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A generic model of pattern formation in Mississippi Valley-Type deposits based on analytical findings

Ulrich Kelka (1), Manolis Veveakis (2), Nicolas Beaudoin (1), Thomas Poulet (2), Daniel Koehn (1), Klaus Regenauer-Lieb (2), Peter Chung (1), and Jasper Berndt (3)

(1) University of Glasgow, School of Geographical and Earth Sciences, Glasgow, United Kingdom (ulrich.kelka@glasgow.ac.uk), (2) University of New South Wales, School of Petroleum Engineering, Australia, (3) University of Muenster, Institute of Mineralogy, Germany

Rhythmically banded dolomites (zebra dolomite) are found worldwide, and are frequently associated with mineralization of the Mississippi Valley-Type (MVT). These rocks consist of dark fine grained and impurity-rich layers alternating with light coarse grained and virtually impurity-free layers. The texture of the light layers is similar to the one of tectonic syntaxial veins where crystals grow towards a median line.

We present petrographic and chemical analysis of zebra dolomite samples from the San Vicente mine, Central Peru. The applied methods are petrographic microscopy, SEM, EBSD, EMP and LA-ICP-MS. The findings influence the development of a generic model of pattern formation.

We found the density and the distribution of second-phase material to be one striking feature. The impurities are accumulated in the dark layers, which show an even higher density of second-phase material than the surrounding impurity-rich dolomite. With CL, it was possible to detect a luminescent structure in the center of the light bands which seems to be present independent of the thickness and spacing of the respective layers. This structure was analysed in more detail with EMP. We further found that the dolomite crystals in the dark and light layers are chemically similar but show a variation in some trace elements.

Based on the analytical findings, we put forward a mathematical model of zebra dolomite formation based on Cnoidal waves. We believe that the light coarse grained layers represent hydromechanical instabilities arising during the diagenetic compaction of a fluid saturated, impurity-rich dolomite. Our approach is based on the extension of the classical compaction bands theory to a viscose, non-linear rheology. In the model, the spacing between two light coarse grained layers is linked to the compaction length during the pattern formation. With the formulation of a 1D steady-state solution we can relate the genesis of the structure to physical parameter, such as permeability and pressure. By this procedure field data can be applied in order to invert for permeability and pressure. Our model can therefore help to develop a new tool for field geologists and might as well be applicable to several other geological problems.