

Weathering mechanisms in the Belgian Ardenne Massif

The Transinne regolith (Ardenne Massif) is a ~65 m thick kaolinite profile, superimposed on folded and faulted rocks from the Devonian Oignies Fm, comprised of shale and sandstone. The unweathered shale/sandstone series of the Oignies Fm is constituted of dominant quartz, illite, chlorite and, to a lesser extent, of illite-smectite mixed layers. These rocks are locally slightly carbonaceous, and contain a few percent of pyrite, nowadays epigenized in iron oxides within the regolith. Neoformed minerals are a monotonous paragenesis comprised of predominant kaolinite, and associated iron oxihydroxides. The nature of (the) acid(s) involved in the hydrolysis process is discussed in this paper.

On the one hand, the lack of sulfate minerals, indicative of low pH (such as jarosite), does not support the hypothesis of a dominant leaching by sulfuric acid originating from pyrite oxidation even if epigenized pyrite cubes are sporadically observed in the profile. Even if these pyrites were oxidized, and actually released sulfuric acid, this probably remained a marginal process, unlikely to account for the whole thickness of the weathered profile.

On the other hand, geochemical modeling suggests that thick kaolinitic profiles are efficiently formed through long-lasting leaching of protoliths by meteoric fluids, especially in periods where these fluids have high CO_2 fugacity. Such was the case of the Early Cretaceous Berriasian to Barremian period, when a weathering event occurred in Transinne (unpubl. radiometric and paleomagnetic data): CO_2 content in the atmosphere was at the time as high as ~2500 ppmv.

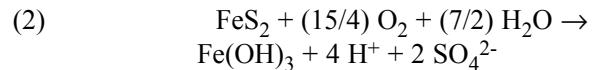
Preliminary modeling of the Transinne system suggests that a “mixed” situation, in which pyrite was oxidized by fluids with high CO_2 fugacity, accounts fairly well for the observed mineralogy (kaolinite + hematite).

The main mechanism would be silicate hydrolysis by meteoric fluids with a high CO_2 fugacity. It resulted in kaolinite neoformation, in a pH range centered on pH~5.4, i.e. (logically) slightly lower than the present-day value:

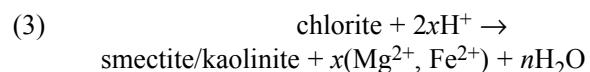


(Note that hematite is *ab initio* saturated within such fluids).

Pyrite was oxidized, according to the following reaction:



Though kinetically fast, this reaction would involve a (much) lesser volume of fluids than silicate hydrolysis. H^+ ions produced in reaction (2) were then continuously consumed through chlorite hydrolysis, according to:



This latter reaction prevented any strong decrease in the pH value of the fluids, and hence any precipitation of sulfate minerals, whose stability field is generally restricted to a narrow low pH range (in the order of pH~1.5 to 3).

As the Transinne protolith is obviously a mature (i.e. poorly reactive) rock, it seems unlikely that the whole regolith was formed in a short, mono-phased, event. In the present state of knowledge, we would rather favor the hypothesis of a long-lasting process, involving dominant carbonic fluids producing, at length, a monotonous thick profile comprised of dominant iron oxides, and kaolinite. The wide date range obtained along the Transinne profile (from Early Cretaceous to Miocene: Yans, this volume) would support this hypothesis.

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