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First approximations to the energy release of giant dikes at Cerberus Fossae, Mars

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Historical dike intrusions in the vicinity of volcanic edifices on Earth are known to produce swarms of seismic activity with cumulative seismic moments between $1{\cdot}10^{12}$ and $1{\cdot}10^{20}$ Nm, equivalent to moment magnitudes between 2 and 7. On Mars, long linear graben systems are likely to host giant dike complexes at depth, which possibly produced significant seismicity during their intrusion. Not only this, but dike intrusions are also candidates to produce crustal seismicity at present day, which may be detected during the lifespan of the InSight mission. In this work we infer the possible geometry of dikes underneath Cerberus Fossae, and make estimations of the energy released during their intrusion.

We used cross section area balancing on topographic profiles orthogonal to several of the Cerberus Fossae graben to estimate proxies for the geometry of the underlying dikes (aperture, height, depth, etc.). This technique has already been used to approximate dike properties at the nearby Elysium Fossae, with successful results. At Cerberus Fossae, the obtained dike aspect ratios are consistent with sublinear scaling, which is characteristic of fluid-induced fractures (as expected for dikes). These results support the presence of giant dikes underneath Cerberus, which may be up to 700 m thick, 140 km long, and have heights of up to 20 km.

Additionally, we used the inferred geometries and assumptions about the host rock mechanical properties to estimate various energy quantities related to dike intrusion, and compared them with the energy releases in terrestrial diking episodes. Two calculations are of special interest; M_d, the energy associated to dike inflation, and M_s, an approximation to the cumulative seismic moment release. The obtained M_d values are between $3.1{\cdot}10^{20}$ and $5.0{\cdot}10^{21}$ Nm, and are 1 to 2 orders of magnitude larger than the equivalent moments in terrestrial events. M_s was calculated from M_d with two key assumptions; 1) that all aseismic energy was released by the dike, and 2) values of seismic efficiency (the percentage of seismic relative to the total energy released) based on terrestrial examples. The obtained M_s are between $6.3{\cdot}10^{19}$ and $2.2{\cdot}10^{21}$ Nm, which are equivalent to moment magnitudes of 6.5 and 7.9. These are comparable to, albeit slightly larger than, the cumulative moments of some of the largest terrestrial diking events, such as the first episode in the Manda-Hararo sequence (Ethiopia, 2005, $M_s = 6.2$) or the Miyake-jima event (Japan, 2000, $M_s = 6.8$).

The Elysium volcanic province is thought to have been active until very recent times, and possibly

even at present day. If this is the case, then intrusions in the lower size of the spectrum investigated at Cerberus, and smaller-sized events, may be detected by InSight as a series of crustal seismic events with cumulative moment magnitudes <6. Further research is needed to fully assess the validity of the comparisons between terrestrial and Martian events, and the possible energy releases of dike-induced marsquakes.