CORRELATED POSITIVE ANOMALIES IN CE AND YB FOUND IN REFRACTORY INCLUSIONS FROM THE NINGQIANG METEORITE: FRACTIONATION OF RARE EARTH ELEMENTS UNDER VARIABLE CONDITIONS.

H. Hiyagon[1], A. Yamakawa[1], T. Ushikubo[2], Y. Lin[3] and M. Kimura[4]. [1]Department of Earth and Planetary Science, The University of Tokyo. E-mail: hiyagon@eps.s.u-tokyo.ac.jp. [2]Department of Geological Sciences and Center for Meteorite Studies, Arizona State University, Box 871404, Tempe, Arizona 85287-1404, USA. [3]Institute of Geology and Geophysics, Chinese Academy of Science, P.O. Box 9825, Beijing 100029, China. [4]Faculty of Science, Ibaraki University, Mito 310-8512, Japan.

Introduction: As a part of the systematic study of refractory inclusions in the Ningqiang meteorite [1], we conducted ion microprobe analyses of rare earth elements (REEs) in various types of refractory inclusions in this meteorite. Some preliminary results have been presented in [2,3].

Results: We analyzed one hibonite-bearing fluffy type A, one hibonite-bearing compact type A, eight fluffy type A, one compact type A, two type B, two spinel-pyroxene, one anorthite-spinel-rich, and two amoeboid olivine inclusions (AOIs). Their bulk chemical compositions lie along the expected condensation trajectory on the anorthite-gehlenite-forsterite plane [1].

The following four REE patterns are recognized: (1) almost flat (unfractionated) REE pattern with or without Eu (and sometimes Yb) anomalies, (2) Group II (Group IIA) pattern [4,5] showing depletions in the heavy REEs (HREEs) except Tm (and Yb), (3) almost flat REE pattern with positive anomalies in Ce, ($\pm$Eu) and Yb (modified Group I), and (4) a pattern similar to Group II but with positive anomalies in Ce ($\pm$Eu) and Yb (modified Group II). There seems to be no correlation between the observed REE patterns and bulk chemical compositions or inclusion type. This suggests that most of the REE patterns have been established prior to condensation of major elements like Si and Mg.

It is interesting to note that 9 out of 18 inclusions show positive anomalies in Ce ($\pm$Eu) and Yb (modified Group I and modified Group II patterns). These are new types of REE patterns which have not been well documented. We performed some condensation calculations to understand the origin of these REE patterns. We suggest that these patterns are produced by a process similar to that produced the Group II pattern but at slightly lower temperatures, where not only ultra-refractory HREEs but also light REEs (LREEs) become partly condensed and removed from the system. The remaining gas will show large depletion in HREE and some fractionation in LREE as well, resulting in positive Ce anomaly (modified Group II). Modified Group I pattern may be interpreted as a mixing of a modified Group II pattern and an unfractionated pattern; this may happen when gas-dust separation is incomplete. The present results show REE fractionation occurred under variable conditions.

References: [1] Lin Y. and Kimura M. 2003. *Geochimica et Cosmochimica Acta* 67:2251–2267. [2] Hiyagon H. et al. 2004. *Meteoritics & Planetary Science* 39:A46. [3] Yamakawa A. et al. 2004. *Workshop on Chondrites & the Protoplanetary Disk (Abstract)* 225-226. [4] Boynton W. V. 1975. *Geochimica et Cosmochimica Acta* 39:569-584. [5] Davis A. M. and Grossman L. 1979. *Geochimica et Cosmochimica Acta* 43:1611-1632.