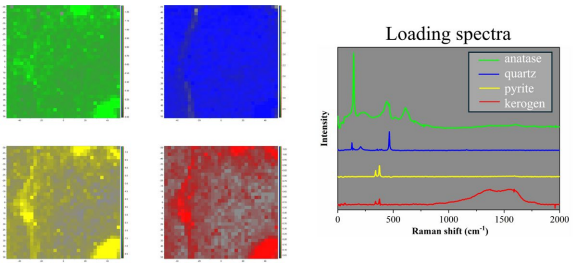
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Revealing spatial distribution and relative abundance of components within a pyrite concretion: implications from CLS-coupled Raman imaging

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The genesis of concretions, compact mineral masses that often encapsulate fossils, is complex and multidisciplinary [1]. Current studies lack a comprehensive approach to bridge the inorganic–organic gap. Raman imaging combined with chemometrics offers a promising solution, as pioneered by Kitanaka et al. (2024) [2], who demonstrated the capability of this approach to effectively map both mineral and organic matter. Building on their work, this study applies classical least squares (CLS)-integrated Raman imaging to analyze a pyrite concretion from northern Taiwan, enabling simultaneous spatial mapping and semi-quantification of mineral and organic components.

Raman imaging was conducted on a 100 × 100 μm² region with a distinct banded structure on its left side. The spectra revealed the presence of anatase, quartz, pyrite, and kerogen (a complex mixture of high molecular organic polymers). CLS analysis shows quartz widely distributed except of the banded structure, whereas pyrite and kerogen are co-localized within it. Histograms illustrate that pyrite and kerogen within the banded structure exhibit higher CLS scores (indicating greater spectral contribution based on reference spectra) compared to other regions. Their co-localization, statistically supported by a high Pearson correlation coefficient (r = 0.943) between their scores, indicates pyrite nucleation occurred in organic-rich zones during early diagenesis. This phenomenon can be linked to bacterial sulfate reduction (BSR) [3], a fundamental microbial activity that promotes concretion formation, and suggests a potential biogenic origin for the banded structure.

This research provides direct visual evidence of BSR-driven concretion growth and establishes a robust analytical framework for studying complex geobiological processes, thereby bridging the inorganic–organic gap in geoscience through CLS-coupled Raman imaging.

References

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