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Rare earth elements as a fingerprint of soil components solubilization

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The retention of rare earth element (REE) in the soil profile are mainly controlled by three factors, (i) the stability of the primary REE-carrying minerals, (ii) the presence of secondary phases as clays and Fe- and Mn-oxyhydroxides and (ii) the concentration of colloidal organic matter (OM). Considering that each soil phases (mineral or organic) displays (ii) various surface properties, such as specific area, surface sites density and nature and (ii) their own REE distribution inherited from the rock weathering, their mobilization through various chemical reactions (dissolution, colloidal release. . . .) may involve the development of various shaped REE patterns in the soil solutions. REE fractionation from the different soil phases may therefore be used to identify the response of the soil system to a particular chemical process such as reductive and/or acidic dissolution.
To test this purpose, an organic-rich wetland soil sample was incubated under anaerobic condition at both pH 5 and uncontrolled pH. The REE patterns developed in the soil solution were then compared to the REE patterns obtained through either aerobic at pH 3 and 7 incubations or a chemical reduction experiment (using hydroxylamine). REE patterns in anaerobic and aerobic at pH 7 experiments exhibited the same middle rare earth element (MREE) downward concavity significant of the complexation of REE with soil OM. By contrast, under acidic condition, the REE pattern exhibited a positive Eu anomaly due to the dissolution of soil feldspar. Finally, REE pattern obtained from the chemical reducing experiment showed an intermediary flat shape corresponding to a mixing between the soil organic and mineral phases dissolution. The comparison of the various REE pattern shapes allowed to conclude that (i) biological reduction of wetland soil involved amorphous Fe(III) colloids linked to OM and, (ii) that the REE mobility was controlled by the dynamic of OM in wetland soil. They also evidence the potential of REE to be use as a tracer of the soil phases involved in the various chemical processes running in soil solutions.