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KEY PROCESSES OF SULFIDE OXIDATION IN MINING ENVIRONMENT: DISPROPORTIONATION MECHANISM AND ISOTOPE FRACTIONATION

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Abstract

The oxidation of sulfide minerals, particularly pyrite, is the primary cause of acid mine drainage (AMD)—a severe environmental issue leading to water contamination and ecological degradation. This review comprehensively examines the mechanisms of pyrite oxidation, with a specific focus on the pivotal role of intermediate sulfur species. It discusses the electron transfer processes during oxidation and the kinetics of microbially catalyzed reactions. The decomposition of thiosulfate ($S_2O_3^{2-}$) is identified as a critical step, linking reductive and oxidative pathways in the sulfur cycle and facilitating solid-liquid phase transitions. A major challenge in elucidating the pyrite oxidation mechanism lies in clarifying the transformation pathways of intermediate sulfur species under varying redox conditions. This review highlights the redox-dependent transformation between elemental sulfur (S^0) and $S_2O_3^{2-}$ as a key knowledge gap. Furthermore, given the limited understanding of microbial involvement in these transformations, especially regarding sulfur isotope fractionation during disproportionation, systematic research on the reaction pathways of S^0 and $S_2O_3^{2-}$ is crucial. To advance the field, we propose a research framework that integrates chemical kinetics with isotope geochemistry. This approach, involving reaction kinetics models, Rayleigh fractionation equations, and temperature-dependent relationships, aims to quantify oxygen sources in sulfate and ultimately elucidate the oxidation mechanism of coal-derived pyrite in mining environments.

Key words: intermediate sulfur species, oxidation, pyrite, S^0, $S_2O_3^{2-}$, sulfur disproportionation

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