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Pyrite, jarosite and iron oxide formation and crystallinity in Acid Sulfate Soils of Senegal, West Africa

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Soils in boundary conditions of contrasting ecosystems generally show unique features. Transition often leads to changes in soil-forming processes, whereby the soil chemistry and mineralogy show different influences. Such an environment was analysed in the Saloum River basin, west-central Senegal. The intrusion of seawater results, in this particular zone, in the formation of saline and acid sulfate soils.

The objective of the present study was to investigate pyrite, jarosite and iron oxides in acid sulfate soils on two landscape positions (floodplain and low terrace) in the coastal plain of the Saloum river basin, West-Central of Senegal, in order to determine the incidence of the landscape position and soil moisture on their formation and crystallinity. Soil profiles were described according to the World Reference Base. The reaction of pyrite to 30% hydrogen peroxide (H_2O_2) was tested. Soil pH and electrical conductivity, total Fe, dithionite-soluble Fe, oxalate-extractable Fe, total sulfur and water-soluble sulfate were measured. Mineralogy analysis was performed by X-ray diffractometry.

The results show higher amounts of jarosite in the upper layers of the floodplain profiles than in the upper layers of the low terrace profiles. Soils on the floodplain contain pyrite, which converts to jarosite upon drying, giving rise to bright-yellow streaks along root channels in the original black–grey matrix. Differences in crystallinity are noted according to the landscape position and hydrological behavior. Jarosite crystals appear nearly amorphous and less structured in the floodplain samples, contrasting with the definite angular blocky structure they show in low terrace samples. Low-terrace soils undergo annual cycles of waterlogging and drying, promoting periodic reduction and oxidation caused by shifting of soil materials between anaerobic and aerobic conditions. The high crystallinity of jarosite and the low pH values (3–5) due to a somewhat higher landscape position support the maturation of the soil material, with almost complete pyrite oxidation and sulfuric acid production. Acid sulfate soil in the low terrace have probably passed through the potential stage to the ripe one, marked by advanced crystallinity of jarosite and iron oxides. The oxidation of pyrite and the redistribution of the main oxidation products (Fe2+ and SO42–) seem the most critical pedogenic process in the formation of jarosite and iron oxides in the studied soils. The Fe2+ produced during pyrite oxidation probably migrates upwards from the reducing sublayers to the oxidized layers, where it accumulates in the form of immobile Fe3+ oxides. This explains the presence of hematite in the mottled horizon starting from $\sim$20 cm below the surface of the low-terrace profiles. The Fe2+ may also migrate towards the soil surface and then become immobile through the formation of jarosite after combination with SO42–.

The most determining parameter remains ultimately the topography: lower landscape position supports high water saturation and low crystallinity of jarosite and iron oxides in the floodplain whereas higher landscape position leads to low water saturation and high crystallinity of jarosite and iron oxides in the low terrace.

Keywords: pyrite – jarosite – iron oxides - acid sulfate soils - Senegal - West Africa