PETROLOGIC COMPLEXITIES OF THE MANICOUAGAN MELT SHEET: IMPLICATIONS FOR ^{40}Ar-^{39}Ar GEOCHRONOLOGY. F. D. Winslow III[1], E.T. Rasbury[1], and S.R. Hemming[2] [1]Department of Geosciences, Stony Brook University, Stony Brook, NY 11794-2100, (fwinslow@ic.sunysb.edu) [2]Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964

Introduction: The Manicouagan melt sheet is comprised of a coarsening upward sequence of three units (lower, middle and upper) [1] that reflect its formation as a result of different stages of the crater formation process that involved the rapid melting of target rock [2], the turbulent mixing of xenocrysts with melt [3], and a relatively slow cooling rate [4]. This process allowed for a complex intergrowth of xenocrysts and melt derived K-bearing phases of interest in geochronologic studies. Here we present the results of petrographic analysis of the Manicouagan melt sheet to illustrate the complex relationship between the K-bearing phases. We evaluate this in light of the implication for sampling for Ar-Ar geochronology.

Manicouagan Impact Crater: The Manicouagan structure is 100 km in diameter and is located approximately 200 km north of the St. Lawrence River in east-central Quebec province near the Grenville front in the Canadian Shield and straddles the Archean parautochthon and allochthonous material with Paleoproterozoic heritage [5]. The target rock consists of amphibolite facies metagabbros, anorthosite, charnockite, and remnants of Paleozoic limestone [1,6].

Crater Forming Process: During the excavation stage of a Manicouagan-size impact event, an acceleration gradient is formed as the rarefaction wave follows the shock wave and the target material unloads [2,3]. This acceleration gradient causes melted material to flow down into the transient crater faster than the less shocked material, creating a turbulent flow that thoroughly mixes melted, shock metamorphosed, and unmetamorphosed target material [3]. During the modification stage, the central uplift structure forms, introducing more material into the melt that can originate from depths of several kilometers [2]. In addition, material can be introduced into the melt as it is sloughed off the sides of the crater as terraces form in marginal collapse zones along the crater rim [2]. Thermal modeling of the Manicouagan event indicates the mixture of melt and clasts would thermally equilibrate in 6000s to 10000s and would crystallize within approximately 6 years at the edges of the melt sheet and 1600 years in the center [4].

Manicouagan Melt Sheet: Floran et al. [1] conducted an extensive petrographic analysis and found that the melt sheet could be broken down into three units (lower, middle, and upper) based primarily on grain size and clast abundance. The lower unit, which is in contact with basement rock, is very fine grained to cryptocrystalline and contains the largest percentage of target rock clasts. The middle unit is fine-grained and transitions, over several meters in some cases, into the upper unit, which is medium-grained. The lower melt unit had 15-40% clasts and resorption rims are prevalent. The middle melt unit has 2-15% clasts and the distinction between inclusions and matrix is blurred by coarsening of matrix, decreasing clast abundance, and increasing resorption of plagioclase. The upper melt unit is medium grained, has less than 2% clasts, and has little evidence of xenocrysts. In terms of minerals relevant to geochronologic studies, Floran et al. [1] indicate that plagioclase and sanidine are ubiquitous throughout both the middle and upper melt units, with plagioclase occurring as xenocrysts and as a melt derived phase, whereas sanidine occurs only as a melt derived phase. The plagioclase xenocrysts occur as relict cores that are mantled by, in some cases, melt derived plagioclase. However, in most cases, the relict cores are mantled in sanidine. Sanidine also occurs as a micropegmatitic component with quartz in the matrix in the middle and upper melt units.

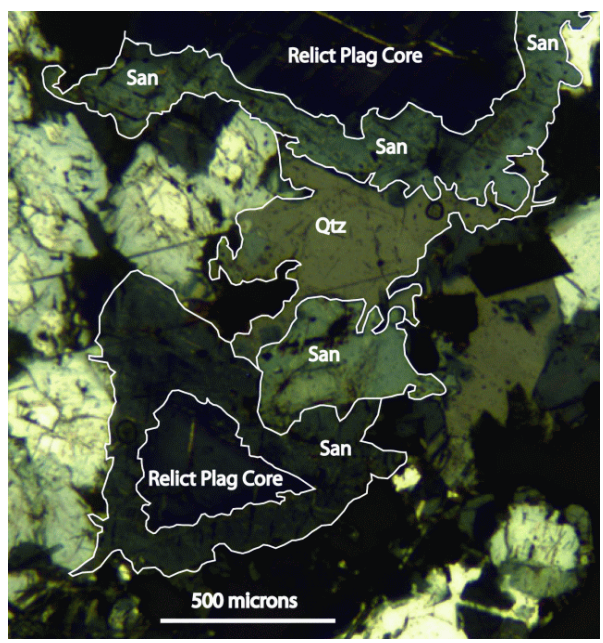

Figure 1: Photomicrograph of the middle melt unit illustrating sanidine mantling relict plagioclase (top and bottom) and micropegmatitic intergrowth of sanidine and quartz (center). The mineral identification was confirmed with microprobe analyses.

Results: Given the geologic complexity present in the melt rock and previous geochronologic studies which indicated widely varying ages between whole rock samples and (multi-grain) mineral separates [7], we sampled individual feldspar grains for laser fusion Ar-Ar analyses. Our results from 13 analyses of single feldspar grains from a single small hand specimen are comparable to the K-Ar results of large aliquot sizes from Wolfe [7]. The range in $^{40}Ar/^{39}Ar$ ages of the individual crystals is greater than can be accounted for with the analytical uncertainty alone, and the range in $^{37}Ar/^{39}Ar$ ages reflects varying degrees of mixing between the relict plagioclase cores and newly formed rims. Petrographic analysis of the middle melt unit reveals why this complexity exists even on the scale of individual grains. The melt rock in thin section (Figure 1) illustrates this complexity. The image shows the micropegmatitic intergrowth of sanidine and quartz, as well as the mantling of relict plagioclase cores with melt derived sanidine. In plane light, the boundaries between the melt derived sanidine and the relict plagioclase phases are indiscernible, making them appear as large, single grains of plagioclase. Clearly what is necessary to overcome the geologic complexity present in the Manicouagan melt rock and accurately date the impact event itself is a means of isolating phases that only formed in the event. This requires high spatial resolution in-situ analyses, which we hope to perform on the melt formed sanidine in thin section to better refine the age of the impact event.

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References: [1]Floran R. J. et. al. (1978) *JGR,* 83(B6), 2737-2759. [2] Melosh H. J. (1989) *Impact Cratering: A Geologic Process*. [3] Simonds C. H. et. al. (1978) *JGR* 83(B6), 2773-2788. [4] Onorato P. I. K. et. al (1978) *JGR* 83(B6), 2789-2798. [5] Dickin A.P. (2000) Canadian Journal of Earth Sciences, 37(2) 165-181. [6] Grieve R. A. F. and Floran R. J. (1978) *JGR* 83(B6), 2761-2771. [7] Wolfe S. H. (1971) *JGR* 76(23), 5424-5436.