On the self-similarity of rifting episodes

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The relative motion of divergent plate boundaries is accommodated by means of rifting episodes, where sequences of magma-filled dikes compensate crustal splitting with creation of volume. Rifting episodes liken main shock - aftershock sequences at convergent or transform plate boundaries in many respects, for example they start with a large intrusion and are followed by several events of smaller magnitude. There is general consensus on the idea that the frequency of earthquakes is self-similar from local to global scale. Self-similarity is generally seen as manifestation of a non-linear chaotic process in which the earth self-organizes critically. The critical state "at the edge of chaos" is mirrored in a power law behavior of several quantities such as the scalar seismic moment or the aftershock decay time. The group properties of the frequency of dike intrusions during rifting and their possible self-organization have never been investigated in detail. In analogy with earthquakes (shear cracks), we derive a basic theoretical power-law equation for the geodetic moment-frequency distribution for tensile cracks, then we investigate whether a power law distribution describes the statistics of dikes from the two rifting episodes recorded since modern monitoring techniques are available: the 1975-1984 Krafla (Iceland) and the 2005-2010, possibly still ongoing, Manda-Harraro (Ethiopia) dike sequences. We find self-similarity over the entire geodetic moment scale of 2 orders of magnitude observed in the diking: as for mainshock-aftershock sequences, a power law relationship describes well the geodetic moment - frequency distribution of the dikes. We also check the correlation between the volume intruded in a dike and the waiting time to the successive intrusion (i.e. interevent time). We find that the volumes and successive interevent times are correlated being indicative of the role played by the magma recharge rate in the occurrence of dike intrusions. At the same time, big dikes trigger successive smaller dikes as in Omori-type sequences. Overall the rifting segments and cluster of dike intrusions seem to be the manifestation of a critical system that reacts to both the tectonic load, long-term magma accumulation and dike induced-stress interaction.