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Variations in chemical composition of oxygen-depleted sediments expressed as a combination of independent components

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The oceans have become oxygen depleted repeatedly throughout Earth's history, and such conditions have been associated with global-scale environmental changes and/or mass extinctions. These environmental changes are recorded in organic-matter-rich sedimentary rocks called black shale. However, why the chemical features of black shales vary throughout geologic time remains an open question. To understand the essential features of black shales and the marine environments in which they formed, we applied independent component analysis to an integrated dataset of the chemical compositions of sediments and sedimentary rocks formed in oxygen-poor marine environments at three different times. Our results showed that oxygen-rich/oxygen-depleted water boundaries commonly developed during the Permian–Triassic boundary (PTB), Cretaceous oceanic anoxic events (OAEs), and in late Cenozoic oxygen-depleted marine environments. In addition, high primary productivity and abundant Fe-sulfides uniquely characterized the Cretaceous OAEs and the PTB, respectively. Our new data-driven approach demonstrates that geochemical variations in black shales/sediments from different times and places can be explained by a combination of geochemical ICs, and that use of ICs that reflect information about multiple elements can be a novel and broadly applicable method to systematically capture the characteristics of black shales and organic-rich sediments.