Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.16876

Self-Organization, Pattern Formation, and Complexity in Geosystems and Geomaterials

MRS. SABINE DIETRICH

Alumna TU Berlin

Presenting Author: sabine.dietrich@alumni.tu-berlin.de

Geological systems in the Earth's crust commonly display rhythmic patterns such as banded formations, layered and folded structures, diapirs or cockade ores that can range in scale from just the micron, and even sub-micron scale, up to several kilometers. This topic has been examined from a thermochemical-mechanical perspective for a long time.

For a long time, physics was limited to describing continuous changes in closed systems. The concept of self-organization (I. Prigogine, 1977), on the other hand, makes it possible to describe discontinuities as sequential spontaneous structure/texture formations. For this purpose, the previously prevailing approach in closed systems under given boundary conditions of existing "ideal gases" is abandoned and instead open systems with distributed components and properties (W. Ebeling, 1976) as well as available free energy are considered. In order to allow spontaneous structure/texture formation, the open systems should be far from thermodynamic equilibrium.

In traditional closed systems, changes inevitably lead to increased complexity through disorder (increase in entropy). The concept of self-organization, on the other hand, enables changes in open systems while increasing order and complexity at the same time, i.e. through the export of entropy and energy dissipation, with phase transitions playing an essential role. Solute reaction mediated precipitate patterns have been discussed in detail since the 1980s (P. Ortoleva, 1982). Another feature of open systems is their scale invariance, which H. Haken displayed in 1978 with his synergetics concept.

Since the earth system is to be regarded as an open system with geochemical processes and geomaterials of all scales that changes through the supply and withdrawal of energy, ordered structures and patterns can often be found in geological systems.

In this session, radiolarite, malachite, reef limestone and banded iron-manganese deposits will be addressed as examples and considered experimentally, theoretically, and numerically using the example of a recent early diagenetic new mineral formation. Finally, generalized results will be derived for future investigation.

[1] Dietrich (1996) Strukturierung Eisen-Mangan-haltiger Schlämme durch komplexe dynamische Prozesse

[2] Dietrich, Jacob (2018) in Complexity and Synergetics

[3] Dietrich (2019) in Spirals and Vortices

[4] Dietrich resp. Dietrich, Jacob at IGC 2012, 2016, 2020 (invited)