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A model for martian seismicity based on lithospheric cooling and the distribution of visible faults

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We present a model of martian seismicity that links the observed distribution of surface faults to the spatial distribution of marsquakes. The annual seismic moment budget is estimated based on the assumption that global cooling and subsequent shrinking of Mars is the main source of strain today. A truncated Gutenberg-Richter relation is used to relate the seismic moment budget to marsquake frequencies. Based on the constant stress drop hypothesis, we have derived a theoretical relation for the limitation of quake size by fault length. We use this to simulate marsquake epicenter catalogs that can be used e.g. as test data for the development of seismological experiments, and as a priori hypotheses for the interpretation of real marsquake data. A range of input parameters is investigated in order to obtain end-member models for high and low levels of martian seismicity.

The strain rate is estimated to be between 0.004% and 0.033% in $100Ma$, yielding an annual seismic moment release between $3.4 \times 10^{16}Nm$ and $7.8 \times 10^{18}Nm$ (Earth: $4.3 \times 10^{22}Nm$ in 2004). For the determination of a Moment-Frequency-Relation, the moment of the largest possible quake is as important as the cumulative moment of all quakes. With a slope of the distribution of $\beta = 0.625$, we obtain a set of Moment-Frequency distributions that predict one $M_w \geq 4$ quake every $17d$ in the case of a large moment budget and size limitation $M_w \leq 4.9$, and one $M_w \geq 4$ quake every $6.7a$ in the case of a small moment budget and a size limitation $M_w \leq 7.6$.

Provided that all faults are seismically active today, we expect the highest density of marsquakes around Alba Patera and Tempe Terra, on Claritas Fossae and in the vicinity of Valles Marineris. If only faults in the areas of youngest surfaces (age $\leq 500Ma$) are active, seismicity concentrates on Valles Marineris, Pavonis and Arsia Mons, and Ulysses Fossae.