VARIABLE METASOMATIC ALTERATION OF ALLENDE-LIKE OXIDIZED CV3 CHONDRITES: A COMPARISON OF ANTARCTIC AND NORTHWEST AFRICA CV3 CHONDRITES WITH ALLENDE

Adrian J. Brearley[1], Jessica M. Johnson[1], Brian Williams[1], and Jerome Gattacceca[2]. [1]Department of Earth and Planetary Sciences, MSC03-2040, 1University of New Mexico, Albuquerque, NM 87131, USA (brearley@unm.edu). [2]CNRS, Aix Marseille Univ, IRD, Coll France, INRA, CEREGE, Aix-en-Provence, France.

Introduction: The fall of the Allende meteorite in 1969 set in play a remarkable series of scientific investigations that have revolutionized our understanding of chondritic materials. Among the many discoveries has been the recognition of significant metasomatic alteration that affected all the primary chondritic components [1-4]. Efforts to understand the environment, timing, and mechanisms of these metasomatic processes has been a provocative scientific debate that has spanned several decades. Many questions still remain to be resolved, but there has been a significant shift in the interpretation of these secondary alteration effects from one that focused on a nebular environment involving interaction with a nebular gas to a parent body environment that involved fluid-rock interactions [4]. Allende is unquestionably the scientific reference for understanding these metasomatic effects. However, many new CV3 chondrites that have been recovered from Antarctica and Northwest African deserts are providing new insights into the diverse styles of alteration that have affected the CV3 chondrites. Here we report petrologic observations from two Northwest Africa and one Antarctic CV3 finds that are all classified as oxidized Allende-like CV3s, but diverge in important ways in their alteration effects from Allende itself.

Results: MET 00430 represents one of the least-altered oxidized CV3 chondrites, but nevertheless has a number of distinct alteration features. It is weakly metamorphosed, but most metal has been replaced by magnetite and sulfides. Pyroxenes show minimal evidence of replacement by ferroan olivine, nevertheless, large, euhedral fayalitic olivines are present in the matrix [5]. CAIs in MET 00430 show minimal replacement of melilite by nepheline, but no sodalite and other Ca-rich alteration phases are absent. Chondrule glass is preserved in many chondrules, but has been replaced by a sequence of Ca-Fe-rich phases including wollastonite, etc. in reaction zones on the periphery of chondrules.

NWA 2364 shows significantly more evidence of thermal metamorphism than MET 00430, comparable to that in Allende. Mg-Fe zoning is more pronounced in forsteritic chondrule olivine and enstatite has been extensively replaced by ferroan olivine around the periphery of type IA chondrules. Replacement of chondrule glass has resulted in significant interchondrule porosity. The abundance of sulfides is remarkably low throughout the meteorite and Na-rich mesostasis glass is absent. Fine-grained CAIs have been extensively replaced, but in coarse-grained compact type A CAIs only minimal patchy replacement has occurred. Melilite and anorthite have been altered to an Al-rich phase which may be kaolinite, but no Na-K-Cl-bearing alteration phases, such as nepheline or sodalite are present.

NWA 8331 has distinct features that set it apart from MET 00430, NWA 2364, and Allende, although its petrologic type is similar to the latter two meteorites. It shows extensive sulfidization of metal in type I chondrules, and enstatite and forsteritic olivine are replaced by massive, featureless ferroan olivine, rather than platy olivine that is typical in Allende. Mesostasis glass has also been replaced by ferroan olivine and relict glass is only present in the core of one large type IA chondrule. CAIs show only minor replacement of melilite by nepheline and minor sodalite and andradite, rather than grossular appears to be the garnet phase that is most common as a secondary alteration phase.

Discussion and conclusions: All three of these CV3 chondrites have been classified as oxidized Allende-like CV3 chondrites [5-7]. Primary metal has largely been replaced by magnetite in all of them. However, they exhibit a wide range of alteration features, which differ in significant ways from Allende. NWA 8331 and MET 00430 clearly show evidence of widespread sulfidization that also affected Allende. In contrast, NWA 2364 is remarkably depleted in sulfides suggest that it may have experienced loss, rather than gain of sulfur. Similarly, NWA 2364 contains no evidence of the pervasive alkali-halogen metasomatism that affected Allende and indeed appears to be highly depleted, rather than enriched in alkalis. The effects of Na-Cl metasomatism are also minimally developed in MET 00430 and NWA 8331. These observations demonstrate that the processes that affected Allende are not necessarily typical of oxidized CV3 chondrites in general and also show that the processes of oxidation, sulfidization, and alkali-halogen metasomatism that affected Allende and other CV3 chondrites are not necessarily coupled. On the contrary, they may represent distinct events and processes that affected different CV3 chondrites to different degrees, including both metasomatic addition and removal of fluid-mobile elements such as alkalis, Cl, S, and Fe.

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