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Modelling of fracture initiation during volume increasing reactions in rocks

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The process of fracture formation due to a volume increasing chemical reaction has been studied in a variety of different settings, e.g. weathering of dolerites by Røyne et al.[3], serpentinization and carbonation of peridotite by Rudge et al.[2] and replacement reactions in silica-poor igneous rocks by Jamtveit et al.[1]. Røyne et al.[3] observed both spherical weathering and hierarchical domain division on a metre scale in the same outcrops, and Jamtveit et al.[1] observed both fractures resembling the spalling of outer layers during spherical weathering and hierarchical domain divisions on a micrometer scale. Both Røyne et al. and Jamtveit et al. have reproduced some of the observations using numerical models, but without any detailed understanding of under which conditions the different fracture types are formed.

In this study, we use a finite element model (FEM) to study initiation of fractures, and a discrete element model (DEM) to study both initiation and subsequent growth of individual fractures. In both cases, we solve a reaction-diffusion equation for the chemicals to find the extent of reaction, and assume a linear volume increase when the extent of reaction is increased. We then use the extent of reaction as input to a mechanical model in either FEM or DEM.

We obtain a quantitative understanding of what parameters control the type of fracture that is initiated, and when initiated, which fractures will continue to grow, thus allowing us to predict which type of fracture is expected to form in specific cases.

References

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