The role of ammonium in native H_2 production in continental lithosphere

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Following the discovery of hydrogen seepages within the continental lithosphere, discovered earlier at mid-oceanic ridges, questions have arisen concerning (i) the origin of this gas, (ii) the mechanisms for such production, and (iii) the conditions of preservation during its migration, since H_2 is known for its rapid diffusion and high reactivity.

In these intracratonic environments, the prevalent H_2 generation hypotheses are the radiolysis of water or/and its reduction by ferrous iron from ultrabasic rocks in the deep basement, over geologic time scale. Nevertheless, the covariation of nitrogen with hydrogen seems to emphasize a common origin for both gases. H_2/N_2 natural seepages are commonly associated in continental contexts with the occurrences of ultrabasics rocks, related to the presence of an ophiolitic belt or an aborted rift, and sediments. Within the continental lithosphere, nitrogen is predominantly present under the form of ammonium (within clay minerals, or micas in granitic rocks) or in the form of N-rich organic mater. However, organic mater is uncommun in basement rocks and ammonium could therefore play an important role in both H_2 and N_2 formation in intracontinental context.

In order to understand the interactions between NH_4 present in sediments and ferrous iron in ultrabasic rocks, as well as their implications for natural H_2/N_2 generation, analogic water-rock interactions experiments were carried out. Multiple runs mixing various ratios of FeO and NH_4Cl were conducted in gold tubes placed within a batch reactor for 3 weeks, at 150°C or 300°C, and 200 bars. Analyses of the gas, water and powder composition were performed after the reaction through GC, IDP-OES, SEM and XRD.

The results of these experiments bring back into question the role of NH_4 as the source for direct H_2 production. This study highlights the implication of NH_4Cl as a possible catalyst in the reduction of H_2O and the FeO oxydation.