TIESCHITZ (H/L3.6): MODAL ANALYSIS BY PIXEL COUNTING. D. DeFelice[1,2] and D. S. Ebel[1,3], [1]Department of Earth and Planetary Science, American Museum of Natural History, Central Park West and 79th Street, New York, NY 10024, [2]Department of Geology, Juniata College, 1700 Moore Street, Huntingdon, PA 16652, [3]Dept. of Earth and Environmental Science, Columbia University, New York, NY

Introduction: Image analysis by pixel counting is a quantitative method for determining the modal abundances of different components (e.g., chondrules, opaque clasts, isolated mineral fragments, Ca-, Al-rich inclusions, exotic clasts, and matrix) in chondritic meteorites. Pixel counting is an alternative to the traditional method of point counting using the petrographic microscope. Optical point counting fundamentally relies on optical phase identification and accuracy is dependent how many points on a grid are counted and on how representative the counted area is of the larger sample. Numbers of points, spacing, and grid size are not always recorded in the literature. Accuracy of pixel counting similarly depends on the physical area analyzed, and the assumption that the area is representative of the whole sample. Both methods critically depend on how well all the meteorite components are identified, and clarity about the criteria used to classify components. Here, pixel counting is applied to the H/L3.6 chondrite meteorite Tieschitz to acquire ratios of chondrules to matrix and opaque minerals present in the sample, and for comparison to earlier work [2].

Method: In AMNH thin section 4141-2, an area ~182 mm^2 was x-ray mapped for Si, Mg, Fe, Ca, Al, Ni, S, Na, Ti and Cr at 25 ms dwell time, 20 nA current and 15 kV accelerating voltage using wavelength dispersive spectrometers on the SX100 microprobe at AMNH. The 10 μm/pixel resolution was not ideal for resolving different components. Maps of smaller areas (2.36 mm^2) at (3 μm/pixel using the same conditions allowed more precise identification of components.

X-ray maps were stacked and identifiable chondrules, opaque grains, and mineral grains larger than 50 μm^2 were outlined (segmented). Pixels in each type of object were then counted using Fiji software.

The 10 μm/pixel map was also synthetically point counted using a 33 x 33 square grid and a step size of 200 microns, chosen relative to the 100μm to ~1mm sizes of chondrules. In total, 1089 points were counted using the component outlines in Fig. 2.

Results: Preliminary analysis in the 182 mm^2 (10 μm/pxl) map (Fig. 2) shows that chondrules and isolated Mg-silicates make up only about 40% of the area, matrix 53%, opaques 4%, CAIs 0.1%, and exotic clasts (dark inclusions) 4.5%. These numbers are preliminary, because some minor metal and mineral grains (isolated olivines) have not been counted completely. Chondrule size varies from tens of microns to millimeter size. Apart from exotic "dark" inclusions, the largest object is a radiating pyroxene chondrule fragment ~2 mm across. Figure 1 (region r4, Fig. 2) is representative of the whole sample. Outlined components are shown in grayscale (legend in Fig. 2). In total, chondrule and relict grains (*n*=137) make up 47.5% of the target area, with opaques (*n*=29) 3% and matrix 49.5%. Analyses of other regions return similar values.

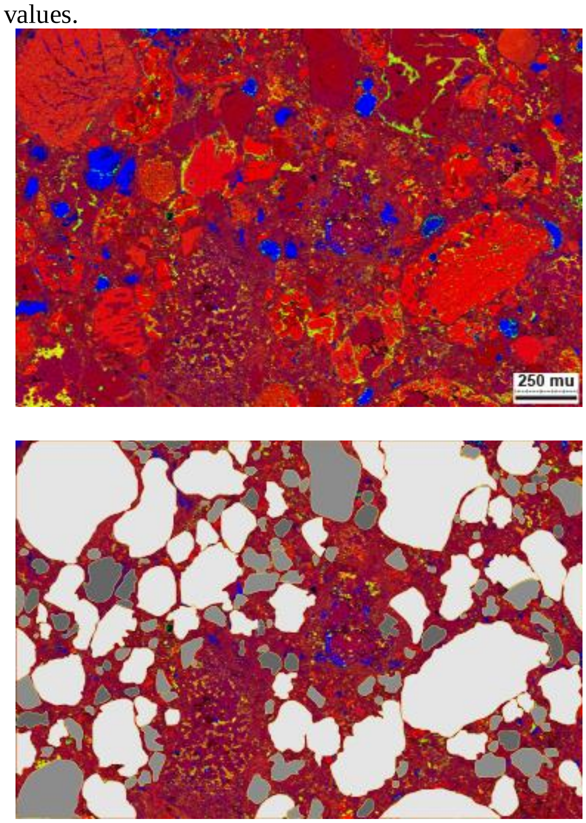

Figure 1: 3 μm/pixel map r4, depicted as in Fig. 2.

Synthetic point counting yielded fractions of matrix, chondrules and opaques (metals/sulfides). Chondrules make up 49.7% of the total area, opaques 4.5%, and matrix 45.8%.

Discussion: Huss et al. [2] concluded that the modal abundances in ordinary chondrites are 60%-80% chondrules, 10%-15% metals/opaque minerals, and the remainder fine-grained matrix. These values occur in many reviews of meteorite properties [e.g., 3]. Huss clearly defined identification criteria for each component. Our preliminary analysis reveals that the percentages of chondrules (including homogenous silicate grains, assumed to be chondrule fragments) and opaques are lower than previously reported in

Tieschitz [2]. However, our analyses of subareas at higher resolution yield lower matrix fractions, indicating increased ability to resolve discrete components at higher spatial resolution.

Conclusions: Pixel counting offers reproducibility in the sense that images can be included in publications, and the image analysis can be scrutinized accordingly. Earlier point counting efforts (e.g., [4]) often lack details such as definition of the target area, number of points, and grid size. This work serves as a preliminary comparison of traditional point counting, and pixel counting using x-ray element maps.

References: [1] Ebel D. S. et al. (2016) *Geochimica et Cosmochimica Acta*, *172*, 322-356. [2] Huss G. R et al. (1981) *Geochimica et Cosmochimica Acta*, *45*, 33- 51. [3] Weisberg M. K. et al. (2006) In *Meteorites and the Early Solar System II*, p. 19-52. [4] McSwwen H. (1977) *Geochimica et Cosmochimica Acta*, *41*, 1777-1790.

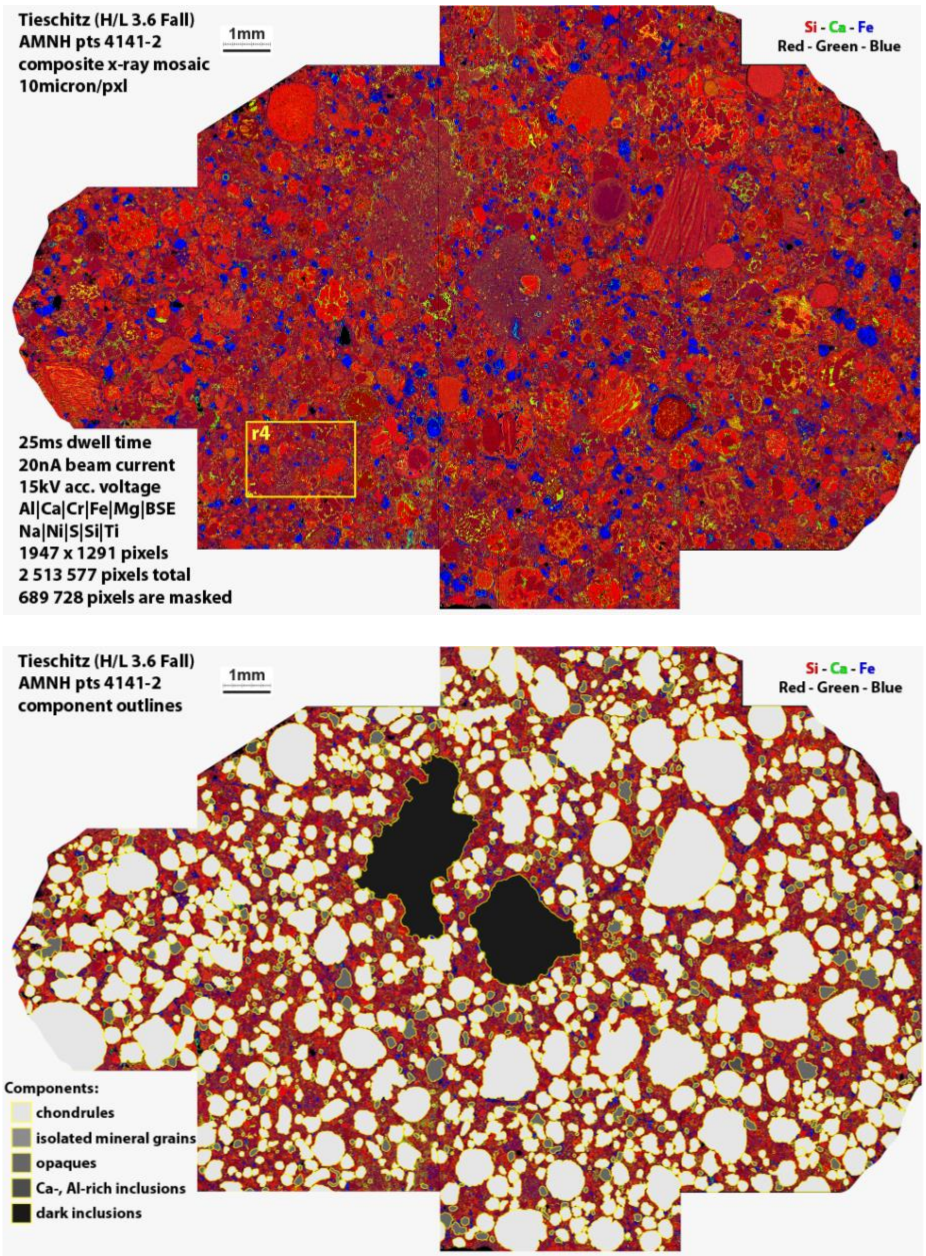

Figure 2: Whole thin section map (AMNH #4141-2) at 10 μm/pixel. Top: Si-Ca-Fe RGB composite, masked. Below: outlined components at different grayscales (see legend).