

Relationships between rate of pyrite oxidation and atmospheric pO_2

Kosei E. Yamaguchi[1]

[1] JAMSTEC and NASA Astrobiology Institute

Presence of apparently 'detrital' pyrite (FeS_2) crystals in sedimentary rocks older than 2.4 Ga have been often used to infer extremely low pO_2 levels, because pyrite is readily oxidized to sulfate and dissolved into solution during chemical weathering under O_2 -rich atmosphere. Based on the available data on the kinetics of pyrite oxidation, we estimate the survivability of pyrite as a function of pO_2 . We estimate that pyrite crystals with volume lower than 10 mm^3 would be completely oxidized in soils or during transport, at $pH = 5$, in warm climate (40°C) within $10^4 - 10^5$ years (i.e., a typical soil retention time), if pO_2 is higher than 10^{-6} atm, i.e., higher than 0.0005 %PAL (PAL: present atmospheric level). This estimate changes little if temperature is increased to 80°C or pH is changed to 4 or 6. 'Detrital' pyrite crystals in the Archaean sedimentary rocks, if any, as claimed by some previous investigators, would be survived ones benefited from rapid transport from source area to the depositional sites followed by rapid burial. Our estimates for pyrite oxidation rate have implications for continental weathering flux of molybdenum, a bio-essential element hosted mostly in pyrite and molybdenite (MoS_2). The oxidation rate of molybdenite would be similar to that of pyrite based on the similarities in their crystal structure. Our estimates suggest that Mo hosted in such sulfide minerals was quantitatively transferred from continents to the oceans within $10^4 - 10^5$ years if pO_2 is higher than 10^{-6} atm. It is likely that availability of Mo in dissolved forms for microbial activity (e.g., FeMo cofactor for N_2 -fixation enzyme) in the oceans had established when the pO_2 first reached 10^{-6} atm in the Archaean or Paleoproterozoic.