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Melt accumulation and migmatite formation: an analogue modelling approach

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The last decade has witnessed an increasing use of non-linear and chaotic dynamics and fractal approaches in Earth sciences. A large number of geological objects show a power-law or fractal distribution. Fractals can be used in studies of magma processes, mantle convection, lava flows and ore mineralization etc. It is shown that the width of migmatitic leucosomes in the Estonian and Southern Finnish Precambrian basement rocks follow power-law distributions and show fractal properties. Partial melting process and its dynamics were studied on the ground of an experiment with sand and carbon dioxide as analogues of the host rock and melt phase, respectively. The observed power law distributions of the gas batch sizes in the analogue experiment and leucosome widths in the migmatites allow to conclude, that the behaviour of the liquid phase could be analogous in both experimental and natural liquid segregation systems. Accordingly, the melt transport through the rock is not diffusional, but ballistical and stepwise. Despite the differences in size and number of measured leucosomes and veins, differences in host rock types and formation conditions, the studied leucosome data set shows good power-law distributions with exponents usually between 1.0 and 1.9. Knowing the power-law size distribution for the melt batches allows us to estimate the total volume of the melt phase, as well as the relative contributions of the largest batch and of the smallest batches. The emerging fractality suggests that the melt accumulation and transport processes are of self-organized critical nature. Inferring of migmatization characteristics such as melting stage or melt depletion percentage from power law statistics requires more investigation of the phenomenon, especially the role of liquid mobility as probably the dominant factor in development of the power law leucosome width distributions with particular exponents.