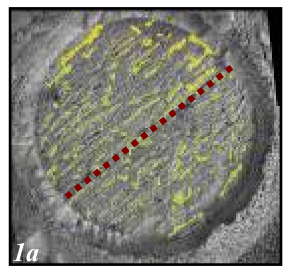
COMPARISON OF SECONDARY POROSITY AND PERMEABILITY FROM EAGLE TO VICTORIA CRATERS, MERIDIANI PLANUM, MARS. S. M. Perl[1], S. M. McLennan[1], and the Athena Science Team [1]Department of Geosciences, State University of New York at Stony Brook, Stony Brook, NY 11794-2100.

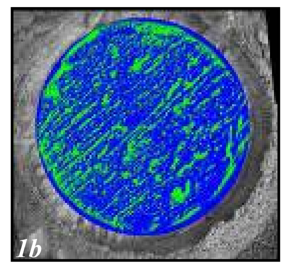
Introduction: Rocks abraded by the *Opportunity* rover reveal extensive evidence of diagenesis resulting from the influence of an infiltrating groundwater table. The Burns Formation, a sequence of well sorted sulfate-rich sandstones [1] contains specific types of void spaces interpreted by McLennan et al. [2] to represent 2-3 types of secondary porosity created by dissolution of soluble evaporate minerals during recharge of the groundwater table. To date, the assortment of porosity types found in the stratigraphic sections in Eagle and Endurance craters is unique to this province and has not been observed by the Spirit rover in sedimentary rocks preserved at Gusev Crater. The purpose of this paper is to examine the differences in occurrence, abundance, and types of secondary porosity including areas studied after leaving Endurance Crater.

Analysis & Tools: We have used 30x30mm images taken by the Microscopic Imager (MI) onboard *Opportunity* throughout this investigation. The best focused images are used to measure secondary pores from RAT-abraded surfaces. Originally we were limited to surfaces where most of the abraded region was free of debris and shadowing (most mosaics do not need shadow corrections). Using additional software techniques we have been able to extract data from all RATed surface types. We have determined (1) the dimensions & orientations of individual pores, (2) overall volume of secondary porosity and (3) volumes of different types of secondary porosity.

Pore Geometry Measurements: The length to width ratios of single pores were measured and one example of their orientations (with respect to the bedding plane) is shown in Fig. 1. Porous features that are interpreted as being further enlarged by later processes were not included in the orientation measurements because the original dimensions cannot be determined. Analyses of this type are structurally biased because pores may orient at an angle to the RATed surface. This issue appears minimal in Eagle and Endurance craters because RATed surfaces are near orthogonal to bedding but may play a significant role in explaining the lack of secondary porosity in other regions (see below) because those surfaces may not be near orthogonal to the bedding plane in all cases.

Total Secondary Porosity: By means of thresholding techniques and contrast modification, areas represented by porous elements are calculated and distinguished from non-porous regions of the RAT hole (Fig. 1b). A major value of this type of analysis is that we estimate total secondary porosity which in turn can be related to permeability of the rock. This part of the study used all secondary porous regions regardless of pore classification. An artifact of the thresholding process is that hematite spherules and certain shadows (if present) are included as porosity. After mapping the initial threshold regions, mosaics are carefully compared to the original image and affected elements are manually edited out. Finally, the total calculated volume of secondary porosity is considered to be a lower limit due to the potential filling in of pores by RAT tailings and other debris.





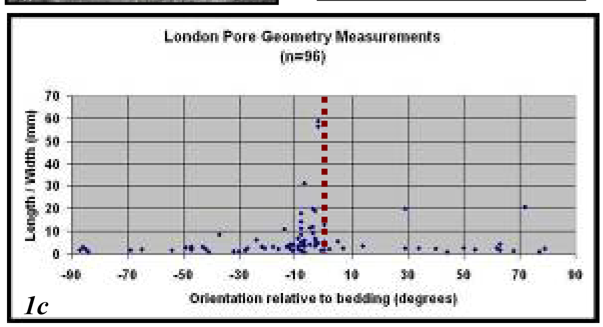


Fig. 1a: MI mosaic used in dimensional analysis of pores in the London RAT hole. Fig. 1b: Thresholded region of abraded surface overlaying the original mosaic. Areas in green represent porosity whereas non-porous areas are blue. Fig. 1c: Graphical representation of 1a showing L/W ratios versus orientation with respect to bedding.

Classification & Comparison: The stratigraphic section in Endurance crater has the most abundant and varied secondary porosity observed thus far. Most RAT-abraded surfaces show crystal molds and elongated to sheet-like / channel porosity and a few samples having significantly modified (enlarged) secondary porosity. Samples with modified pores (Virginia, Grindstone, Wharenhui) are located in close proximity to the Whatanga contact that separates the middle and upper units of the Burns formation and interpreted to represent the site of a stagnating paleo-water table [1]. In the Eagle and Endurance sections, elongated to sheet-like vugs / channel porosity orient mostly parallel to bedding whereas crystal molds orient non-parallel to bedding (Figs 1a,c). The ratio between crystal molds and sheet-like vugs is essentially constant in these sections. Since leaving Endurance the rocks studied by *Opportunity* show several differences in the nature of secondary porosity. For example, an additional type of crystal mold, with apparent cubic habit, was observed near Erebus crater and interpreted to represent halite "hoppers" [3,4]. Outside Endurance crater, there is a significant decrease in the total volume of secondary porosity (Fig. 2). In some cases, this difference may be due partly to the bias associated with non-orthogonal relationships between RAT surfaces and bedding (discussed above) but the general trend appears robust. Whether this volume difference represents stratigraphic trends or an effect related to the present-day surface may be revealed by further investigation in Victoria crater.

"Bladed Porosity" or Crystal Molds?: We have also identified a possible additional variant of previously identified crystal molds, termed bladed porosity, that differs in size and depth (Fig. 3). At present, we can not exclude the possibility that these "bladed" pores are essentially the same as crystal molds that were observed previously [2], but oriented at a different angle.

Permeability & fluid flow: Relationships between porosity and permeability is complicated, especially in sedimentary rocks with complex pore structure, such as seen in the Burns formation [5]. The decrease in porosity seen outside Endurance crater is almost certainly accompanied by a decrease in permeability but quantitative estimates require a better understanding of pore structure and pore connectivity. We are currently attempting to better quantify permeability within the Burns formation, for example, by using digital elevation models of MI images to constrain pore structure.

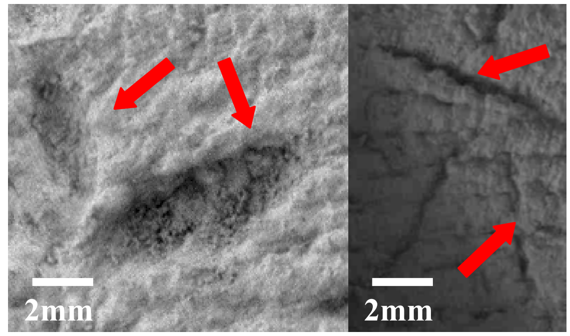


Fig 3 Cropped MI image showing the type of crystal mold found in the majority of abraded rocks (left). "Bladed" molds found in the Paikea rock target thought to possibly represent a different type of secondary porosity(right).

References: [1] Grotzinger, J. P., et al. (2005) EPSL, 240, 95-121. [2] McLennan, S. M., et al. (2005) EPSL, 240, 11-72. [3] Squyres, S. W., et al. (2006), Science 313, 1403-1407. [4] Grotzinger, J. P., et al. (2006) Geology, 34, 1085-1088. [5] Lock, P. A. et al. (2002) J. Appl. Phys, 92, 6311-6319.

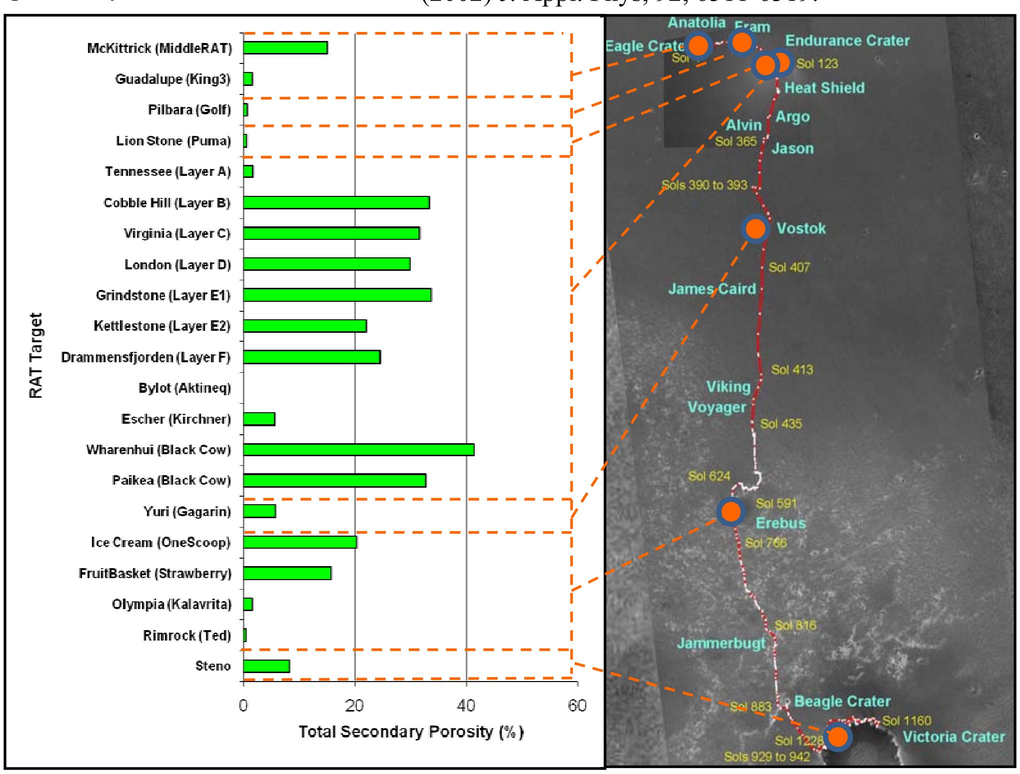


Fig 2: Overall secondary porosity of all abraded rocks from Eagle to Victoria Crater including all classifications (left). The traverse map (right) shows the approximate locations of these rocks.