# Nepheline formation in CAIs and matrix in the Ningqiang carbonaceous chondrite: Evidence for unusual parent-body alteration.

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Ningqiang is an anomalous carbonaceous chondrite that cannot exactly be assigned to any known chondrite groups. It is petrographically and chemically similar to the CV chondrite group but is clearly resolvable from CV in terms of lower abundances of refractory lithophile elements (Rubin et al., 1988). We here present the results of detailed mineralogical and petrographic study of Ca-Al-rich inclusions (CAIs) and matrix in Ningqiang. We found that unusual nepheline ($NaAlSiO_4$) formation occurred in CAIs and matrix in Ningqiang.

64 CAIs were found in 820 $mm^2$ total area of four thin sections. The modal abundance of CAIs is 0.9 vol%, which is much lower than the mean CV abundance (5.1 vol%). Approximately half of these inclusions contain various amounts of nepheline, which has been formed mainly by replacing melilite. In addition, there are numerous smaller CAI fragments scattered in the matrix. These small CAI fragments also contain various amounts of nepheline. We suggest that the CAIs in Ningqiang became fine-grained and porous in the nephelinization process that occurred on the meteorite parent body, and during brecciation, they were disaggregated and distributed into matrix. Thus relatively large CAIs decreased in abundance, whereas small CAI fragments became abundant in the matrix.

The matrix in Ningqiang consists of an intermixture of two distinct regions, Fe-rich and Fe-poor. The Fe-rich regions consist mainly of relatively coarse grains of Fe-rich olivine, Fe sulfide and magnetite, whereas the Fe-poor regions consist mainly of smaller grains of relatively Fe-poor olivine and nepheline. These characteristics have not been known from any other carbonaceous chondrite matrices. The matrix in Ningqiang may be a mixture derived from two different reservoirs, Fe-rich (Na-poor) and Fe-poor (Na-rich), in the parent body. Alternatively, the Fe-rich regions in the matrix may have been derived from olivine aggregates with opaque minerals. The olivine aggregates have gone through Fe-enrichment and comminution, presumably during thermal metamorphism and brecciation, and so became fine-grained, porous, forming Fe-rich regions that we now see in the matrix.