Abstract # 1499

A small proportion of the CM chondrites have been thermally metamorphosed, leading to loss of volatiles. The aim of this project is to evaluate how liquids and gases moved through the parent body during metamorphism. 3D slice and view using a plasma focussed ion beam instrument combined with chemical analysis by energy dispersive x-ray spectroscopy reveal that thermally metamorphosed CM chondrites such as Elephant Moraine (EET) 96029 have a larger pore size and higher porosity than unmetamorphosed CM chondrites. In particular, the boundary between fine grained rims and matrix acts as an effective conduit for fluids, and soluble elements are concentrated at this interface. Thus, matrix-rim interfaces facilitated volatile loss from the parent body during thermal metamorphism.

II. Methods

• 110×70×60 μm of EET 96029 was extracted across a matrix-fine grained rim (FGR) using a plasma focussed ion beam (P-FIB) (Fig. 1).
• 2 x 150, 60 nm thick, sections were cut and imaged using back scattered electrons (BSE).
• An energy dispersive X-ray spectroscopy (EDS) chemical map was collected at the end (Fig. 2).
• 3D data were reconstructed using Dragonfly 3.0 software.
• Pores and porosity were extracted from low contrast areas of BSE images (Fig. 3, Table 1).

III. Results

• EDS map show the matrix-FGR interface is Ca- and S-rich (Fig. 2).
• The matrix and FGR contain several large (1-20 μm) pores.
• The matrix-FGR interface has higher porosity than the matrix or FGR with continuous fractures ~1-2 μm wide along its length. (Fig. 3).

Table 1. Porosity and permeability of both matrix-FGR interface serial sections. Permeability is estimated based on the pore size and fracture width from [1] and [4].

<table>
<thead>
<tr>
<th>Region of interest</th>
<th>Porosity (%)</th>
<th>Permeability (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ROI1</td>
<td>ROI2</td>
</tr>
<tr>
<td>Fine grained rim</td>
<td>3.6</td>
<td>5.8*</td>
</tr>
<tr>
<td>Matrix</td>
<td>3.2</td>
<td>5.1</td>
</tr>
<tr>
<td>Rim matrix interface</td>
<td>4.7</td>
<td>14.3</td>
</tr>
<tr>
<td>All areas</td>
<td>3.5</td>
<td>6.0</td>
</tr>
</tbody>
</table>

*Porosity is dominated by one large pore that elevates porosity to 7.5%.

IV. Discussion

• EET 96029 pores are larger than other CMs [1].
• This may be due to thermal dehydration [3].
• The matrix-FGR interface is a continuous network of fractures 2-5 μm in width.
• This interface provides a localised permeability spike of ~10⁻¹³ m² [4], four orders of magnitude higher than the typical chondritic range [1].
• The matrix-FGR interface is also enriched in soluble elements (e.g., Ca and S), suggestive of fluid flow.
• If these inter-faces interconnect throughout the rock, they would enable fluid flow on the metre length scale [1], and so provide a conduit for fluid flow during metamorphism. These observations suggest that fluids migrated and were lost during thermal metamorphism of EET 96029 [3].


Acknowledgements: The authors would like to thank ANSMET for the loan of EET 96029.