Pyrite sulfur isotopes reveal glacial-interglacial environmental changes.

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The sulfur biogeochemical cycle plays a key role in regulating Earth's surface redox through diverse abiotic and biological reactions that have distinctive stable isotopic fractionations. As such, variations in the sulfur isotopic composition ($\delta^{34}S$) of sedimentary sulfate and sulphide phases over Earth history can be used to infer substantive changes to the Earth's surface environment, including the rise of atmospheric oxygen. Such inferences assume that individual $\delta^{34}S$ records reflect temporal changes in the global sulfur cycle; this assumption may be well grounded for sulfate-bearing minerals, but is less well established for pyrite-based records. Here, we investigate alternative controls on the sedimentary sulfur isotopic composition of marine pyrite by examining a 300 m drill core of Mediterranean sediments deposited over the past 500,000 years and spanning the last five glacial-interglacial periods. Because this interval is far shorter than the residence time of marine sulfate, any change in the $\delta^{34}S_{pyr}$ record necessarily corresponds to local environmental changes. The stratigraphic variations (>76.8‰) in the isotopic data reported here are among the largest ever observed in pyrite, and are in phase with glacial-interglacial sea level and temperature changes. In this case, the dominant control appears to be glacial-interglacial variations in sedimentation rates. These results suggest that there exist important but previously overlooked depositional controls on sedimentary sulfur isotope records, especially associated with intervals of substantial sea level change. This work provides important perspective on the origin of variability in such records and suggests novel paleoenvironmental information can be derived from pyrite $\delta^{34}S$ records.