THE RATE AND MECHANISM OF DEEP SEA GLAUCONITE FORMATION

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The conditions and mechanism of glauconitization in shallow shelf environments (< 300 m water depth and 15-25 °C) are generally well understood, whereby glauconite formation takes place close to the seawater-sediment interface. In contrast, the key factors controlling the rate and mechanism of deep-water glauconitization are still poorly constrained.
Cores from the Ivory Coast-Ghana Marginal Ridge (ODP Site 959) were recovered in 2100 m water depth and related 3-6 °C seawater temperature. Sediments from Hole 959C comprise of foraminifera and nannofossil oozes mixed with detrital silicates and authigenic green grains. This sedimentary record was found to be without large hiatuses since the Miocene. In order to identify the process and rate limiting factors for recent deep sea glauconitization, green grains were collected from 0.16, 11.69, and 24.91 meter below sea floor, corresponding to sediment ages of ~10, ~900, and ~2500 ky. Mineralogical and chemical changes within the green grains were studied by X-ray diffraction and various electron microscopic methods, together with the burial-related changes in bulk sediment composition and interstitial solution chemistry
Our results reveal that the green clay was formed mainly in foraminifera tests, which provided the post-depositional conditions ideal for glauconitization. Within these tests, an early micro-environment was generated, wherein microbial biofilm with incorporated gels containing Fe, Mg, Al, and silica were formed. Fe-smectite precipitated from these gels (~10 ky), supported by microbial activity and cation supply from the interstitial solution. With increasing burial (~900 ky), the Fe-smectite reacted to form mixed-layered glauconite-smectite (Gl-S) and finally almost pure glauconite developed (~2500 ky), without any miscibility gaps between the Fe-smectite and glaucony group. This burial-related glauconitization process is controlled mainly by the interstitial solution chemistry, which strongly depends on early diagenetic oxidation of organic matter, microbial sulfate reduction, silicate alteration and carbonate dissolution, and in particular Fe redox reactions. As evident by progressively more glauconite layers in Gl-S, ongoing with a notably higher Fe_2O_3 content in Gl-S with increasing state of early marine diagenesis, it is the availability of Fe which may is the rate limiting factor for glauconitization. This explains the greening of the grain colour with depth and the various states of green grain maturity within the samples. The glauconitization rate is given by $\%Gl_{Sed} = 22.6 \log(age_{Sed}) + 1.6$, where Gl_{Sed} is the state of overall glauconitization of the sediment and age_{Sed} is the sediment's age (in ky) (BALDERMANN et al., 2013). The rate of deep-water glauconite formation at this site is 5-times less than that in shallow shelf regions, probably reflecting the lower temperatures and limited cation supply within deep sea environments.

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