Effect of geologic and biologic cycling on Se variability in a soil ecosystem with high level of nonagenarians

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Introduction

The spatial variability of Se in soils is affected by geologic and biologic cycling and has the potential to induce human health problems through food chains. The objectives of this study were to determine the effect of sedimentation and pedogenesis on the spatial variability of Se in an agriculturally soil ecosystem with high level of centenarians in Rugao County, Jiangsu province, China and discuss the Se bioavailability to rice and human longevity.

Materialas and Methods

342 surface soil samples and 9 of soil profiles in the studied area with 1,450 km^2 of land area and 1.54 million populations were taken. Total and water soluble Se (H_2O-Se) in surface soils and H_2O-Se in profile soil samples were determined using atomic fluorescence spectrometer (AFS). 97 of rice grain and drinking water samples were taken for Se determination using AFS. The ratio of population of nonagenarians over total population (90-rate) was calculated using the data of the national census in 2002.

Results and Discussion

The results showed that the total Se concentrations (0.127±0.021 mg kg^{-1}, n=203) had a narrow variation in top-soils derived from paleo-alluvium, lacustrine deposits or neo-alluvium, while H_2O-Se (2.42±1.09 μg kg^{-1}, n=342) had a wide variation among the soils derived from different parent materials. The concentrations of H_2O-Se in the soil series on lacustrine deposit with fine texture and long-term development were greater than those on paleo-alluvium with long-term development but coarse texture or neo-alluvium fine texture but short-term development. Increased H_2O-Se in the topsoil of soil profiles was, in part, related to the changes of soil properties due to weathering, pedogenic processes, and human activities. Correlation analysis between Se in the soils and rice Se or 90-rate in the study area showed that H_2O-Se in topsoil had a significant relationship with rice Se or the 90-rate at village level ($p<0.01$), but total Se had no any relationship between them ($p>0.05$). Similar variation of Se in drinking water to H_2O-Se in soils was found as well.

Conclusions

In conclusion, the geologic and biologic cycling in the studied area didn't cause the significant variation of total Se in soils, but significantly affected the variation of H_2O-Se in soils, and further Se uptake by crops, Se in ground water, and human health. It suggested that H_2O-Se in soils of the agricultural ecosystem might be one of the most important geochemical factors affecting human health or longevity.

Mg and Fe isotopes as tracers of temperature gradient driven diffusive differentiation

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The development of high precision MC-ICP-MS has led to breakthrough observations which have fundamentally called into question our current understanding of melt-mineral equilibrium and chemical differentiation processes. Although the mafic terrestrial igneous earth appears to have a near constant Fe isotopic composition with $\delta^{56}Fe_{IRMM}$ of ~ 0.07‰, a majority of granites and rhyolites with SiO_2 content > 71 wt.% have a significantly heavier Fe isotope signature than the mean mafic earth with $\delta^{56}Fe_{IRMM}$ up to 0.4‰ (e.g. [1]). This has generated vigorous debate [2], since the origin of Fe isotope variation with differentiation remains unclear.

A thermal migration experiment using wet andesite (AGV-1) along a temperature gradient from 950°C to 350°C over 2 cm in a 3/4" piston cylinder apparatus for 66 days at 0.5 GPa produces silicic solid, melt + solid, and more mafic melt from the cold bottom to the upper top of the charge, respectively. Major-trace elements and mineralogy vary with temperature due to temperature gradient driven chemical differentiation (thermal migration). Most importantly, Fe-Mg isotopes of the experiment vary consistently as a function of position. The bottom solid portion does not deviate significantly from the starting material, AGV-1. However, the heavy isotopes of Mg and Fe are depleted in melt at the hot end and enriched in the middle melt + solid portion. $\delta^{56}Fe_{IRMM}$ and $\delta^{26}Mg_{DSM-3}$ vary by 2.8‰ and 9.9‰, respectively.

These total variations in Fe-Mg isotopes are much greater than those observed in the terrestrial igneous Earth. These variations are not caused by kinetic diffusion or equilibrium isotope fractionations. Instead, they appear to result from Soret diffusion, in which light isotopes are known to preferentially migrate up temperature gradient. Notably, this experiment shows isotopic variations despite essentially no concentration gradient in the melt. Thus, isotopic variations in natural samples could record soret effects that do not appear in melt compositions. Thus we speculate that compositions of high SiO_2 igneous rocks with long cooling histories may indeed reflect long time scale differentiation in a temperature gradient.

References

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[2] Beard, B.L., and John, C.M. (2006) *Chem. Geol.* **235**, 201-204.