MICROCRACK POROSITY IN THE L/LL METEORITE KNYAHINYA: HOW HOMOGENEOUS? M. M. Strait[1] and G. J. Consolmagno SJ[2], [1]Alma College, Alma, MI 48801, USA (straitm@alma.edu), [2]Vatican Observatory, V-00120, Vatican City State (gjc@specola.va).

Introduction: For several years we have been comparing the porosity of meteorite hand samples with microcracks visible in SEM images of meteorite thin sections [1, 2]. Among the issues is the degree to which a meteorite's primordial porosity has been filled by terrestrial weathering products. Using the image based technique we have developed [3], we can differentiate between the cracks that are empty and cracks that have been filled with weathering products (characteristically high in Fe and Cl, low in Ni). By summing the relative volume of both of these types of cracks, we can estimate the primordial microcrack porosity present in the meteorite. Finding and characterizing the primordial porosity information will lead to a better understanding of how individual grains accumulate and lithify to form bodies in the Solar System.

The observations so far support the model proposed by Bland et al. [4] that meteorites weather in two stages: a fast rapid oxidation followed by a slower destruction of the fabric. In our samples, finds appear to be near the end stages of the initial fast weathering stage, while falls from the last two centuries are just starting to show signs of the initial weathering.

Furthermore, measurements made using the image analysis technique used here produce porosity values that agree well with estimates made using other methods, suggesting that the porosity of ordinary chondrites is essentially completely accounted for by microcrack porosity. Since these cracks clearly cut across grain boundaries, this suggests that ordinary chondrites originally lithified with essentially zero porosity; this in turn puts serious limits on the conditions under which these rocks were originally formed. This observation also has serious implications for the structure of asteroids whose densities are known to be significantly lower than the densities of their proposed meteoritic constituents.

However, in the course of our work we have encountered several analytical problems. Meteorites are not necessarily homogeneous from one thin section to another, and in some cases, we have had concerns about homogeneity within a sample. Since a thin section is usually represented by only a few images, any variations in porosity could cause significant variations in our results depending on where the images were taken.

Present Work: We began our studies of variations in porosity across a meteorite with a thin section of Knyahinya (L/LL 5). Knyahinya (L/LL 5) fell in Ukraine in 1866; its unusual classification (L/LL) arises because it contains metallic iron in an abundance typical of LL chondrites, but trace element concentrations more characteristic of L chondrites [5].

Our thin section of Knyahinya was recently cut and polished at the Natural History Museum (London) from a sample of the Vatican Observatory collection. It was imaged over the entire surface using a JSM 840A SEM at Central Michigan University. Data was collected on a digital imaging system at resolutions of 2000 x 1600 pixels and 1000 x 800 pixels. A total of 436 images were acquired. Three sets of images at magnifications of 250x, 300x and 500x were collected that cover about 30% of the section. Another set of 91 images was acquired at 80x that covered the entire section.

In evaluating the distribution of the porosity in the sample, we observed that the porosity tended to be higher at the edges of the section, where large cracks were evident. Several interior areas also had significantly higher porosity. These areas tend to have major cracks through the fabric of the section, large holes, or gaps at the edges of large inclusions. Some areas with low porosity were where large metal inclusions filled most or all of the image area.

The final data set averaged over the areas measured compute an average porosity of 4.8% $\pm$ 2%, with about 8% of the total porosity being filled with weathering material. The hand specimen of Knyahinya measured for porosity at the Vatican Observatory had a porosity of 4.7% $\pm$ 1.8%.

Assuming a primordial unweathered grain density of 3.56, typical of LL chondrites (to approximate Knyahinya's metal content), and using the measured bulk density one, can calculate a model porosity of 5.8% $\pm$ 0.6%. The difference between model and measured porosity is presumably a measure of the pore spaces now filled with weathering material, which in this case would suggest that 19% ($\pm$ 8%) of the pore spaces should be filled with weathering material. This is somewhat larger than the 8% seen in the thin section, but this difference is probably not significant, given the uncertainty in the original primordial grain density (dropping it to 3.54 would be enough to remove the difference). The qualitative inference is the same in both cases: porosity in Knyahinya is lowered, but not eliminated, by weathering product in the pore spaces.

The variation in porosity tends to be limited, with most of the imaged areas ranging from about 2% up to 8% with an average at 4.8% (See Figure 1). In this section of Knyahinya, we found that the porosity does appear to vary slightly from one end of the thin section to the other, with about a 1% difference between the two parts of the thin section.

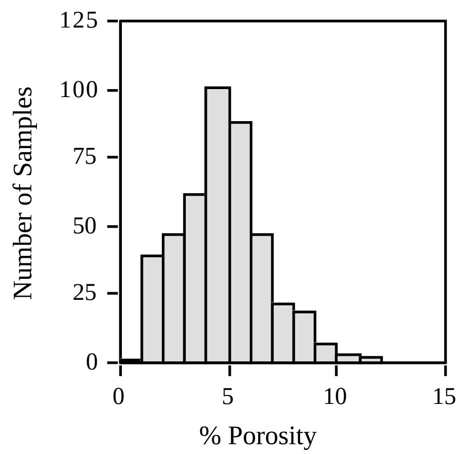

Figure 1. Knyahinya Porosity Distribution

The range of porosities determined in this extensive study of the surface of one meteorite thin section show a similar range to that determined from a limited number of random images used to represent the sample. This confirms the assumptions made in our previous work, and suggests that we can continue to draw conclusions about the porosity of a sample based on a limited number of images. However, this may not apply to measurements on more than one thin section of the same meteorite.

To confirm this observation for one meteorite, we are presently looking at a new set of samples from the Vatican Observatory collection to verify the results. We have been looking at four L6 ordinary chondrites and an EH4 enstatite chondrite. Ness County was found in 1894, Kermichel was found in 1811, Durala fell in 1815 and Tenham fell in 1879. The EH4 Abee fell in 1952. The four L6 meteorites will allow us to also confirm correlations made relative to the amount of weathering present as indicated by filled microcracks and whether the meteorite is a fall or find (an indication of terrestrial residence). In addition, we are moving into another class of meteorites and will be able to extend our observations on current porosity and implications for original porosity from ordinary chondrites into other types of primordial chondritic material.

References: [1] Consolmagno G.J. *et al.* (1999) *LPS XXX* ; [2] Consolmagno G.J. *et al.* (1999) *MAPS 34.* A28-A29; [3] Strait M.M. *et al.* (1996) *LPS XXVII.* 1285-1286; [4] Bland P.A. *et al.* (1998) *GCA 62.* 3169-3184; [5] Strait M.M. and Consolmagno G.J. (2001) *MAPS 36.* A199.