CF_4 and CO_2 - coupling weathering and carbon cycle

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The analysis of CO_2 and its stable carbon isotopes from ice cores revealed large changes of atmospheric CO_2 related to changes in ocean circulation, marine biological processes and contributions from the terrestrial carbon storage. These processes dominate the glacial/interglacial CO_2 variations. Yet, CO_2 is also modulated by the marine alkalinity balance. The net alkalinity influx to the ocean is driven by silicate weathering drawing down atmospheric CO_2. Conversely, alkalinity is lost when $CaCO_3$ is buried in marine sediments. On orbital time scales, these fluxes are assumed to be almost balanced as atmospheric CO_2 and its climatic effects feedback on the weathering rates providing a negative feedback loop.

Trace elements from marine sediments are widely applied to derive weathering rates or changes in the weathering style for a certain region. Here, we use a novel approach to provide a global weathering estimate using the ppt-level trace gas CF_4 archived in polar ice cores. CF_4 is found as a trace gas in granites, and during weathering it escapes to the atmosphere. Because CF_4 is inert in the lower atmosphere, its only sink is destruction by UV radiation in the mesosphere. This chemical inertness is responsible for an exceptionally long atmospheric lifetime which is expected to range between 50 kyr and 400 kyr. We developed a vacuum melt-extraction system for ice core samples to precisely measure these trace amounts of CF_4 and applied it to ice over the entire Dome C ice core. During the last 800 kyr, atmospheric CF_4 varied in a narrow band between 31 ppt and 35 ppt, i.e. only 10-15 % variability, providing a first estimate of the long-term weathering rate fluctuations. Our record shows that CF_4 increases during interglacials and falls during the coldest, glacial phases. However, our CF_4 record also shows a pronounced shift toward higher CF_4 levels after 430 kyr. With the beginning of MIS 11, we find a rise in CF_4 that probably relates to intense weathering during the first full interglacial after a series of lukewarm interglacials. This dataset lends support to a strong positive coupling of continental weathering and climate.

Multitracer paleoclimate and recharge study of groundwater in the North China Plain

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A multitracer study of groundwater in the North China Plain (NCP) was conducted in the framework of a Chinese-German cooperation project whose main objective is to obtain groundwater ages and recharge rates in order to refine a groundwater flow model of the NCP and to help find ways for sustainable groundwater management [1]. Additionally, the obtained data adds to an existing data set from a previous paleoclimate and groundwater recharge study in the NCP [2][3].

Samples were taken on two sampling campaigns in 2011 and 2012 from 36 wells along a transect in the northern NCP starting at the mountains in the west, passing south of Beijing and leading to the Bohai Sea at Tianjin. In addition, seven wells were sampled on a short transect near Handan, further south in the NCP.

Dating tracers being used are ^3H-^3He, SF_6 and CFCs 11, 12 and 113 for young ages and ^{14}C as well as ^4He for a longer time scale. The climate information is obtained through dissolved noble gases and stable isotopes. The combined use of SF_6 and CFCs allows us to identify and correct for possible SF_6 from natural sources and CFC contamination in the highly industrialized area near Beijing.

Dating results show that the groundwater age mainly increases with depth rather than distance along the transect, with an abrupt rise at a depth of around 100m. Enhanced concentrations of both SF_6 and CFCs are unrelated, indicating different sources. The noble gas temperatures suggest a temperature difference between the Holocene and the last glacial period of about 5°C. Overall, the new data confirm and complement previous results from the NCP [2][3].

[1] Cao *et al*. (2013), *Water Resour. Res*. **49**, 159-175. [2] Kreuzer *et al*. (2009), *Chem. Geol*. **259**, 168-180. [3] von Rohden *et al*. (2010), *Water Resour. Res*. **46**, W05511

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