MULTIPLE APPROACHES TO DOWN SIZING OF THE LUNAR SAMPLE RETURN COLLECTION. G. E. Lofgren[1] and F. Horz[2], [1]KT, NASA Johnson Space Center, Houston, TX 77058, gary.e.lofgren@nasa.gov, [2]LZ Technology INC., ESCG, JE23, 2224 Bay Area Blvd., Houston, TX 77058.

Introduction: Future Lunar missions are planned for at least 7 days, significantly longer than the 3 days of the later Apollo missions. The last of those missions, A-17, returned 111 kg of samples plus another 20 kg of containers. The current Constellation program requirements for return weight for science is 100 kg with the hope of raising that limit to near 250 kg including containers and other non-geological materials. The estimated return weight for rock and soil samples will, at best, be about ~175 kg. The proposed missions with long stay times and 4 crew members could easily exceed the return weight limit. There will be a need to carefully manage the return weight of samples collected and there may be a need to reduce this mass before return to Earth. One method proposed to accomplish down-sizing of the collection is the use of a GeoLab in the lunar habitat to complete a preliminary examination of selected samples and facilitate prioritizing the return samples. The estimated throughput of such a lab is 5-10 samples per day based on current curation practice [1]. The rate of examination may be adequate in a habitat that is occupied for months, but not for shorter missions of 7-60 days. We will consider two additional methods and protocols for optimizing the return sample collection to reduce the returned sample weight. The first method is careful selection at the time of collection; the second protocol is sample selection by a Science Support Team in real time.

Down-Sizing at Collection Site: Down-sizing at the collection site requires the presence of a geologist as one of the crew and extensive training on collection techniques and sample recognition for all crewmembers. Choosing the important samples will be an acquired skill that requires a keen eye and experience in recognizing various types of lunar rocks. This is a skill aided by extensive training with existing Apollo lunar samples. Sample selection can be further aided with analytical tools such as a hand held XRF. The instrument would be programmed to complete a rapid analysis for a few critical elements that would allow the distinction, for instance, between types of basalts or types of impact melt rocks. This could be done e.g., with Fe, Ti, Ca, Al, and Mg analyses completed in 1-2 minutes with currently available instruments.

We have learned that uniform, fine to medium grained samples (either basalts or impact melt rocks) can be much smaller on the average than those collected by the Apollo Crews. Analytical techniques today can use small amounts of material, 10-20 grams, to do a through scientific study of an individual sample. Apollo crews averaged over 500 grams for such samples; but they were less constrained by return weight. Crews could be trained to collect smaller samples on the order of 100-200 grams. We recognize that choosing the right size samples or, if necessary, trimming rocks to a sufficiently small size presents challenges for field protocols especially rocks sitting on the regolith surface. The most important part of this down-sizing effort is the ability to break rocks into smaller, collectible sizes efficiently; a common technique in terrestrial field geology. The technique for breaking rocks was not emphasized in the Apollo training, but it will need to be a part of the new training effort. On the moon breaking rocks must be done timely and with skill.

There is an important exception to limiting the size of returned samples. Clast rich impact breccias are known to be a resource for a variety of important rock types. Breccias need to be evaluated in the field as to whether they are monomict or polymict and contain a variety of rocks types or show relationships between rocks types not otherwise available.

The Lunar Electric Rover (LER) should be equipped with additional analytical tools to assist in discriminating sample types and the hardware to split samples to reduce weight. We envision these down-sizing operations to be conducted outside the pressurized cabin. These tools could include “lab” versus “field” tools such as XRF, XRD, Raman and IR spectroscopy, laser ablation that are currently under development for inclusion on a LER and should mature within a decade. To aid in the splitting of rocks, a mechanical splitter would be placed inside a containment-box, which would allow the safe and purposeful fracturing and subdivision of homogeneous rocks or the isolation of specific clasts or matrix of polymict breccias. The time to complete these tasks will be well spent if it results in a collection that is carefully chosen, sized and meets mass and volume requirements for Earth return.

Missions with long distance excursions will involve two LERs working together for safety. One option has the rovers working with complimentary missions. For example, LER A may do all of the geophysical investigations while LER B concentrates on geologic field observations and sample acquisition [2]. The geophysical investigations will be less time consuming possibly allowing time to support the acquisition of samples by the crew of LER B. LER A could be designed and manned such that it contributes to the down-sizing of the sample collection

Down-Sizing by the SST: The second effort relies on the Science Support Team (SST). The prospects for a new generation of imaging tools available on the lunar surface will provide the SST with the kind of data the necessary to choose the best suite of samples for return [3]. The SST will able to characterize the rock types and textures with images from the Crew suit cameras, Fig. 1. They will also record any analytical data that is produced. The SST can build a database that will allow the team to prioritize samples and cull less important samples, such as ones of which many examples were collected. It will even be possible to estimate the weight of individual rocks by noting critical dimensions and approximate rock densities so that weight could be determined and help determine which samples are retained all other factors being equal. The SST can then recommend to the crew in real time whether a given sample should be collected. Even more importantly the SST could be prepared to determine which samples bags to eliminate from the collection without further examination at the end of the mission.

Figure 1. *Image captured from suit camera video stream in real time. Crew member holds rock steady for a few seconds so that the SST can capture the image. The bottom image is an enlargement of the rock showing the detail available to characterize the sample and estimate weight.*

Conclusion: The composition of the suite of samples returned from the Moon is a scientific treasure that will be mined for information for decades as has occurred with the Apollo collection. It is our contention that the shaping of this collection is a task that must be nurtured at every opportunity. The initial selection by the crew at the time of collection is most important and must be considered carefully and samples sized appropriately. The crew must have the best possible scientific training, analytical tools and the means to appropriately size the samples. The SST has the role of refining the selection of samples based on an overview of the collection not available to the crew. We further suggest that when 2 LERs are in use, one LER should be configured such that they conduct complementary investigations to increase productivity. The crew from one LER could perform the geophysical investigations and sample downsizing while the other crew perform geologic field observations and basic sample acquisition.

References: [1] Evans C. et al. (2009) LPS XLI, this volume. [2] Horz et al. (2009) LPS XLI, this volume. [3] Lofgren G. E. et al. (2009) LPS XLI, this volume.