50TH ANNIVERSARY OF THE WORLD'S FIRST EXTRATERRESTRIAL SAMPLE RECEIVING LABORATORY: THE APOLLO PROGRAM'S LUNAR RECEIVING LABORATORY.

M. J. Calaway[1], J. H. Allton[2], R. A. Zeigler[2], and F. M. McCubbin[2]. [1] Jacobs, NASA Johnson Space Center, Houston, TX; [2] NASA, NASA Johnson Space Center, Astromaterials Acquisition and Curation Office, Houston, TX; michael.calaway@nasa.gov.

Introduction: The Apollo program's Lunar Receiving Laboratory (LRL), building 37 at NASA's Manned Spaceflight Center (MSC), now Johnson Space Center (JSC), in Houston, TX, was the world's first astronaut and extraterrestrial sample quarantine facility (Fig. 1). It was constructed by Warrior Construction Co. and Warrior-Natkin-National at a cost of $8.1M between August 10, 1966 and June 26, 1967. In 1969, the LRL received and curated the first collection of extraterrestrial samples returned to Earth; the rock and soil samples of the Apollo 11 mission. This year, the JSC Astromaterials Acquisition and Curation Office (hereafter JSC curation) celebrates 50 years since the opening of the LRL and its legacy of laying the foundation for modern curation of extraterrestrial samples.

Fig. 1: 1967 Aerial Photograph of LRL MSC Building 37

Design and Construction: In February 1964, MSC scientists Elbert A. King and Don A. Flory forwarded the first LRL concept design to Max Faget, MSC Director of Engineering that detailed a vacuum chamber with remote manipulators for handling lunar samples [1]. At the time, vacuum sample processing was thought to preserve lunar volatiles for analysis and protect against the possibility of reactivity with terrestrial air. The following year, the U.S. Public Health Service (PHS) Communicable Disease Center (CDC) published recommended procedures for lunar sample handling and quarantine [1]. In July 1965, NASA and PHS recommended that biological barriers be constructed in the LRL for both astronauts and returned samples.

The Interagency Committee on Back Contamination (ICBC) was consequently established in January 1966 with Dr. David Sencer of the CDC as chairman along with representatives from the Department of Agriculture, Department of Interior, Department of Health, Education, and Welfare, National Academy of Sciences, and NASA [1, 2]. In May 1966, NASA's Planetology subcommittee of the Space Sciences Steering committee formed the LRL Working Group [2]. After construction began in August 1966, the NASA LRL design was described in the literature [3, 4]. The LRL Working Group and ICBC continued working to formulate the LRL facility processing and outfitting design through September 1967, a few months after the building structure was finished.

The 84,326 ft^2 (7,834 m^2) LRL facility was designed to the following functional requirements:

- Biological quarantine of astronauts, spacecraft, equipment, and samples
- Biohazard clearance testing
- Preparation of sample return containers and astronaut geologic hand tools before flight
- Receiving sample return containers and conducting preliminary sample characterization
- Time-sensitive primary scientific analyses
- Sample curation: cataloging, sample storage, repackaging and distribution of lunar samples to the scientific community for analysis

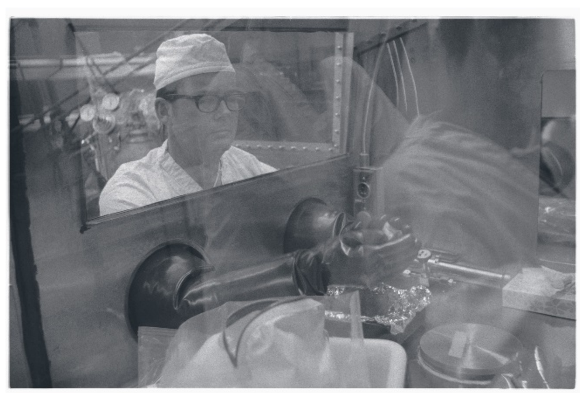

Fig. 2: Elbert A. King working on Apollo 11 Contingency Sample

The MSC LRL Program Office was managed by Joseph V. Piland until the summer of 1967, when Wilmot N. Hess was chosen to head the newly formed *Science and Applications Directorate*. In addition, Persa R. Bell from Oak Ridge National Lab was hired to manage the LRL development as Chief of the *Lunar and Earth Science Division* with Elbert A. King as the first Lunar Curator (Fig. 2). After the establishment of the LRL, the Lunar Sample Analysis Planning Team (LSAPT) and the Lunar Sample Preliminary Examination Team (LSPET) were established to plan the handling and analysis of all Apollo samples [2].

High Vacuum Complex: Behind the LRL biological barrier during Apollo 11 and 12, scientists worked with quarantined lunar material inside a series of isolation chambers called the "high vacuum complex", operating at a 10^{-6} torr environment (Fig. 3) [5]. The complex system design was based on technology derived from handling nuclear material at Oak Ridge National Lab. At the core of the complex, the F-201 isolator was a vacuum glovebox designed for initial sample processing. The atmospheric decontamination (R) cabinets of the complex used peracetic acid sterilization for sealed sample containers and heat sterilization for tools and containers without samples [5]. Construction materials for the complex were carefully selected to reduce contaminates; including stainless steel, Teflon, aluminum, Viton, and Pyrex glass for view ports [5]. The complex also used liquid nitrogen cold traps to reduce vacuum oils and other unwanted contaminates.

Fig. 3: LRL's High Vacuum Complex in 1968

Biohazard Testing: A subset of lunar samples were required for biohazard clearance testing. Separated from the geologic investigations, biologists used series of negative pressure Class III Biosafety Cabinets (BSC) (gloveboxes) to evaluate the risk of biological pathogens and other signs of back contamination. The BSC isolation technology was based on Biosafety Level 4 practices utilized by the U.S. Army Medical Unit at Fort Detrick for handling the most extreme pathogens on Earth.

The biohazard clearance testing methods were derived from the *Comprehensive Biological Protocol for the Lunar Receiving Laboratory* by Baylor University College of Medicine in 1967 [2]. Nicknamed the *Baylor Protocol*, the series of tests included bacteriology, mycology, virology mycoplasma, mammalian animals, botanical systems, and invertebrate/lower vertebrate systems. While the entire protocol was never fully implemented, it served as the basis for most clearance tests.

The biohazard clearance testing for Apollos 11, 12, and 14 concluded that there was no evidence of life nor any biological hazard to impede the release and distribution of geologic samples for scientific research outside the LRL biological barrier. Organic analyses on samples from Apollo 11 and 12 also concluded that all soluble organic compounds and amino acids found in the samples were indigenous to Earth. Following the Apollo 14 mission, all quarantine protocols were abandoned and only a few carbon studies were done on later missions [2].

Post Sample Quarantine: The high vacuum complex was notoriously prone to leaks and glove failure since installation in 1968. After Apollo 13, the high vacuum complex was deactivated in November 1970 and was replaced with gaseous nitrogen gloveboxes based on BSC designs called the Sterile Nitrogen Atmospheric Processing (SNAP) Line and a Nonsterile Nitrogen Processing Line (NNPL) [1].

During Apollo 14, the SNAP Line was used as the primary quarantine and was set at 1.0 inH_2O negative pressure with oxygen at 25 to 50 ppm and moisture restricted to 85 to 125 ppm [6]. The NNPL was used to process lunar material more quickly after the quarantine period in the SNAP line. The NNPL was set at a slight positive pressure nitrogen environment with O_2 at 10 to 30 ppm and moisture at 15 to 25 ppm [6].

After Apollo quarantine requirements were abandoned, the LRL continued to operate more as a curation laboratory than a quarantine facility for Apollo 15, 16 and 17. In April 1972, the newly constructed lunar curation laboratory began operations on the 2nd floor of JSC building 31. With the cancellation of the Apollo program after mission 17, all Class III BSCs and the high vacuum complex were abandoned in 1973. After Apollo, most equipment was excessed and the high vacuum complex was disassembled and relocated to Los Alamos National Lab for use on other government projects.

Future Sample Receiving Facility: Since Apollo's LRL, NASA has not required a facility to conduct biohazard testing and quarantine of returned samples. However, the LRL legacy has inspired generations of future scientists. The LRL lessons learned and institutional knowledge at NASA JSC has remained; passed down to the next generation of curatorial scientists who stand ready, when called upon, to build the next 21st century extraterrestrial quarantine receiving laboratory.

Reference: [1] Meltzer, M. (2011) NASA SP-2011-4234. [2] Mangus, S. et al. (2004) NASA/CR-2004-208938. [3] McLane, J. C. et al. (1966) MSC Internal Report. [4] McLane, J. C. et al. (1967) *Science*, 155(3762): 525-529. [5] White, D.R. (1976) NASA JSC Tech. Note D-8298. [6] Simoneit, B.R. et al. (1973) *In Analytical Meth. Dev. for App. to Lunar Samples Analyses*, ASTM STP 539:16-34.

Acknowledgements: Dedicated to the hundreds of Apollo program civil servants and contractor employees who helped rapidly build and test the LRL in time to receive samples.