

Geochemistry of Iron, Sulfur and Related Heavy Metals in Metal-Polluted Taihu Lake Sediments*¹

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ABSTRACT

To understand the geochemical characteristics of iron and sulfur and the extent of iron-sulfide minerals influencing heavy metal behaviour in metal-polluted sediments of Taihu Lake, two sites, in Meiliang Bay (ML) and Wuli Lake (WL), were selected to study the fractionation of iron, sulfur and related heavy metals. There were relatively high concentrations of Fe²⁺ and low concentrations of total S²⁻ in porewaters, indicating that conditions in these sediments favored iron reduction. The concentrations of acid volatile sulfides in sediments were 1.9–9.6 μmol g⁻¹ at ML and 1.0–11.7 μmol g⁻¹ at WL, both in the range of values detected in unpolluted lakes. Pyrite-S was 10.2–49.4 μmol g⁻¹ at ML and 10.3–33.0 μmol g⁻¹ at WL, accounting for more than 69% of the reduced inorganic sulfur at both sites. The low degree of sulphidization (< 14%) and pyritization (< 10%) indicate that sulfate may be the limiting factor for pyrite formation. The extractability of Mn, Cu, Pb, Zn, Ni, and Cr in sediments all suggest that sulfides are not the major binding phase for these metals during early diagenesis. Sulfur may play a modest role in the geochemistry of iron and traced metals in the sediments.

Key Words: heavy metals, reactive iron, reduced inorganic sulfur, Taihu Lake

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The authigenic formation of iron-sulfide minerals plays an important role in the cycling and distribution of trace metals in anoxic lake sediments (Wolfenden *et al.*, 2005). Some trace metals can be absorbed on or coprecipitated with the iron-sulfide minerals in anoxic sediments. As such, the potential mobility and bioavailability of heavy metals in anoxic sediments are largely determined by the geochemical characteristics of iron and sulfur.

Acid volatile sulfide (AVS) is operationally defined as the fraction of sulfides that is extractable by 1 or 6 mol L⁻¹ cold HCl. Some bivalent cation metals, such as Cu, Pb, Zn, Cd, Ni, and Cr, can react with sulfides to form insoluble metal sulfides (Di Toro *et al.*, 1992; Morse and Arakaki, 1993). These reactive trace metals can be extracted during extraction of AVS. When the molar amount of AVS is greater than the molar sum of all the reactive metals, there is expected to be no trace metals available to biota. Using the difference between AVS and reactive metals to assess sediment quality has been adopted widely (Di Toro *et al.*, 1990; Hare *et al.*, 1994; Burton *et al.*, 2005a, 2006a).

AVS is a part of inorganic reduced sulfur in anoxic sediments and is the most reactive sulfur component compared to pyrite-S and elemental S (S₀) (Burton *et al.*, 2006b). During early diagenesis, AVS may react with hydrogen sulfide or polysulfide to form pyrite. This process is evidenced by a high ratio of pyrite-S to AVS in anoxic sediments over time. During this process, some trace metals will be released from AVS and be sequestered during pyritization. Hence, trace metals availability can only be

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controlled by AVS temporarily, but pyrite-S can bind it more permanently (Berner, 1984; Howarth and Jørgensen, 1984).

Iron is often the most important metal with which sulfur is associated (Burton *et al.*, 2006c). The iron fraction that is reactive towards dissolved sulfide at early diagenetic time scales is normally extracted by dilute HCl (Berner, 1970; Raiswell and Canfield, 1998).

Using dilute HCl to extract AVS, reactive iron, and related heavy metals in sediments have been adopted by many researchers (Simpson *et al.*, 1998; Burton *et al.*, 2006a, c). By examining the extractability of trace metals in sediments, the extent of iron-sulfide minerals influencing heavy metals behaviour, such as metal mobility and bioavailability in lake sediments, can be determined.

The objective of this study was to understand the geochemical characteristics of iron and sulfur and the extent of iron-sulfide minerals influencing heavy metals behaviour in Taihu Lake sediments.

MATERIALS AND METHODS

Study site

Taihu Lake is the third largest freshwater lake in China. It is situated in the middle and lower reaches of the Yangtze River and has a surface area of 2338 km². Mean depth is 2 m, and it is a typical shallow eutrophic freshwater lake. Some areas of the lake, such as Meiliang Bay and Wuli Lake, have become eutrophic in recent decades due to non-point and point source pollution (Fan *et al.*, 2004). Taihu Lake sediments were characterized by no heavy metal pollution in the southern area to moderate pollution in the northern area. The northern areas of Meiliang Bay and Wuli Lake have suffered the most serious heavy metal pollution, including Hg, Pb, Cd, Cr, As, Ni, and Cu contamination (Qu *et al.*, 2001).

Wuli Lake is located near Wuxi City and has been seriously polluted by domestic sewage and industrial wastewater. The lake was originally connected to Meiliang Bay, but now is separated to protect the water, which was dredged in 2003 (Fan *et al.*, 2004). Unfortunately, the water condition only improved for three years after dredging, then algae blooms appeared again in 2006. Meiliang Bay is situated in the north of Taihu Lake and is the largest bay. The bay was heavily polluted by nutrients due to massive input of domestic sewage and industrial wastewater from the Liangxi River. The north of the bay suffers seasonal algal blooms each year since the mid-1980s (Fan *et al.*, 2004).

Two representative sites located in the northern part of Taihu Lake were chosen. One is located in Meiliang Bay (ML, 31° 30' 51.1" N, 120° 11' 27.6" E) and the other is in Wuli Lake (WL, 31° 31' 25.5" N, 120° 14' 8.3" E) (Fig. 1). The water depths at sites WL and ML are 1.55 and 2.20 m, respectively.

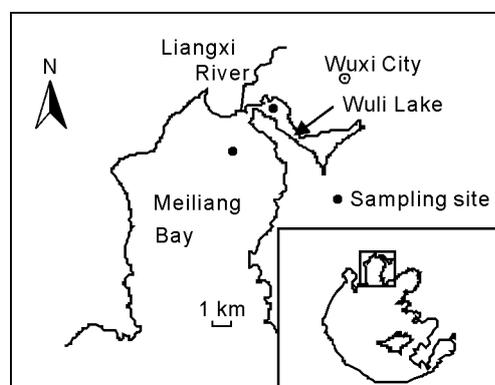


Fig. 1 Location of sampling sites in Meiliang Bay and Wuli Lake.

Sediment sampling and handling

Triplicate sediment cores about 30 cm long were collected at the two sites using a core sampler (10

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