

The dissolution mechanisms of forsterite and enstatite: Constraints from ^{29}Si and ^1H MAS NMR

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Forsterite and enstatite play important roles during the weathering of ultramafic and mafic rocks. However, the aqueous dissolution mechanisms of these minerals are still controversial. We now report new ^1H and ^{29}Si MAS NMR, and ^1H - ^{29}Si cross polarization (CP)-MAS NMR results that shed light on this matter.

Hydrated Mg_2SiO_4 forsterite and MgSiO_3 enstatite samples were prepared by immersing gently crushed synthetic minerals in deionized water at 90°C for 2 days and drying at 100°C for 20 minutes. The ^{29}Si MAS NMR spectrum for the unhydrated forsterite consists of a single, sharp peak at -61.8 ppm. The ^{29}Si MAS NMR spectrum for the unhydrated enstatite consists of two sharp peaks at -80.5 and -83.2 ppm attributable to clinoenstatite, and a third one at -84.9 ppm attributable to protoenstatite. The ^{29}Si MAS NMR spectra of the hydrated minerals are nearly identical to those of the unhydrated. The ^1H - ^{29}Si CP-MAS NMR spectra of the hydrated forsterite and enstatite both consist of two peaks near -86 and -93 ppm that can be attributed to Q^2 and Q^3 species (SiO_4 tetrahedra sharing 2 and 3 corners with other tetrahedra), respectively. Similar spectra have been previously reported for hydrated diopside (Peck et al., 1988). The ^1H MAS NMR spectra of hydrated forsterite and enstatite both contain a relatively narrow peak near 0.4 ppm and a broader, asymmetric peak near 4.6 ppm. The former can be assigned to MgOH , and the latter to hydrogen-bonded SiOH and/or molecular H_2O .

The predominance of Q^2 and Q^3 peaks in the ^1H - ^{29}Si CP-MAS NMR spectra of hydrated forsterite and enstatite suggest that the dissolution of both minerals is accompanied by the formation of a polymerized hydration layer consisting mainly of Q^2 and Q^3 units. The detection of a large amount of MgOH by ^1H NMR implies that the hydration layers retain a significant amount of Mg. These hydration layers could consist, in part, of biopyriboles as observed for naturally weathered enstatite (Eggleton and Boland, 1982), and may play a dominant role in determining the dissolution kinetics of these minerals.

References

- Eggleton R.A. and Boland J.N.(1982) *Clays Clay Mineral.* 30, 11-20.
Peck J.A., Farnan I. and Stebbins J.F. (1988) *Geochim. Cosmochim. Acta* 52, 3017-3021.