Carbon and oxygen kinetic isotope effects during soil uptake of atmospheric carbon monoxide

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Carbon monoxide (CO) plays an important role in atmospheric photochemistry, since it strongly affects oxidative capacity of the troposphere. Soil uptake is the major sink for tropospheric CO next to photochemical reaction with OH radicals. The global flux, however, remains highly uncertain, with estimate ranging from 15 to 640 Tg/year. The stable isotopic compositions ($\delta^{13}C$ and $\delta^{18}O$) of CO provide important and unique information for the relative strength of each source or sink in global budget. By using the kinetic isotope effects (KIEs) during each removal process of atmospheric CO, we can estimate the relative strength of each sink to global budget. The KIEs for carbon and oxygen during the reaction of CO + OH have been determined in many past studies, but no published data have been available as for the KIEs during soil uptake. Here, we report the first KIEs data for carbon and oxygen during soil uptake of atmospheric CO and estimate the contribution of CO consumption by soil to global CO sink using isotopic mass balance. We calculated the KIEs for carbon and oxygen of CO during soil uptake from the temporal_$\delta^{13}C$ and $\delta^{18}O$ variation within *in situ* static flux chamber (17L) at two different sites in Hokkaido, Japan: native cool temperate forest and cultivate land. Gas samples were taken into pre-evacuated 200 ml glass bottle at every 5 to 10 minutes after deployment. CO content and stable isotopic compositions of CO were analyzed using a isotope ratio monitoring gas chromatography/mass spectrometry system. CO consumption rates coincide well with previous studies, ranging from –0.26 to 1.10 $\mu gCOm^{-2}min^{-1}$ and from 0.58 to 2.67 $\mu gCOm^{-2}min^{-1}$ for the forest and cultivate land, respectively. Carbon and oxygen isotopic fractionation factors (k_{12}/k_{13} and k_{16}/k_{18}) of CO during soil uptake were calculated to be 1.006~1.008 and 1.013~1.027 for forest soil and 1.003~1.009 and 1.008~1.020 for cultivate land, indicating that not only gaseous diffusion but also microbial activity in soils controls the KIEs during soil CO oxidation. Difference in KIEs among two soil types is littele. These values are significantly different from the KIEs of CO+OH reaction (k_{12}/k_{13} =1.005 and k_{16}/k_{18}=0.990 in atmospheric pressure). We estimate the contribution of soil uptake to global sink of atmospheric CO to be about 25%, which is the same order as previous estimates from flux measurements.

The application of EBSD to the study of amoeboid olivine aggregates

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Introduction

Amoeboid olivine aggregates (AOAs) are fine-grained aggregates of solar nebula condensates (forsterite, spinel, Al-diopside, anorthite, and FeNi-metal) that could have experienced annealing without substantial melting [1]. Textural and mineralogical studies of AOAs can potentially constrain their thermal history after aggregation. Here, we present mineralogical and structural study of AOAs in the CO3.0 carbonaceous chondrite Yamato-81020 (Y81020) using electron back-scattering diffraction (EBSD) technique that can provide crystallographic information for micron-sized regions on the surface of a polished thin section.

Results and Discussion

AOAs in Y81020 CO3.0 chondrite are up to 700 µm in size, and are composed of olivine ($Fo_{99.5\text{-}99.9}$), Al-diopside (Al_2O_3, 1-17 wt%), anorthite, and Mg-spinel. Clear EBSD patterns were obtained from all these minerals in AOAs, indicating they are well crystallized. We have collected EBSD patterns from about 200 points in the desired region of an AOA so far. Based on the EBSD study, the grain size of forsterite is varied in the range of 1-9 µm. There is no orientation relationship among the adjacent olivine grains. Al-diopside occurs as thin (<10 µm) rims around forsterite. EBSD patterns show that the individual grain size of Al-diopside is up to 5 µm. Anorthite is present in the core region of a Ca,Al-rich area. The grain size of anorthite is less than 8 µm. Spinel nodules are heterogeneously distributed in anorthite and are composed of small, <8 µm in size, grains.

The textures and chemical compositions of AOAs in Y81020 are similar to those of AOAs in the CV and CR carbonaceous chondrites [1,2]. However, the sizes of AOAs in Y81020 tend to be smaller than those from other type of chondrites. In addition, EBSD studies show that the grain sizes of forsterites are smaller. Because AOAs appear to have escaped extensive melting [1], the difference in grain sizes of the constituent minerals of AOAs may indicate a different thermal history of Y81020 from CV and CR chondrites.

References

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