ACIDITY CHARACTERIZATION IN AN ACID SULFATE SOIL RECIPIENT ESTUARY IN WESTERN FINLAND

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SCOPE AND SUMMARY OF STUDY

The estuary Södra Stadsfjärden (area 16 km^2, volume 19.2 M m^3) in Vasa, western Finland, is recipient to two major rivers, Toby å (506 km^2 catchment area, 30 % arable land) and Solf å (144 km^2 catchment area, 38 % arable land), which drain known coastal lowland acid sulfate soils [4]. Since artificial drainage and cultivation started to increase, the subsequent oxidation of hypersulfidic [5] soil material in the catchment area has led to several tons of sulfate, organic matter and heavy metals (e.g. Al, Cd, Co, La, Mn, Ni, Zn) getting flushed into the estuary during high water flow conditions [5][2].

Bacterial re-sulfidisation processes in the estuarine sediments has consequently been rapid due to high influx of organic carbon and available iron and sulfate. Due to heavy influx of suspended material the estuary has a high sedimentation rate and therefore approximately 115 000 m^3 of sediments was dredged in 2016 to prevent the rivers from overflowing. The dredged materials were deposited next to the estuary with the intention of turning the area into arable farmland [7].

The estuarine sediments are very acid – after a 16-week incubation period, pH values ranged from 2.0-3.9, and the titratable incubation acidity (TIA) [3] was in the order of 300 mol H$^+$ ton^{-1} or more, which is relatively high as compared to known acid sulfate soils in the catchment area. This equals an acidity potential capable of releasing several tons of sulfuric acid and affecting the mobility of heavy metals for a considerable amount of time [6].

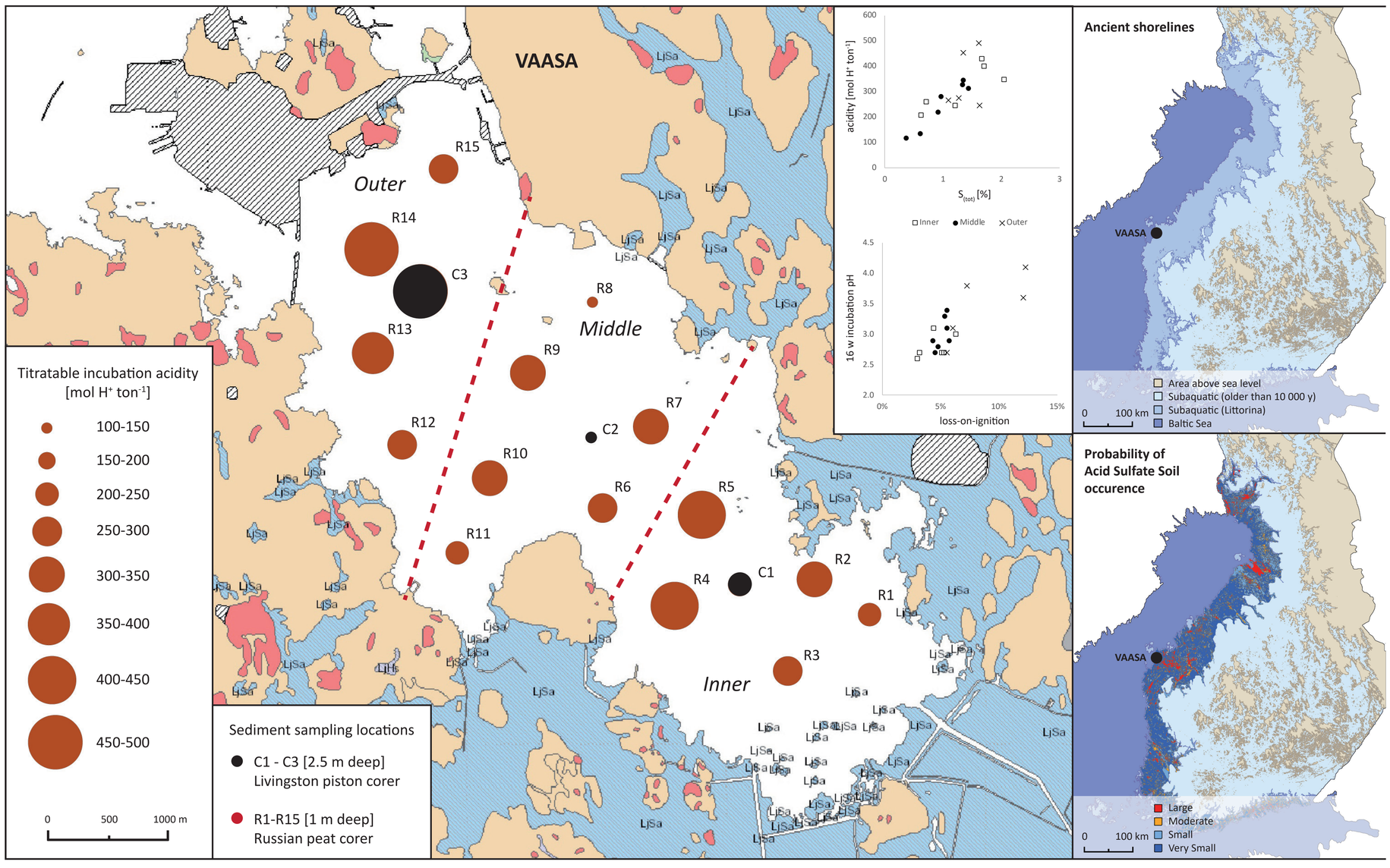


Fig. 1: Map of titratable incubation acidity [3] spatial variation in the *inner, middle* and *outer* area of the Södra Stadsfjärden estuary. The study area is located in western Finland by the city of Vaasa. The catchment area consists of fine-grained postglacial deposits, till and bedrock outcrops, and was once under the former Littorina Sea. The area has a high probability of acid sulfate soil occurence [4].

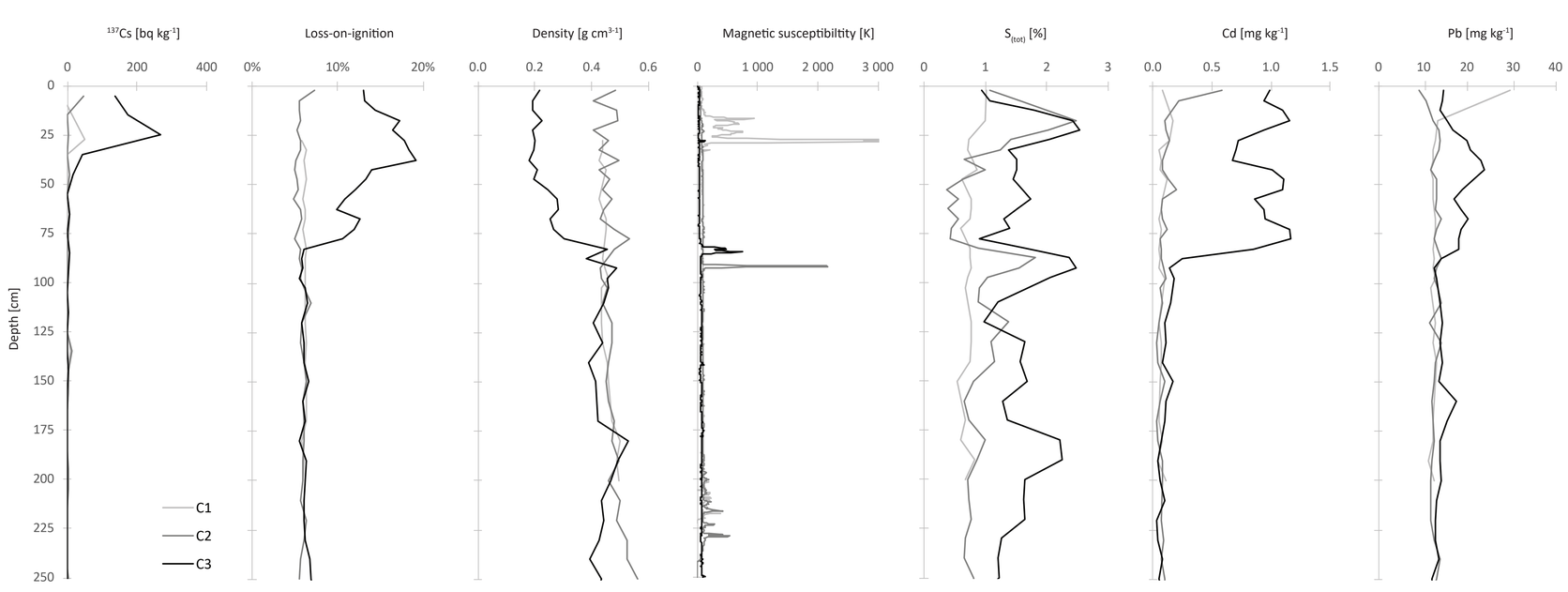
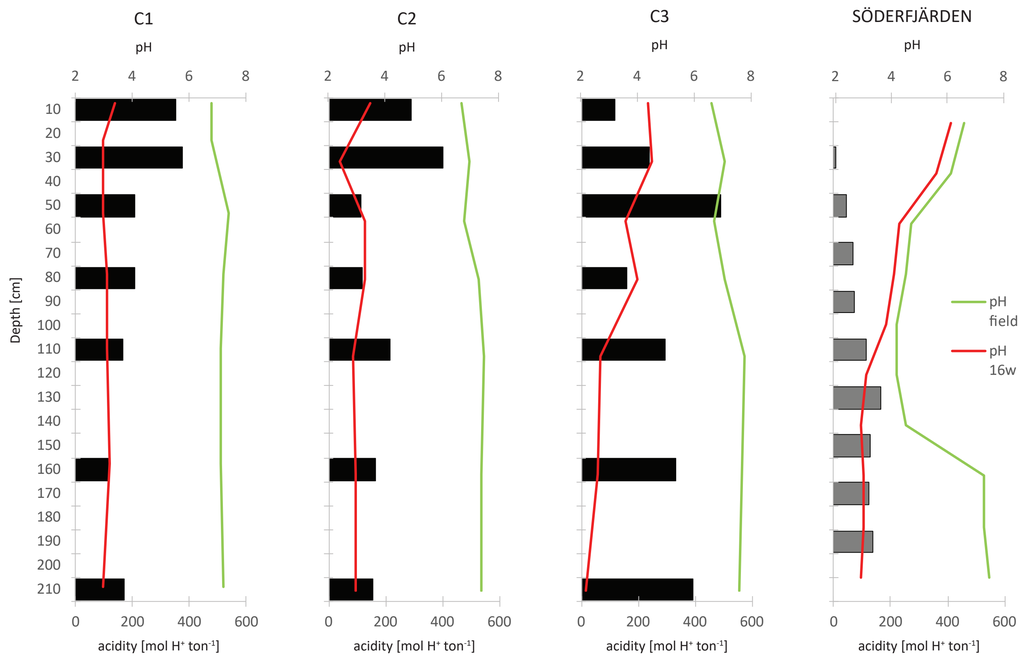


Fig. 2: Sedimentation history of the estuary. Using ^{137}Cs values a sedimentation rate of 15 mm yr^{-1} since 1986 was estimated for the core (C3) furthest from the rivermouth. A clear ^{137}Cs peak representing the 1986 Chernobyl incident could not be established in the two other cores, indicating that wind waves, currents and winter ice reduce sediment deposition close to the river mouths. Similar peaks for magnetic susceptibility and total sulfur ($S_{(tot)}$ %) values indicate similar sedimentation history for cores C2 and C3. Cadmium and lead, as well as other heavy metals, are significantly enriched in C3 and correlate well with higher organic content.



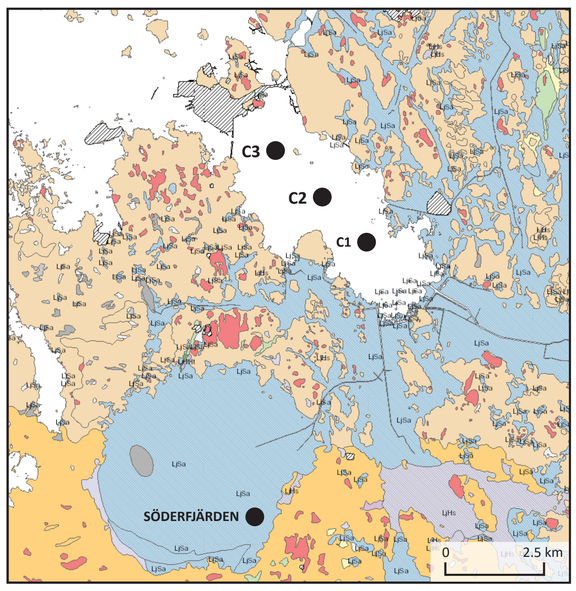


Fig. 3: Acidity potential comparison for estuary sediments and known lowland acid sulfate soil. Profile from AS-soil (GTK ID: AKBO-2016-8) taken from nearby Söderfjärden meteorite crater, which consists of fine-grained parent hypersulfidic material and an oxidised soil horison. Cores C1-C3 have similar 16 w incubation pH [1] values as typical AS-soil, but comparatively much higher titratable incubation acidity values.

Fig. 4: (From the top) Timo Saarinen and Arto Peltola preparing for sampling. Sediment core (R11) with black colour typical of metastable iron sulfides. Very low pH value in oxidised dredge material. Low pH value in drainage water from an active acid sulfate soil in the Toby river catchment area.

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