Uncovering the Influence of Crystal Growth, Dissolution, Crack Propagation, and Vein Formation on Earth's Subsurface : A Phase-field Investigation

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The Earth's subsurface is a dynamic environment where various geological processes such as crystal growth, dissolution, crack propagation, and vein formation play a pivotal role in shaping the planet's structure and resource distribution. Understanding the intricate interplay of these processes is essential for elucidating geological phenomena, resource formation, and environmental challenges. Our research presents a phase-field investigation that aims to uncover the fundamental mechanisms underlying crystal growth, dissolution, crack propagation, and vein formation within Earth's subsurface.

Here, we showcase phase-field modeling, a powerful numerical technique, to simulate and analyze these processes at different temporal and spatial scales. The modeling technique integrates geology, physics, and materials science to provide a comprehensive understanding of how the subsurface evolves over time. It explores how crystal growth and dissolution affect mineral formation and resource concentration, demonstrating their significance in resource exploration and extraction. Furthermore, our research investigates crack propagation, shedding light on the factors that trigger faulting, seismic activity, and reservoir containment. By examining the mechanisms driving vein formation, it reveals how valuable mineral deposits are often concentrated, offering insights into mineral exploration strategies.

The phase-field method provides a coherent framework for simulating subsurface evolution, opening the door to research into the interplay between these many geological processes. Over the past decade, our extensive research efforts have significantly advanced our comprehension of the Earth's subsurface, therefore laying the groundwork for more effective and sustainable resource extraction practices as well as environmental preservation.