Does clay activation matter? A study of prebiotic RNA polymerization

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The abiotic polymerization of canonical nucleotides is a reaction at the center of the RNA world hypothesis for the emergence of life on the early Earth. Although central to the formation, reproduction and preservation of genetic information, this prebiotic reaction was only successfully carried out in the lab using activated nucleotides and catalytic clays prepared with the Banin process. This treatment, described as a cation-exchange process for swelling clays, produces catalytic homoionic clays that participate in the formation of up to 13-base long RNA oligomers in a 3-day one-pot reaction under limited geochemical conditions. However, only one clay mineral, over several hundreds tested, reportedly produced such long oligomers. Historically, the other phyllosilicates tested, treated or not, do not favor the formation of significantly long RNA strands.

The Banin treatment is not the only published method reporting the formation of homoionic clays, but is the only one that has been able to produce catalytic clays. Moreover, recent studies suggest that the interlayer space of swelling clays, where exchangeable cations would be located, is in fact inaccessible to RNA monomers [1-3].

In order to understand the mechanistic effect of the Banin process, we carried out a systematic study characterizing carefully prepared and treated clays and comparing these attributes to outcomes of prebiotic reactions. The catalytic Volclay montmorillonite was compared to other swelling and non-swelling clays to observe the specific effects of the Banin treatment on surface properties and mineralogy of the samples. The results of this study provide new insights on the general parameters controlling the catalytic effect of mineral surfaces and we propose a mechanism for nucleotides-clay interactions involved in these reactions.

REFERENCES

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