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Scaling of crack size distributions: from Solid Mechanics to Geophysical Systems

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In the last three decades some works emphasized the scaling laws underlying the geometrical characteristics of geological faults. Fault shear displacements are found to scale linearly with fault length. This similarity condition led to a reinterpretation of the celebrated Gutenberg-Richter (GR) frequency-magnitude distribution, in terms of a power-law distribution of source rupture areas of earthquakes.

In the framework of Solid Mechanics, power laws are also employed for the description of microcrack size distributions in damaged materials. Considering that microcracking is a dynamic process accompanied by a sudden rearrangement of stress field, which is represented by the well-known phenomenon named 'Acoustic Emission' (AE), a similarity between seismic events in Earth's crust and AE events in damaged materials naturally comes out. In particular, common values of certain characteristic exponents, such as the b-value of GR law, shared by these two classes of phenomena, suggest the existence of a unique inclusive class ranging from laboratory to geological scale. In this framework, the b-value acts as a stress meter that depends inversely on specific differential stress instead of the simple stress drop.

Therefore, it seems to be reasonable thus transposing some interesting results obtained studying the scaling properties of microcrack size distributions in Solid Mechanics into the Theory of Plate Tectonics. In this paper an interpretation of the b-values observed in Tectonics is proposed in terms of power-law defect size distributions. Still exploiting the scaling properties of these power-law distributions, the link between scaling of earthquakes and scaling of faults in the crust is explored.