Searching for seismic sources around the InSight landing site: focus on sol 173 and 235 marsquakes

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The NASA InSight mission has detected more than 300 seismic events since February 2019. It is dedicated to study the seismic activity and to propose the first internal models of Mars. On sols 173 (S0173a, May 23rd 2019) and 235 (S0235b, July 27th 2019) the two largest seismic events have been recorded with Mw > 3 and showing clear P and S waves. The InSight MarsQuake Service has estimated their locations: S0173a probability density function (PDF) is at 28±3° distance and 91±10°N azimuth and S0235b, at 26±3° distance and 74±10°N azimuth. Both PDF are centered on the Cerberus Fossae fault system (CF), which is one of the largest tectonic structure on Mars of about 1200 km long.

From orbital imagery of MRO CTX and HiRISE cameras, we study the morphology and the lateral segmentation of the CF. We expect that marsquakes are more likely to initiate in intersegment zones, as they usually correspond to structural discontinuities where stress concentrates along faults on Earth . Besides, assuming the scaling law existing between the rupture length and the seismic moment, fault segments of 1 to 10 km long should be involved during such events.

In addition, we represent the moment tensor of the two events as it is a robust visualization of the source geometry. First, we compute Green functions from synthetic seismograms with the Direct Solution Method using Martian velocity models and the estimated locations. Then, the synthetics are inverted with the InSight data, by matching their arrivals of P and S waves on a narrow time window. We select the best fit models to retrieve the focal mechanisms of the marsquakes. We also provide updated constraints on the depth of the events through the lack of detection of surface waves.

Our tectonic analysis show that small inter-segments at several eastern graben tips of CF are good candidates for marsquakes locations. Despite the uncertainties on the internal model and event depths, our moment tensors inversion is consistent with the fault azimuths and dips, showing an extensional slip motion for S0173a.