EFFECT OF THERMAL AND AQUEOUS ALTERATION ON THE COMPOSITION OF MONOCARBOXYLICS ACIDS IN CARBONACEOUS CHONDRITES. M. R. Alexandre[1], Y. Wang[1], Y. Huang[1*], A.J. Brearley[2] and C. M. O'D. Alexander[3], [1]Department of Geological Sciences, Brown University, RI02912 (*Yongsong_huang@brown.edu), [2]Department of Earth and Planetary Sciences, University of New Mexico, NM87131(brearley@unm.edu), [3]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015 (alexander@dtm.ciw.edu)

Introduction: The organic matter in carbonaceous meteorites potentially records a succession of chemical histories that started with reactions in the interstellar medium, followed by reactions that accompanied the formation and evolution of the early solar nebula, and, ultimately, ended with reactions driven by hydrothermal alterations in the meteorite parent bodies [1]. The soluble organic content of meteorites has been focus of many studies in the past 40 years. For example, aliphatic and aromatic hydrocarbons [1,2], amino acids [3], alcohols [4], etc. in Murchison meteorite have been extensively investigated. Among soluble organic compounds in carbonaceous chondrites, monocarboxylic acids (MCAs) are often among the most abundant [6]. Compound-specific hydrogen isotope measurements have been particularly useful for determining the origin of meteoritic organic compounds. Typical hydrogen isotopic values for terrestrial organic compounds, for example, are lower than -30‰, [5] but the values for extraterrestrial compounds are much higher, up to +2000‰ for monocarboxylic acis (MCAs) [6]. However, most of molecular and isotopic studies in the past few decades have focused on the Murchison meteorite. Despite of major progress, we still do not have a good understanding of how thermal and aqueous alteration affects the organic compositions of carbonaceous chondrites. Our goal in this study is to investigate the variability of chemical structure of MCAs in three different meteorite samples: Orgueil (CI1); EET87770 (CR2); MET00430 (CV3). We seek to assess the relationship between MCA distributions and mineralogical compositions in these three samples.

Procedures: The water solutions of meteorite extracts were analyzed qualitatively and quantitatively using solid phase micro extraction (SPME) coupled with GC-FID and GC-MS as described in [6]. Briefly, Quantification of samples was done using a HP6890 GC with a flame ionization detector. Identification of MCAs in the samples were obtained using a HP6890$^+$ GC interfaced to 5973 N MSD. In all analyses, a 30m × 0.25 mm × 0.25 μm NUKOL capillary column (Supelco) was used. The oven temperature programming was 35 to 135 ^{o}C @ 25^{c}C min^{-1} – 185^{o}C @ 1.5^{o}C min^{-1} and hold for 10 min (except for Orgueil: 40 to 185^{o}C @ 8^{o}C min^{-1} and hold for 15 min). The SPME optimal condition was 15 min adsorption with magnetic stirring, followed by 5 min desorption in the GC port maintained at 210^{o}C.

Results and Discussions: The differences in the MCA distribution (Figure 1) in these carbonaceous meteorites may be the result of several different factors, including variations in the composition of the organic material that was accreted by each chondrite group, and processes that occurred after accretion, such as aqueous alteration and thermal methamosphism. The effects of aqueous alteration and thermal metamorphism on MCAs are likely to be complex and are currently poorly understood. They will likely involve both the synthesis and destruction of these compounds depending on the exact conditions of secondary alteration. In the case of aqueous alteration, numerous variables may influence the behavior of MCAs, including temperature, pH and oxidation state. As a consequence, it seems probable that aqueous alteration may result in both the synthesis and breakdown of MCAs. Our data provide evidence to support this conjecture as discussed below. For thermal metamorphism, the issue of the thermal stability of MCAs becomes the most important factor, although oxidation state will also likely play a role because of the potential for oxidative breakdown of MCAs. The effects of thermal metamorphism are most likely to destroy MCAs as the upper thermal stability of these compounds is exceeded.

The carbonaceous chondrites that we have analyzed span a range of chondrite groups, that reflect varying degrees of aqueous alteration. The effects of thermal metamorphism are only likely to be of significance in the CV3 chondrite MET00430. The least altered of all the chondrites that we have studied is the CR chondrites EET87770. Although the mineralogy and petrology of this chondrite has not been studied in detail, the information that is available suggests that EET87770 has experienced minimal alteration. Thus, EET87770 is likely to retain a quite pristine record of the characteristics of the organic material. Given the minimum degree of alteration of EET 87770, the MCA distribution is a good reference point for considering the effects of more advanced aqueous alteration, as well as the effect of temperature on MCA evolution.

The Orgueil MCA distribution is distinctly different from the other chondrites, most notably in the fact that higher molecular weight MCAs are present in higher concentrations than the others. Temperatures of aqueous alteration in CI chondrites are generally viewed as being higher than those experienced by CM2 chondrites and are probably in the range 50 to 100ºC. The observed MCA distribution could, therefore, represent the result of the evolution of MCAs over a very extended period of time. The reason for the presence of higher concentrations of high molecular weight MCAs that appear to be unique to Orgueil in this suite of meteorites is not clear. However, we postulate that this might have occurred because alteration in Orgueil probably extended for much longer at specific temperature conditions that favored the synthesis of higher molecular weight MCAs.

According to [7], MET00430 has petrologic characteristics which are intermediate in between the Bali and Allende subgroups of the oxidized CV3 chondrites. This chondrite has therefore experience metamorphic temperatures that are probably in excess of 300ºC and hence it is the most thermally processed of the chondrites studied. Compared to the other two meteorites, MET00430 has the most limited range of MCAs, as well as the lowest concentrations for both straight chain and branched MCAs.

Conclusions: We suggest the following interpretation for the dataset that is consistent with other petrographic and isotopic data. EET87770 probably represents the most primitive MCA distribution of all the chondrites studied, even in comparison with Murchison [6]. The characteristics of Orgueil could be interpreted as representing the end product of alteration under oxidizing conditions, but at intermediate temperatures (in the range of 50 to 100^{o}C). Finally, MET00430 appears to reflect processing at higher temperatures than EET87770 and Orgueil. The diversity of MCAs found in EET77770 and Orgueil is not present in this meteorite, perhaps reflecting alteration in the presence of aqueous fluids at temperatures in excess of 150ºC.

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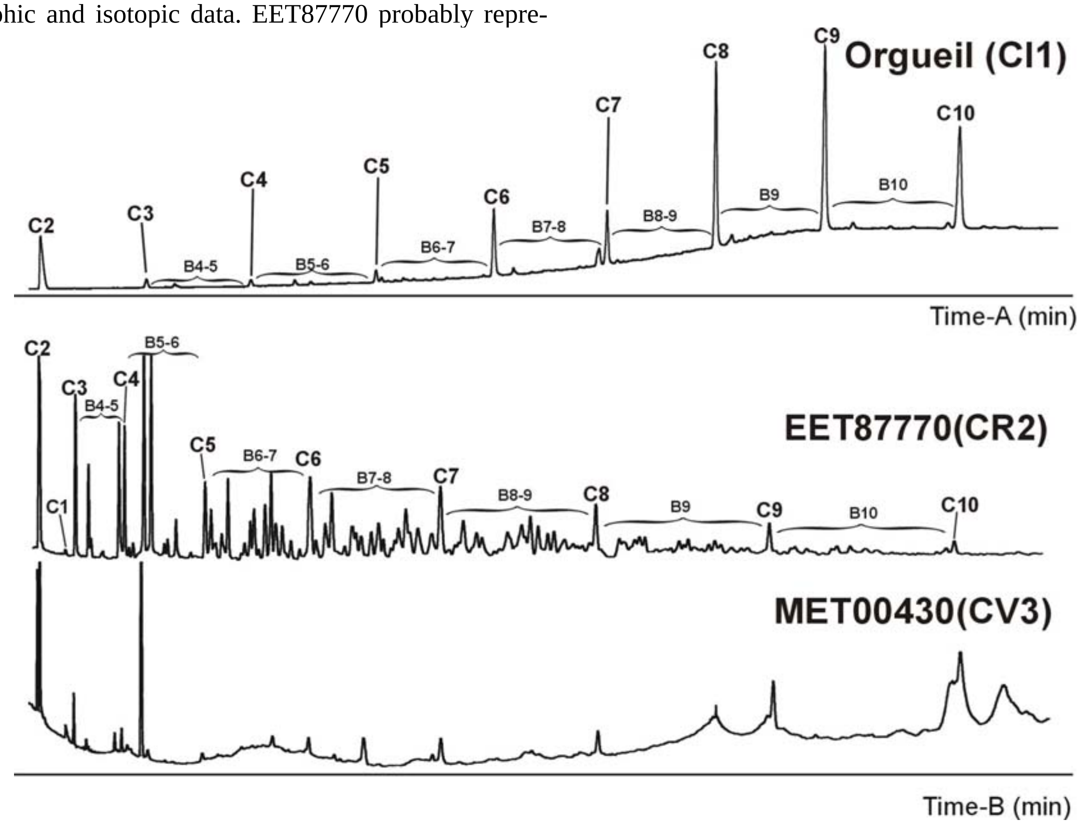

Figure 1 – Chromatograms of Monocarboxylic Acids distribution in three different meteorites. Time – A is different from Time – B, as mentioneted in the text. C*n* = Straight chain MCAs with *n* carbon atoms. B*n*-*y*= Branched chain MCAs with *n* and *y* carbon atoms.