EVOLUTIONARY TRENDS IN ACAPULCOITES AND LODRANITES: EVIDENCE FROM N AND XE SIGNATURES; Y. Kim, J. Zipfel and K. Marti, Department of Chemistry and Biochemistry, University of California, San Diego, La Jolla, Ca 92093-0317, USA;

Summary: We present N and Xe isotope abundances in mineral separates of two Acapulcoites and three Lodranites. The comparison of isotopic signatures allows to trace the evolution of Acapulcoites and Lodranites. The light N signatures in metals of Acapulco, ALHA81261 and Lodran reveal primary signatures which were not erased during the high temperature history of these meteorites. Some exchange of N probably occurred between kamacite, taenite and graphite. Trapped Xe in Acapulco and EET84302 is always associated with $^{129}Xe_{rad}$. High concentrations of trapped Xe were found associated with metal inclusions in Acapulco silicates and associated with silicate inclusions in Lodran metal and probably were introduced during differentiation of these meteorites at silicate melting temperatures in the form of gas bubbles. The large $^{129}Xe_{rad}$ component found in the Cl-rich flaky phase on metal grain boundaries in Acapulco was probably introduced by a Cl and I rich melt at low temperatures.

Introduction: Recently a large number of achondrites were recovered which are texturally and chemically related to the meteorites Acapulco [1] and Lodran [2,3] and have the same isotopic signature of oxygen [4]. Textural evidence indicates that Acapulco-like and Lodran-like meteorites can be distinguished [5] and are, therefore, separately called Acapulcoites and Lodranites. Based mainly on the study of Acapulco it has been suggested that the parent body of the Acapulcoites was an asteroid of chondritic composition which cooled fast after experiencing a heat pulse very early in its history [6]. Although the bulk chemical composition of four Acapulcoites is almost identical and chondritic, signatures of different degrees of igneous alterations are observed. Lodranites on the other hand are depleted to quite different extents in elements which are mainly sited in plagioclase (e.g. Na, K and Eu) [7]. Several workers have assessed a possible relationship between Acapulcoites and Lodranites and an origin from one parent body [4, 5, 7]. We are here using the isotopic signatures of nitrogen and Xe as tracers in addressing some evolutionary issues between these two meteorite groups.

Results: Nitrogen: The light N isotopic signature ($\delta^{15}N$ = -150‰) which characterizes metal samples of Acapulco [8] is also found in varying proportions in metal separates of the Acapulcoite ALH81261 and of the Lodranite Lodran, yet the absolute N concentrations are very different. Metal inclusions in orthopyroxene and olivine grains and "matrix" metal in Acapulco have higher N concentrations (13.5 to 16.6 ppm) than metals in ALH81261, Lodran, FRO90011 and EET84302 (all ~1 ppm). Metal separates of EET84302, possibly a transitional lithology, and of the Lodranite FRO90011, however, reveal the same heavy nitrogen signatures ($\delta^{15}N \approx$ +10 to +15‰) as their silicates, indicating isotopic equilibrium.

Xenon: Large trapped Xe components are observed in Lodran and EET84302, but not in FRO90011. The metal separate A of Lodran shows a very high Xe concentration ($^{132}Xe = 3034 \times 10^{-12}$ccSTP) which is released mainly in combustion steps at 900, 1050 and 1200 °C. After an acid treatment which revealed many silicate inclusions, the analysis of metal residue B shows that metal retained only ~5% of the trapped Xe. Therefore, the carrier of trapped Xe in Lodran is associated with inclusions rather than the metal itself as previously suggested [9]. We note that radiogenic ^{129}Xe components are always associated with trapped Xe in Acapulco including the metal inclusions in olivines and orthopyroxenes. This is not the case in ALH81261. Furthermore, a huge enrichment of $^{129}Xe_{rad}$ is observed in the flaky phase on grain boundaries of metal and also sulfides.

Discussion: The observed N and Xe isotopic signatures in Acapulcoites and Lodranites show evidence of a complex evolution of the Acapulcoite-Lodranite parent body. The formation of Lodranites from a Acapulco-like starting material by simply varying the fractional loss of plagioclase cannot explain the observed chemical and isotopic differences. The release pattern of N in the Acapulco metal separate [8] suggests that at least two N carriers are responsible for the observed N signatures. Nitrogen released in combustion steps is heavier than that released in pyrolysis steps (Fig. 1). Does this indicate different isotopic signatures for kamacite ($\delta^{15}N$ = -130‰) and taenite ($\delta^{15}N \approx$-150‰) [8]?. It is difficult to isotopically fractionate N in the process of formation of kamacite and traenite, but since the N is enriched in taenite (28 ppm) compared to kamacite (4.5 ppm), N exchange with an isotopically distinct phase could change the isotopic signature of kamacite and taenite to varying degrees. Ion probe data [10] show that graphite associated with Acapulco metal is a major carrier of N ($0.006 < CN^-/C^- < 0.035$) and has a light isotopic signature ($\delta^{15}N$ = -67‰ to -154‰), a range similar to that seen in Acapulco metal separates. In addition a relationship of C (0.041 to 0.73 wt.%) and metal contents in bulk samples of Acapulco is observed [11]. This suggests that the apparent enrichment of N in Acapulco metal may be related to the occurrence of graphite. The light N signature of metal inclusions in orthopyroxene and olivine grains may possibly be inherited from metal

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and graphite since their chemical composition indicates that these inclusions are melt droplets enriched in S and P (and probably in C) and formed during partial melting of the Acapulco meteorite [6]. Lower N contents (~1 ppm) of ALH81261 and of FRO90011 metals are consistent with lower bulk C contents (0.043 wt.% and 0.049 wt.% C, respectively) of these meteorites. A comparison of the N signature in metal separates from Acapulco, Lodran, FRO90011 and EET84302 is shown in fig. 1. The N signature which is consistent with equilibria between silicates and metal was only obtained in FRO90011 and EET84302, but not in Acapulco and Lodran (also not in ALHA81261 which is not shown). It is interesting to note that chromites preserved a light N isotopic signature in Acapulco. Chromites in Acapulcoites and Lodranites may turn out to be useful evolutionary tracers since their high melting point may be responsible for the partial retention of isotopic signatures even at silicate melting temperatures.

It was suggested that trapped Xe components in the meteorites Lodran and Acapulco, both associated with inclusions, may have been incorporated in the form of gas bubbles [12, 13]. This is indicated by the loss of Xe during crushing of inclusions in Acapulco [12] or the laser-zap release characteristics of inclusions in Y-74063 [13]. Light REE and U enrichments in bulk Acapulco as well as in phosphates and clinopyroxenes and the high $^{129}Xe_{rad}$ component found in a Cl-rich flaky phase sited at grain boundaries may suggest the addition of a melt enriched in volatile (halogenes, e.g. Cl and I) and incompatible elements at low temperatures. However, indications for a similar enrichment in other Acapulcoites and Lodranites are absent so far.

Conclusions: The N and Xe signatures in Acapulcoites and Lodranites reveal similarities as well as differences. Acapulco itself has an altered composition as it is enriched in some trace elements as well as N which is more abundant than in other Acapulcoites or Lodranites. The light N component found in metal separates of Acapulco, ALH81261 and Lodran might indicate a common origin for N in the metal phase. Metal of other Lodranites (FRO90011 and EET84302) do not show this light N signature, although EET84302 is considered to be intermediate between Acapulcoites and Lodranites. Therefore, it appears that the N signatures reflect primary inhomogeneities which were not erased during the high temperature history of these meteorites. Trapped Xe in EET84302 is (like in Acapulco) always associated with a $^{129}Xe_{rad}$ component while Lodran and FRO90011 show an OC-Xe composition in the trapped Xe component. The introduction of trapped Xe components during the high temperature differentiation of Acapulcoites and Lodranites is indicated by gas bubbles associated with inclusions. The high $^{129}Xe_{rad}$ component found in the Cl-rich flaky phase on grain boundaries of Acapulco was probably introduced by a Cl and I rich melt at low temperatures.

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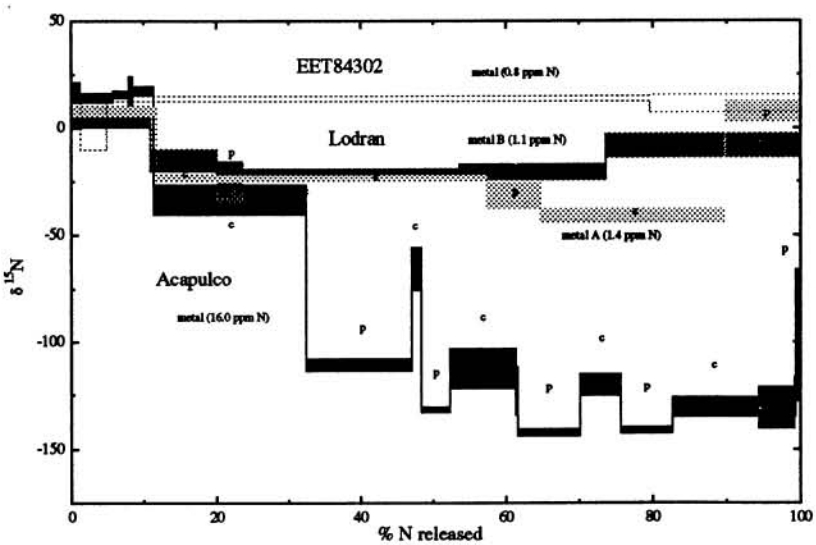

Fig. 1 N signatures in metal separates of Acapulco, Lodran, EET84302 and FRO90011 (c = combustion, p = pyrolysis).