

carbonate rocks. The weathering front is a main place of geochemical reaction, and at this limited-thick interface, with quick dissolution of carbonates, acid-insoluble residues begin to obviously decompose. On the basis of this, the evolution of weathering crusts is very slow. Weathering intensity of residues at the weathering front is correlative with their weathering history. During the weathering of carbonate rocks, accompanied with gradual downward extension of weathering front, acid-insoluble residues gradually sink downwards. Owing to preferential dissolution of carbonates at solution grooves, the top of weathering crusts at solution grooves is slower and slower than that at stone teeth. Thus, under the action of gravity, residues are gradually transported and piled from stone teeth to solution grooves, and this kind of micro area transportation of residues would stop until gravity equilibrium. As a result, at the scope of a little thin thickness from basement rock surface at solution grooves upwards, weathering residues show *in-situ* weathering characteristics. More upwards up to the top, different weathering residues are gradually transported and stacked from adjacent stone teeth, and compose principal part of weathering crusts at solution grooves. Their weathering intensity indices show strong undulation with the depth. On the basis of this, weathering crusts start advanced evolution. Through a later long weathering history, the red weathering crusts gradually show weathering features of normal weathering crusts from the top downwards.

**Key words** micro area transportation; red weathering crust; carbonate rock; acid-insoluble residue; Guizhou

## Aqueous geochemistry of rare-earth elements in karst lakes, southwestern China

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Due to the unique chemical properties that are similar but still progressively change, the rare earth elements (REEs) are useful tracers of various geochemical processes in the lithosphere and hydrosphere. However, despite many studies of REE geochemistry in the ocean, the aqueous geochemistry of REEs in lake waters has been poorly documented. In the present study, two special karst lakes are chosen as case studies to investigate the distributions of dissolved REEs in lake water. Although the two lakes, Hongfeng and Aha, are both alkaline and have high pH from 7.9 to 8.7 and high carbonate concentrations, the Aha Lake has been more severely affected by acidic mining drainage with high Fe, Mn and  $\text{SO}_4^{2-}$  concentrations. In the present study, the concentrations of dissolved rare-earth elements in lake waters were determined by inductively coupled plasma mass spectrometry. The result shows that the concentrations of dissolved REEs in the studied alkaline karst lakes, as compared to the concentrations of REEs in seawater, are much lower than the other investigated terrestrial surface waters in previous studies. The key factor controlling dissolved REE distributions is pH value which is negatively correlated with REE concentrations. Due to high concentration of carbonate ion and alkaline character of water chemistry, the shale (PAAS) normalized patterns of dissolved REEs show marked HREE enrichment in all water samples. This is primarily the result of the preferential formation of stronger carbonate complexes with the HREEs. In alkaline or intermediate waters, REE-carbonate complexes are the dominant and typical species, which account for about more than 90% of the total dissolved REEs. The shale-normalized REEs patterns of the dissolved phase also show very remarkable Ce anomaly in all lake water samples with the Ce/Ce\* values ranging from 0.1 to 0.8, mainly from 0.2 to 0.4. Moreover, the vertical distributions of Ce anomaly in the studied lakes are similar to the distribution of dissolved Mn, implying redox reaction is the main process for controlling the Ce anomaly in the lakes. This also shows Ce anomaly and Mn are two sensitive tracers of redox process in surface waters.

**Key words** rare-earth elements; karst lake; carbonate complex; Ce anomaly; redox

## Effect of *Aspergillus niger* on weathering of phosphorite rock

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Weathering mechanism of phosphorite rock by *Aspergillus niger* has been studied. Ten strains of phosphate-solubilizing fungi were isolated from rhizosphere soils by using dilute plate method in solid inorganic phosphorus culture. According to the size of soluble phosphate circle in the medium, a strain of stronger phosphate-solubilizing fungus was acquired, which was identified as, *Aspergillus niger* using identification methods of morphology and ITS sequences comparison in Genbank. In liquid culture, incubation in static state, the weathering of apatite rock with the fungus by contrast method: putting apatite powder (200 mesh) in liquid culture medium