Ureilite Thin Section Preparation.

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Introduction: Preparing thin and thick sections of ureilite type meteorites is a challenge that can confound even the most experienced section preparer. A common characteristic of these samples is the presence of carbon phases, particularly nanodiamonds, in the matrix along silicate grain boundaries, fractures, and cleavage plains [1]. The extreme hardness of the nanodiamonds presents a challenge to the section preparer in the form of high surface relief on the section. This hard material also causes considerable wear and tear on equipment and materials that are used for making the sections. These issues will be discussed and potentially helpful measures will be presented.

The Problem: The section preparer has to contend with the surface topography that develops during polishing of the cut section. The nanodiamonds appear as peaked areas when the section is viewed under a reflected light microscope (Fig. 1). The relatively softer silicate grains wear away easier during polishing, and thus they compose the valley material between the peaked areas.

Fig. 1 - LAP 03 587,21 under reflected light at 20x magnification. The dark masses contain nanodiamonds. *(NASA JSC)*

Materials used for section making such as cutting blades, grinding media, and polishing media tend to be degraded as the nanodiamonds in the sample wage a battle of attrition with them. The two Antarctic ureilite samples LAR 06 618 and PCA 82 506 come to mind in this regard (Fig. 2). Each time that we have cut a section off of the potted chips for these specimens, it has taken no less than three diamond saw cut-off blades to complete the task. In all fairness, these two samples represent one extreme. Some ureilite samples that we have sectioned exhibited little to no diamond content.

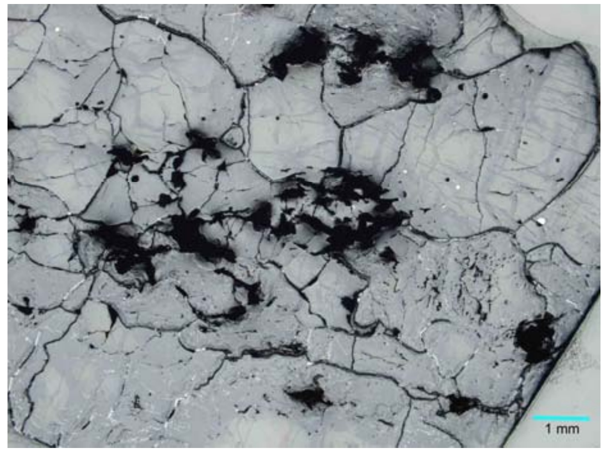

Fig. 2 – PCA 82 506,5 under reflected light at 5x magnification. *(NASA JSC)*

A Solution: The following is the procedure that we use in the Meteorite Thin Section Lab at NASA Johnson Space Center for preparing thin or thick sections of ureilite meteorites. As with thin sectioning of other meteorite types, this process requires patience and a great deal of experience.

The first few steps are similar to those used for other sample types. The sample chip is impregnated in epoxy within a Teflon mold under vacuum so that the epoxy can deeply penetrate any voids or cracks in the chip. After a 24-hour curing period, the potted sample is removed from the mold and the sample at the bottom end is exposed using 320-grit silicon carbide lapping film clamped to an 8-inch lapping wheel. At this stage, the exposed sample needs to be made as flat as possible prior to polishing for the initial slide mounting. This is accomplished by sanding the exposed surface in a figure eight motion on a clean sheet of 400-grit silicon carbide lapping film. This step is best performed by laying the film on a clean, flat surface and using ethyl alcohol as a lubricant. As a rule, we do not use water for any of our thin section lab work because of oxidation, hydration, or other alteration of samples.

After cleaning the sample in an ethyl alcohol ultrasonic bath, it is polished on a sheet of 100% cotton polishing paper that is charged with 3-micron diamond paste. If the sample develops relief during polishing, use a 6-micron diamond bonded metal plate to lightly abrade the diamond "peaks". The sample is moved on the stationary plate surface using a figure eight motion.

Ethyl alcohol is again used as a lubricant. This step can be alternated with the 3 micron diamond paste polishing as needed until the sample surface is suitably polished for mounting to a glass slide.

The exposed and polished sample can now be re-impregnated with epoxy under vacuum prior to having a glass slide mounted to the surface [2]. Ureilites do not tend to be porous, but the grain edges can lift if the matrix is not secured with epoxy. The section/potted sample assembly is allowed to cure for 24 hours on a hot plate at 100 degrees Fahrenheit. The cured section is then cut off using a Buehler Isomet low-speed diamond saw. Expect time and saw blades to be consumed at this stage due to the diamond bearing nature of ureilites. We make an effort to cut the section off within 150 to 200 microns of the slide. This not only saves sample material for future use, but it also minimizes the use of the Ingram grinder for thickness reduction.

Lapping and final polishing of the cut section comes next. Clean the sample in an ethyl alcohol unltrasonic bath in between all lapping and polishing steps. This is the point where the procedure becomes unique to ureilites. The section is lapped with 400-grit silicon carbide film on a rotating lap at 60 rpm until it is within 20 microns of final desired thickness. Any sample wedging needs to be eliminated during this stage. The section is now polished on 100% cotton polishing paper charged with 1-micron polishing paste. The lap speed for this polishing should be in the 250 - 300 rpm range. Using a very light touch, work the section in the direction opposite the direction that the lap wheel is turning. Make frequent checks of polish quality and thickness with a petrographic microscope. If surface relief develops, hand polish the section on the same 6-micron diamond bonded metal plate that was used earlier for the potted sample. Alternate between the 1 micron lap polishing and 6 micron hand polishing until the desired polish and thickness are achieved.

References: [1] Mittlefehldt, D.W., McCoy T.J., Goodrich, C.A. and Kracher, A. (1998) *Non-chondritic Meteorites From Asteroidal Bodies* in *Planetary Materials* edited by Papike, J.J. Mineralogical Society of America, p. 4-81. [2] Moreland, G (1968) *The American Mineralogist*, 53, 2070-2074.