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Framboidal pyrites flourished in sulfate-methane transition zones of cored sediments in the northern South China Sea

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The diameter of framboidal pyrites was widely used as a measure of redox condition in modern and ancient sedimentary environments, the proposed critical values of average size and standard deviation of framboids are about $8\mu\text{m}$ and $3\mu\text{m}$ respectively. However, a few reports proposed that the exceptionally large size and standard deviation of framboidal pyrites in cored sediments from northeastern South China Sea is closely related to the anaerobic oxidation of methane (AOM) processes mainly dominated in sulfate-methane transition zones (SMTZ). Here we investigate the occurrence of framboidal pyrites in two cored sediments of sites SC-W02B-2017 and SC-W03B-2017 at Shenhu area during the first offshore gas hydrate production test in northern South China Sea. Combined with the statistics of size and standard deviation of framboidal pyrites, the relative concentrations and sulfur isotopic compositions of bulk pyrites, we verified that the AOM could enhance the framboidal pyrite formation. Our data show that both the size and the standard deviation of framboidal pyrite present an unusual positive excursion in cored sediment column. By interpreting the coupling occurrence of positive excursions both pyrite concentrations and sulfur isotopes, four main paleo-sulfate-methane transition zones (Paleo-SMTZ) are roughly recognized in depths around 50 meter below seafloor (mbsf), 90-100 mbsf, 135-225 mbsf and 180 mbsf, where unusual strong AOM and unusual methane releases might happened. The morphology shows most of the pyrite framboids occur in framboidal cluster with a rod-like, irregular block shape and secondary overgrowth. The size of pyrite framboids in site W02B ranges from $8.1\mu\text{m}$ to $40.1\mu\text{m}$ with maximal about $40.1\mu\text{m}$ and in site W03B from $8.6\mu\text{m}$ to $25.3\mu\text{m}$ with maximal about $101.2\mu\text{m}$ ($n=2686$ from 13 samples). Our data show the average size and the standard deviation of pyrite framboids are more than $20\mu\text{m}$ and $3.0\mu\text{m}$ respectively, and the higher $\delta^{34}\text{S}$ value and larger size of framboid mainly occur near the intervals of paleo-SMTZs in marine sediment columns. Therefore, we propose again that the enhancing AOM in SMTZs could flourish the growth of pyrite framboids and enlarge the standard deviation of framboidal size, which might be implication for more precise interpretation of redox condition of sedimentary environments using framboidal pyrite diameter.