EPSC Abstracts
Vol. 12, EPSC2018-34, 2018
European Planetary Science Congress 2018

Nature and occurrence frequency of heating processes in CM and C2-ungrouped chondrites as revealed by insoluble organic matter

E. Quirico[1], L. Bonal[1], P. Beck[1], C.M.O'D. Alexander[2], H. Yabuta[3], T. Nakamura[4], A. Nakato[5], L. Flandinet[1], G. Montagnac[6], P. Schmitt-Kopplin[7] and C. Herd[8], [1]IPAG UGA France, [2]DTM Carnegie Institution Washington USA, [3]Hirosima University Japan, [4]Tohoku University, Sendai, Miyagi 980-8578, Japan, [5]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Sagamihara,Japan, [6]Laboratoire de Géologie de Lyon, CNRS, Ecole Normale Supérieure de Lyon, 46 allée d'Italie – BP 7000, 69342 Lyon Cedex 07, France [7]Helmholtz-Zentrum Muenchen-German Research Center for Environmental Health, Institute for Ecological Chemistry, Ingolstaedter Landstrasse 1, D-85764 Oberschleißheim, Germany. [8]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta T6G 2E3, Canada

Abstract

Here we report a Raman and infrared study of the composition and structure of Insoluble Organic Matter (IOM) in a series of 39 CM and C2-ungrouped chondrites. These parameters are tracers of the extent and nature of thermal metamorphism a meteorite has experienced. We propose a carbon-based classification of heated C2 chondrites that reveals a high occurrence frequency of thermally processed C2 chondrites (> 36 %). The post-accretional history is discussed thoroughly for a number of chondrites, and we propose that impacts constitute the major heating (against solar heating).

1. Introduction

Chondrites are exhumed from the interiors of their parent bodies by impacts, which at the same time can result in heating and mechanical modification (compaction, deformation, fracturing, etc.). However, whether impacts are responsible for the occurrence of heated C2s remains controversial since radiogenic and solar heating have also been invoked to explain them [1,2]. Here we report a Raman and infrared study of the composition and structure of Insoluble Organic Matter (IOM) in a series of 39 CM and C2-ungrouped chondrites. These parameters are tracers of the extent and nature of thermal metamorphism a meteorite has experienced and reflect the degree to which the thermally driven and irreversible carbonization of IOM has proceeded.

2. Results and discussion

IR measurements distinguish two groups of chondrites: R1 as primitive unheated and R2 as heated. Heating effects result mostly as an increase of the CH_2/CH_3 ratio, a loss of carbonyl groups and overall and aromatization. Raman data reveal three groups: R1, composed mainly of primitive objects; R2, slightly heated chondrites and R3, mildly heated chondrites (Fig. 1).

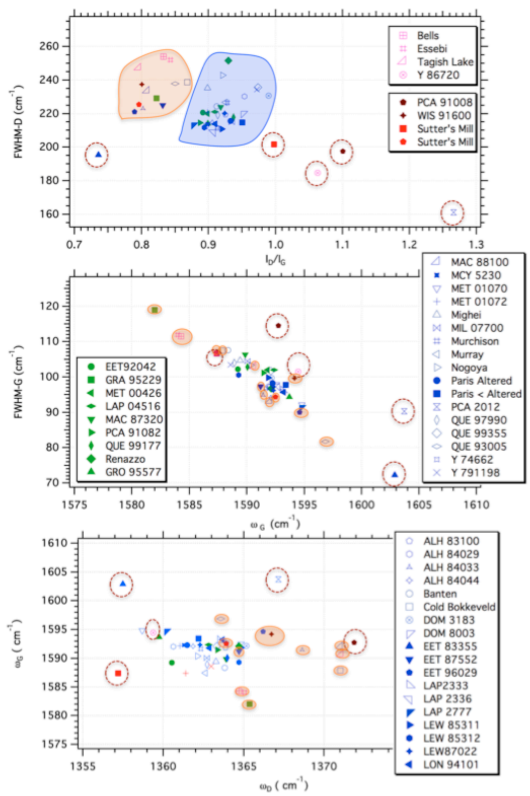

Figure 1: Raman spectral parameters revealing the groups R1 (blue are), R2 (orange) and R3 (detached in top.

Based on combinations of IR and R groups, we propose a carbon-based classification of heated C2 chondrites that reveals a high occurrence frequency of thermally processed C2 chondrites (> 36 %) (Tab.1). This classification is in agreement with the mineralogical classification scheme of [3]. Strongly heated C2 chondrites (PCA 02012, PCA 91008, Y 96720) display an IOM structural evolution that is dissimilar to that of type 3 chondrites that experienced long duration radiogenic thermal metamorphism. These differences almost certainly reflect kinetic constraints on IOM modification during short duration heating events. QUE 93005 is a weakly heated chondrite that experienced a retrograde aqueous alteration. Its very aliphatic-rich IOM points to a parent body hydrogenation through interactions with water. The closed-system conditions required by this mechanism could be satisfied by a *kinetic confinement* during a very short duration impact. MET 01072, a heavily compacted and uni-axially deformed chondrite, did not experience post-accretional heating. In this case, the deformation features probably reflect a low-velocity impact. In contrast, the weakly metamorphosed chondrite EET 96029 experienced one or several low pressure impacts that triggered mild heating and partial dehydration without deformation features.

The study of a series of lithologies from the Tagish Lake C2-ungrouped chondrite confirms the coexistence of various degrees of post-accretional alteration, the most altered lithologies having experienced a moderate degree of heating. Overall, the high prevalence of heating in C2 chondrites, the evidence of short-duration heating in the most heated C2s and the ability of low velocity collisions to trigger heating favor impacts (against solar heating) as the dominant heating mechanism. Finally, our set of data does not support the action of a low temperature oxidation process that would control the aliphatic abundance in unheated primitive C2s.

Table 1: C2 chondrites taxonomy based on IOM structure and composition.

R1:IR1 TI[1]	R2:IR2 TIII/IV[1]	R3:IR2 TII[1]	R1:IR2 TII[1]	R3:IR1 ?	Unclassified
ALH 84044	EET 83355	ALH 84033	MIL 07700	Bells	ALH 84029
ALH 83100	PCA 2012	Cold Bokkeveld		Essebi	Mighei
DOM 3183	PCA 91008	EET 87522			Murray
DOM 8003	Y 86720	EET 96029			LAP 2333
LAP 2777		MAC 88100			LAP 2336
LEW 85311		QUE 9300596.			Y 74662
LEW 85312		WIS 91600			Y 791198
LEW 87022		Tagish Lake 11h, 11i, 4, 10a			
LON 94101		Y793321			
MCY 05230					
MET 01070					
MET 01072					
Murchison					
Nogoya					
Paris altered					
Paris less altered					
QUE 97990					
Tagish Lake 5b					

[1]Classification of Nakamura (2005).

References

[1] Lindgren, P. et al. (2015). *Geochim. Cosmochim. Acta* 148, 159–178.

[2] Nakato, A., et al. (2008). *Earth Planets Space 60*, 855–864.

[3] Nakamura, T. (2005). *J. Mineral. Petrol. Sci.* 100, 260–272.