

## When did aqueous alteration occur on the Martian surface?

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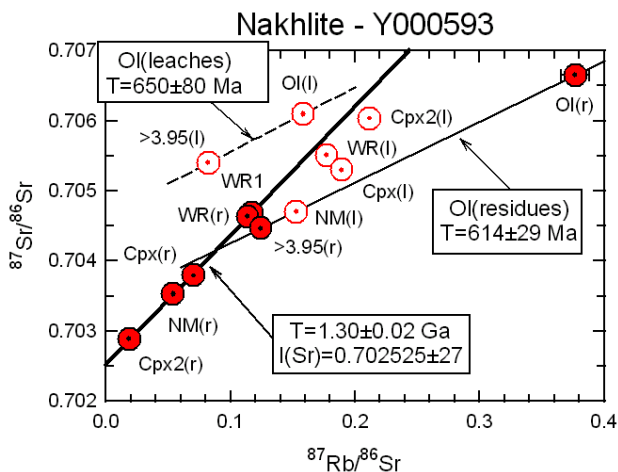
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We have been studying aqueous alteration products in Yamato nakhlite, Y000593, in an attempt to determine radiometric ages. The two-point Rb-Sr ages of olivine leachates (650 Ma) and of olivine residues (614 Ma) obtained by [1] are in good agreement with the oldest K-Ar age of 670 ± 91 Ma for the iddingsite sample [2] and with the Rb-Sr age of ~650 Ma for HCl leachates from the iddingsite-rich samples [3] from Lafayette. Our olivine samples (Ol and ρ>3.95) were obtained by density separation using heavy liquids of 3.60 and 3.95 g/cm<sup>3</sup>. The olivine (Ol) sample consisted of yellow olivines with lamellar exsolutions. Although adhering brown alteration products, iddingsite, are much less abundant in the Ol sample compared with the ρ>3.95 sample, the data point for the Ol residue is plotted far from the 1300 Ma isochron.



An olivine grain oriented normal to [100] was observed by TEM. It contains exsolution lamellae, which are composed of symplectic intergrowth of magnetite (<3 wt % Cr<sub>2</sub>O<sub>3</sub>) and augite. The magnetite lamellae are ~150 μm in width, similar to those in Nakhla [4]. There are no obvious clues to the aqueous alteration in the symplectic exsolution. In the olivine grain, screw dislocations elongated to [001] were observed locally. Dislocation density is on the order of 10<sup>8</sup> cm<sup>-2</sup>. No signs of aqueous alteration were observed in the areas where dislocations were concentrated.

### References

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## Polyamino acid formation in the abiotic conditions

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Many model experiments had been performed to obtain information on the prebiotic formation of polyamino acids because those had gathered special interest as a model of protoprotein on the primitive Earth. Most of these investigations had revealed that aspartic and glutamic acids, their amides, and lysine. Recently, we revealed that molten urea (mp 135 °C) serves as a highly polar reaction medium in the nitrogen-incorporating thermal polycondensation of unsaturated dicarboxylic acids producing polyaspartic acid (Terasaki, *et al.*, 2002a). In addition, we reported that alanine, which had been known incapable of undergoing thermal polymerization, was polymerized in the molten urea (Terasaki, *et al.*, 2002b). This result showed that there was little restriction of amino acid specie to polymerized in the molten urea. We, therefore, attempted to polymerize many kinds of amino acid in the molten urea, and characterized produced polyamino acids.

We heated equimolar mixtures of amino acids and urea at 140 °C for 24 h in the sealed test tubes, and the aqueous extracts of the reaction mixtures were analyzed by LC-MS. We detected four types of oligomers those were free peptides, carbamoyl derivatives at *N*-terminus or *C*-terminus, hydantoin derivatives at *N*-terminus, and unidentified derivatives, from glycine, alanine, β-alanine, aminobutyric acid, norvaline, valine, norleucine, leucine, and aspartic acid. Oligomers of serine, diaminopropionic acid, and cysteine were not detected, and there were little remained amino acids in the extracts. It seemed that those amino acids were decomposed during the reaction.

The largest oligomers detected in the extracts were 13-mer from glycine, 11-mer from alanine, 7-mer from aminobutyric acid, 4-mer from valine and leucine, and 8-mer from aspartic acid. Long oligomers from valine and leucine were not detected on the LC-MS chromatograms, because of their low solubility. When the reactions were finished, reaction mixtures of valine and leucine were soluble in the molten urea, however produced oligomers did not soluble in the aqueous solution completely. Therefore, the molten urea played the role of a good solvent.

From the viewpoint of chemical evolution, this study offered a new candidate for a dehydrating agent or a polycondensation medium that can be present on the primitive Earth.

### References

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