MICROSCALE DISTRIBUTION AND SPECIATION OF Pb AND Sb IN SHOOTING RANGE SOILS

D. Vantelon (SOLEIL, F and SLS-PSI, CH) and R. Kretzschmar (ITOe, ETHZ, CH)

Abstract: An undisturbed soil section was investigated with a combination of µ-XRF and µ-XAS on the beamline LUCIA. Elemental maps collected by µ-XRF in the vicinity of a corroding Pb-bullet showed a spatial correlation between Pb and Fe concentrations, which can be explained by the high affinity of Pb for iron oxyhydroxide surfaces. No spatial correlation was observed between Pb and major low-Z elements in soil minerals, such as Si and Al. Sb L_{III} edge XANES spectra collected in an Fe-enriched area of the section and in a bulk soil, when compared with reference spectra, suggest that Sb(V) adsorbed to Fe oxyhydroxides is the most abondant Sb species in the soil.

INTRODUCTION

Contamination of soils with Pb and Sb is of substantial concern considering the toxicity of both elements. A significant source of pollution with these trace elements is the use of Pb(-Sb)-based ammunition on shooting ranges. Currently, little is known about the behavior of Sb in the soil environment. Pb is regarded as rather immobile in soils, although Pb migration along preferential flow paths has been reported (1).

The aim of this study is to investigate Pb and Sb distribution and speciation in contaminated shooting range soils. The LUCIA beamline offers two major advantages for this study: (i) the X-ray energy range (0.8 – 8.0 keV) allows observation of Pb, Sb and of low-Z elements (e.g., Si, Al, Ca) constituting most soil minerals; (ii) the small spot size of the X-ray beam allows elemental mapping at the micrometric scale.

Preliminary investigations were performed on a top-soil section collected in a slightly acidic soil profile in a forest, 30 m behind a shooting range target area (Zuchwil, CH). XAS measurements were performed at the Sb L(III) edge on the soil section and on powdered soil samples and references. The µ-XRF elemental maps and Sb µ-XAS spectra were measured in fluorescence mode using a Si(111) double crystal monochromator with a spot size of ~10x10 μm^2.

RESULTS AND DISCUSSION

A µ-XRF elemental map collected in the vicinity of a corroding bullet is shown in Fig. 1. The positive spatial correlation between Pb and Fe is clearly visible, while no correlations between Pb and other elements were observed. This can be explained by the high sorption affinity of Pb to iron oxyhydroxide surfaces (2).

Mapping the Sb distribution is difficult because of the high Ca concentration in the soil: the Ca K fluorescence lines overlap with the Sb L lines. However, previous experiments performed at the Sb K edge (beamline X26A, NSLS) showed that Sb is also associated with Fe (2). Thus, we collected a Sb L(III) XAS spectrum in a Fe enriched area (Fig2). Comparison with reference spectra suggests that Sb is mainly present as Sb(V) adsorbed to Fe oxyhydroxides. Similar spectrum was also obtained for another shooting range soil (Quartino). These results are in agreement with previous work we performed at the Sb K edge (3) (beamline ROBL, ESRF).

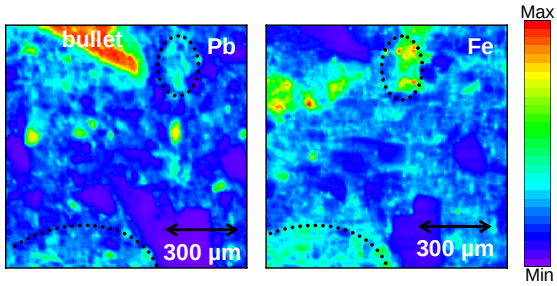

Fig. 1: µ-XRF elemental map showing the correlation in Pb and Fe distribution in the soil located in the vicinity of a corroded bullet

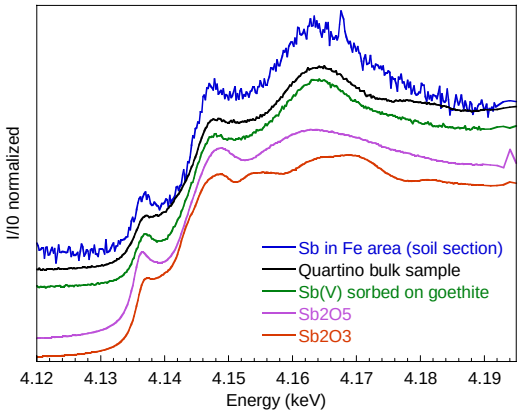

Fig. 2: Sb L_{III} XANES spectra collected in the section, a bulk soil and references.

REFERENCES

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