA’s ‘InSight’ seismic data. This temporal link is tentative however, due to the length of time (~9 Earth years) between images analyzed. With an increasing number of Marsquakes detected by InSight, and further high-resolution repeat imagery, the link between mass wastage events and seismic activity is an ongoing and continuous process.

**References:**