Martian Seismicity: Implications of the Global Surface Fault Distribution and of Lithospheric Cooling. M. Knapmeyer[1] , J. Oberst[1], E. Hauber[1], M. Wählisch[1], C. Deuchler[1] and R. Wagner[1], [1]German Aerospace Center, Institute of Planetary Research, Rutherfordstr. 2, D-12489 Berlin, Germany, martin.knapmeyer@dlr.de

Introduction: This contribution presents a model that links the observed distribution of surface faults to the spatial distribution of marsquakes. The annual seismic moment budget is computed based on the assumption that global cooling and subsequent shrinking of Mars is the main source of strain today [1]. A truncated Gutenberg-Richter distribution is used to relate the seismic moment budget to marsquake frequencies. We have derived a theoretical relation for the limitation of quake size by the lengths of the individual faults. This relation is used for the simulation of epicenter catalogs that may serve as input data for the development of seismological experiments.

Mars Surface Faults: In order to test the performance of an experimental setup and to simulate the possible scientific outcome of a mission it is neccessary not only to estimate the number of quakes that can be expected, but also to produce a realistic spatial distribution that allows to compute synthetic travel times and waveforms. To achieve this, we have mapped surface faults visible in the 64pix/deg MOLA grid [2]. These faults are used as candidate sources of marsquakes.

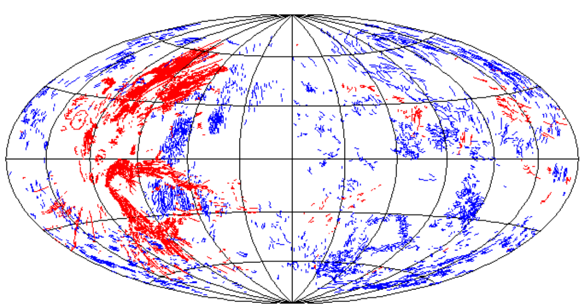

Fig. 1 : Surface Faults on Mars. Red : normal faults, Blue : thrust faults. Map in Hammer's projection, centered to 0ºN0ºE.

We obtained a dataset of 3642 thrust faults and 3746 normal faults with a cumulative length of ≈680000 *km* [3], shown in fig. 1. The individual faults have lengths between 4 *km* and 1445 *km*.

Moment-Frequency Relation: The cumulative seismic moment available per year is estimated from the thermal contraction of the seismogenic lithosphere as described by [1], but with new and competing sets of parameters, based on a recent modeling of Mars' thermal evolution [4]. The models differ in cooling rate, seismogenic thickness, shear modulus and other parameters. We obtain cumulative moments between $3.4\times10^{16}\ Nm$ (WEAK models) and $4.8\times10^{18}\ Nm$ (STRONG models) per Julian year.

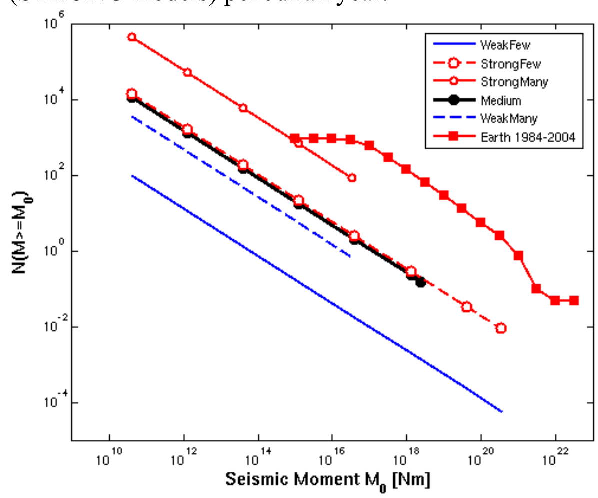

Fig. 2: Moment-Frequency Relation for one Julian year. Data for Earth are averaged from the catalogs of the Harvard CMT project [5].

By assuming a slope of 0.625 [6] for the moment-frequency distribution, we get the distributions shown in fig. 2. The number of events is controlled not only by the cumulative moment, but also by the size of the largest possible quake, yielding the differences between the FEW and MANY variants of our models. The WEAKFEW and STRONGFEW models essentially cover the range given already by Golombek [7], but if the quake size limitation is severe, as in the STRONGMANY model, the number of small quakes can be much higher. This effect could indeed increase the number of globally detectable marsquakes, if low-noise instruments are used [8].

Moment-Length Relation : A list of seismic moments is generated by a Monte Carlo process. To connect these moments to the cataloged faults, it is necessary to have a relation between the mapped length of a fault and the largest moment it can release: Big quakes must not be assigned to short faults. We have derived a theoretical relationship based on the constant static stress drop model [9] and by adopting fault geometries found in the literature [e.g. 10]. Fault dip angles of 25º for normal faults and 60º for thrust faults are assumed

[10, 11]. Our models differ in the assumed static stress drop and the rupture area aspect ratio, yielding the slightly different moment length relations shown in fig. 3.

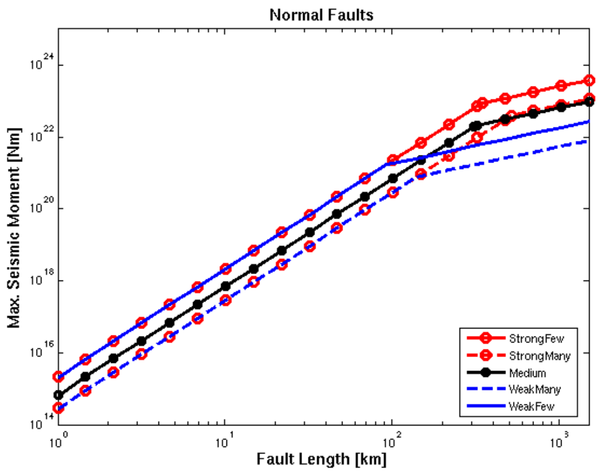

Fig. 3: Moment-Length Relations for normal faults, using several different material parameters. The kinks denote the rupture length at which the rupture area reaches the bottom of the seismogenic layer.

Epicenter Maps : The seismic moments are distributed over the faults assuming that quakes are equally likely on all seismically active faults. In fig. 4 we assume that all mapped faults are still active today.

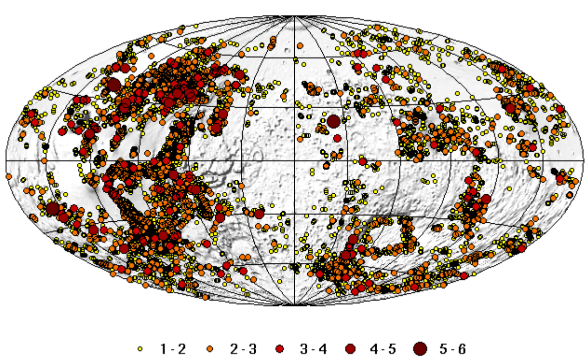

Fig. 4: Epicenter Map for the MEDIUM model Different symbols denote moment magnitude M_w. Map as in fig. 1.

To determine which faults are seismically active today and which ones are not is indeed a crucial part for the production of an epicenter map. One could argue that old faults may be healed, e.g., by magmatic or hydrothermal processes at depth and that only the youngest faults produce quakes. Currently, the only means to estimate the age of a fault is the age of the surface units it cuts: the fault must be younger than the youngest of these units. We can thus produce a quake catalog which, for example, uses only faults that cut areas less than 500 *Ma* old. In this case, the quakes will be concentrated on few areas in Valles Marineris, at some of the large volcanoes and on some areas in the northern plains. The distinction between active and healed faults is therefore an important issue. We plan to further investigate this topic based on high resolution imagery and by combining the individual faults into tectonic systems of common activity.

Summary: We present new models of martian seismicity which are compatible with previous models [e.g. 1, 7], but are more closely connected to the physical properties of the martian lithosphere and to the quake source process. We incorporate recent find-ings on martian tectonics and thermal evolution model-ing as well as an extensive global catalog of surface faults. The result is a set of synthetic distributions of marsquakes with realistic sizes and a reasonable spatial distribution, well suited to simulate seismological experiments onboard of future Mars missions.

References: [1] Solomon S.C. et al. (1991), *LPI Tech Rep.* #91-02 [2] Smith et al. (2003), *NASA Planetary Data System*, MGS-M-MOLA-5_MEGDR_L3_V1.0 [3] Oberst J. et al. (2004), *Geophys. Res. Abstracts 6*, 02939, [4] Schumacher S. and Breuer D. (2006), *J. Geophys. Res*., in press [5] Dziewonski, A. et al. (1983), *Phys. Earth Planet. Int 33*, 3, 76-90 and follow-ups [6] Kagan, Y. Y. (2002), *Geophys. J. Int. 149*, 731-754 [7] Golombek M.P. (2002), *LPS XXXIII*, Abstract #1244 [8] Mocquet A. (1999), *Planet. Sp. Sci. 47*, 397-409 [9] Kanamori H. and Anderson D. L. (1975), *Bull. Seis. Soc. Am. 65*, 1073-1095 [10] Schultz R.A. and Lin J. (2001), *J. Geophys. Res. 106*, 16549-16566 [11] Watters, T.R. (2003), *J. Geophys. Res. 108*, 5054, doi: 10.1029/2002JE001934