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Compaction instabilities described by cnoidal waves in ore-hosting dolomites

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Rhythmically banded dolomites are found worldwide, and are frequently associated with mineralization of the Mississippi Valley-Type (MVT). These rocks, referred to as zebra dolomites, are built up by alternating dark and light layers of chemically similar dolomite. Apart from the color, a considerable difference in grain size and impurity content is observable comparing the different layers. The grain size and impurity content can differ by several orders of magnitude between the coarse grained light and the fine grained dark bands. In addition to that, the crystals in the light, virtually impurity-free bands are elongated towards a central line in these layers. This gives them a texture similar to syntaxial veins, where crystals grow from the rims of an opening fracture towards the center of the crack. The structure has been studied by several authors and different generic models have been proposed. Nonetheless, a complete model which can explain all features has not been developed, yet.

We present a new generic model of a coupled solid-fluid system which is able to relate the spacing of the respective layers to physical parameters such as pressure and permeability. The model is a 1D steady-state solution based on Cnoidal waves. In our approach the light coarse grained layers of the zebra dolomites are related to instabilities developing during the diagenetic compaction of fluid saturated carbonates. These compaction instabilities form high permeability channels in which an elevated pressure arises. The dolomite in these channels recrystallizes, forming a secondary, impurity free generation of crystals. The subsequent grain growth is influenced by the distribution of impurities, and is most effective in the minerals of the second dolomite generation. During the progressive grain coarsening a fracture can develop in the central part of the light layers along which dissolution occurs. The crystals will then grow towards this fracture leading to the elongated shape of the grains. The model can explain the equidistant spacing of the layers, the grain size difference of the zebra bands, and might also explain the elongated shape of the crystals in the light layers.

Because our model relates the structure to certain rheologic parameters, we believe that this approach might help to increase the understanding of economic mineralization of the MVT.