

Mineralogy and petrogenesis of quenched angrite meteorites

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The angrites constitute an enigmatic achondrite group characterized by unusual mineralogy and ancient crystallization ages. Due to recent discovery of new angrites (Sahara99555, D'Orbigny and NWA1670), the current angrite collection is dominated by "quenched" angrite samples (samples listed above plus LEW87051 and Asuka881371) and distinct from the classic "slowly cooled" angrites (Angra dos Reis and LEW86010).

The quenched angrites show ophitic to porphyritic textures and often contain large olivine grains out of Fe/Mg equilibrium with the groundmass melt. Our previous studies pointed out that these olivine grains are essentially Cr-rich and Ca-poor than the groundmass olivines and are possibly xenocrysts [e.g., 1]. The similar mineralogy of the groundmass minerals as well as the presence of Cr-rich and Ca-poor olivine xenocrysts indicates that these quenched angrites are closely related and are co-magmatic.

We found strong correlations among major elements in these quenched angrites well understood by olivine control. Because olivine xenocrysts are absent or very rare in Sahara99555 and D'Orbigny, we suggest that their bulk compositions represent an angrite magma composition that is not contaminated by the xenocryst component. In contrast, LEW87051 and Asuka881371 contain ~10% olivine xenocrysts and appear that their bulk compositions include dissolved olivine xenocryst components. The newest angrite NWA1670 is also abundant in olivine xenocrysts and would be closer to LEW87051 and Asuka881371 in bulk composition. There is also a correlation between the core Fo components of the groundmass olivine and the bulk mg#s.

The origin of olivine xenocrysts is unclear. The forsterite component of xenocrysts ranges from Fo₉₆ to Fo₇₀. The presence of Fo₉₆ olivine is quite unique among achondrites and it is the most magnesian olivine except for olivines in aubrites and ureilites. Because it is hard to produce such a magnesian olivine by normal igneous differentiation processes, some reduction process may have been involved or it may be a completely exotic component related to the other class of meteorites. The heat source generating the angrite magma is also unclear. Either impact melting or endogenous melting is possible for producing rapidly cooled magma with xenocrysts.

References

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Alteration of marble and hyperalkaline groundwater evolution at Maqrarin (northern Jordan)

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Introduction

Hyperalkaline Ca-OH-SO₄ type (pH>12.5) groundwaters are associated with the retrograde hydration and alteration of pyrometamorphosed bituminous clay biomicrites, at Maqrarin (northern Jordan). Two groundwater systems ('Eastern' and 'Western') are differentiated on the basis of pH, Na, K, SO₄, Cr, Se and Re. The evolution of these groundwaters is being studied as a natural analogue for the evolution of the alkaline porewater environment of a cementitious waste repository.

Observations

The primary marbles contain larnite, spurrite, wollastonite, ellestadite, brownmillerite, periclase, brucite, portlandite, lime and other calcium aluminosilicate-sulphates and ferrites.

K and Na are present within major primary calcium silicate-sulphates, and in a discrete fine grained unnamed K-Cu-selenide-sulphide trace mineral associated with oldhamite (CaS). Oldhamite and K-Cu-selenide-sulphide are readily dissolved during early hydration. Calcium silicate-sulphates also alter early during hydration to produce secondary K-Na-free thaumasite. Brownmillerite, larnite, ellestadite and calcium aluminate-sulphate react more slowly to form a complex secondary assemblage which includes thaumasite, ettringite, portlandite, calcite, aragonite, vaterite, gypsum and hydrated calcium silicates and aluminosilicates.

Discussion and conclusions

K and Na are leached from the marbles during retrograde hydration. Early alteration of the more reactive primary K-Na-bearing minerals would appear to explain the enhanced K, Na, Se and SO₄ in the highest pH (12.9) site. Groundwaters in this part of the site may represent an earlier stage of the cement alteration process, so providing an excellent analogue to long-term repository evolution.

References

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