THE RISE OF ASTROMATERIALS CURATION: NASA'S 50 YEARS OF PRESERVING PRISTINE SAMPLES FROM THE SOLAR SYSTEM.
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Introduction: The Astromaterials Acquisition and Curation Office at NASA Johnson Space Center (JSC) is a legacy of the Apollo program and set forth the modern era of curating pristine astromaterials from the solar system. Curating astromaterials, as meteorites, has its origin in the history of meteoritics and often cited are key museum collections in Vienna, Berlin, Moscow, Paris, and London during the 18th and 19th century [1]. In the U.S., James Smithson's European estate collection bequeathed to the U.S. government in 1835 included meteorites and helped establish the Smithsonian Institution (SI) in 1846 [1]. Beyond traditional storage of specimens in wooden cabinets with detailed cataloging, the modern craft of curating astromaterials was forged in the Apollo program and 20th century technology. For the first time, the Apollo program was able to secure pristine extraterrestrial (lunar) samples and preserve the scientific integrity of each sample for future generations.

The roots of the Apollo program are entrenched in every past and future sample return mission. Fundamental techniques and methodologies for processing and preserving samples were first developed for Apollo and are still used today along with the integration of new state-of-the-art technologies. This is prevalent in the use of cleanrooms, inert environment gloveboxes and isolation chambers that maintain a high degree of cleanliness to mitigate terrestrial cross-contamination. The use of sample handling equipment and construction materials with low to zero particulate shedding and outgassing mechanical properties and exposing samples to as few materials as possible to minimize potential trace contamination was first orchestrated under Apollo and continues today. This abstract is a very brief historical overview of these world-renowned astromaterial collections and a tribute to its past curation leadership and hundreds of support contractors that have been the custodians of these U.S. *Limited Natural Resources* for the last 50 years [2].

Apollo Lunar Collection (est. 1969): From 1969 to 1972, six Apollo program missions returned 382 kg of lunar rock and soil. The collection also houses a subset of Soviet Union Luna program material (est. 1971). All pristine samples are curated and processed in an inert gaseous nitrogen (GN2) environment inside 32 gloveboxes and operated in an ISO Class 6 cleanroom laboratory. As of 2018, there are currently 8,200 lunar samples allocated to ~140 scientists throughout the world. In addition, the Lunar collection has 254 educational disks available for allocation and 290 Apollo samples are currently on public display worldwide.

Lunar Curators:
- Elbert A. King: 1968 – 1969
- Daniel Anderson: 1969 – 1970 (Acting)
- Michael Duke: 1970 – 1977
- Patrick Butler, Jr.: 1978 – 1981
- Douglas Blanchard: 1981 – 1988
- John W. Dietrich: 1988 – 1991
- James L. Gooding: 1991 – 1997
- Charles Meyer: 1997 – 1998 (Acting)
- Gary Lofgren: 1998 – 2012
- Ryan Zeigler: 2012 – Present

Antarctic Meteorite Collection (est. 1977): The JSC meteorite collection has been part of the Antarctic Search for Meteorites (ANSMET) program since its conception [3]. Today, the U.S. Antarctic Meteorite program is a cooperative effort among NASA, the National Science Foundation, and the SI. Meteorites found during ANSMET expeditions are shipped frozen from Antarctica to Houston. The collection is stored in -20°C freezers and GN2 desiccators inside an ISO Class 6 cleanroom. The samples are processed using 8 GN2 purged gloveboxes and class 100 flow benches. After initial sample processing, many samples are sent to SI for long-term storage and SI allocation. As of 2018, the total number of ANSMET samples recovered is ~22,730 and ~26,000 meteorite samples splits have been allocated to over 1,000 scientists worldwide.

Meteorite Curators:
- Michael Duke: 1977 (Acting)
- Donald Bogard: 1978 – 1984
- James L. Gooding: 1984 – 1986
- Marilyn Lindstrom: 1987 – 2000
- David Mittlefehldt: 2000 – 2001
- Carl Allen: 2001 to 2002 (Acting)
- Kevin Righter: 2002 to Present

Cosmic Dust Collection (est. 1981): This collection consists of extraterrestrial particulates that fall to Earth and collected from high altitude aircraft operating in the stratosphere (e.g., WB-57F aircraft). These samples are processed in an ISO Class 5 cleanroom and stored in GN2 purged desiccators. As of 2018, 597 cosmic dust collectors have been flown with 3,275 particles/clusters/flags/mounts allocated to roughly 97 scientists worldwide.

Cosmic Dust Curators:
- Uel Clanton: 1981
- James L. Gooding: 1981 – 1985

- Michael Zolensky: 1985 to 2017
- Marc Fries: 2017 to present

Microparticle Impact Collection (est. 1985): Formally called *Space Exposed Hardware*, this collection consists of an assortment of spacecraft and flown components that have been impacted by natural and human-made microparticulates that are preserved for scientific study. The collection includes parts from Surveyor III, the Long Duration Exposure Facility (LDEF), the Solar Maximum satellite, the European Recoverable Carrier (EuReCa), the MIR space station and the Hubble Space Telescope. In addition, the collection houses the sample return capsules from the Genesis and Stardust missions. The materials are not stored in any special environment, but are processed in an ISO Class 7 cleanroom. Michael Zolensky has been the curator since 1985.

Genesis Solar Wind Collection (est. 2004): The Discovery-class Genesis mission was the first sample return mission since Apollo and returned solar wind from Earth-Sun Lagrange point 1. Despite the hard landing that fragmented the high purity collectors into thousands of small pieces, the mission still achieved all of its prime mission objectives and almost 2,000 fragments have been characterized to date. Genesis samples are handled in NASA's cleanest cleanroom at ISO Class 4. Karen McNamara served as curator from 2001 to 2005 and Judith Allton has been the curator since 2005.

Stardust Collection (est. 2006): The Discovery-class Stardust mission captured Comet samples in aerogel from the coma of comet Wild 2. In addition, the reverse side of the aerogel collector captured a few trace particles of interstellar origin. The collection is stored in GN2 desiccators and processed in an ISO Class 5 cleanroom. As of 2018, ~197 cometary tracks and ~50 interstellar tracks have been harvested. Michael Zolensky has been the curator since mission conception.

Hayabusa Collection (est. 2012): In an agreement with the Japan Aerospace Exploration Agency (JAXA), a subset of Itokawa asteroidal material from the Hayabusa mission is curated at JSC and available for allocation to the international science community. The samples are stored in an ISO Class 5 cleanroom within a GN2 glovebox. Michael Zolensky is the curator of the collection.

Remote Storage Facility: In case of a catastrophic event in Houston, TX, the Lunar curation facility established a remote storage facility for a subset of the samples at Brooks Air Force Base in San Antonio from 1975 to 2002. Since 2002, the remote storage facility at NASA White Sands Complex has been used and currently houses a subset of Lunar, Cosmic Dust, Genesis and Stardust collections.

JSC Curation Analysis Committee: The idea of an independent science analysis committee to discuss the preservation and distribution of astromaterials was formulated during Apollo as the Lunar Sample Analysis Planning Team (LSAPT) (1967 to 1978). The LSAPT provided findings to NASA on the Lunar Receiving Laboratory [4] and creation of the Lunar curatorial facility in JSC bldg. 31 in 1972 and bldg. 31N in 1979. From 1978 to 1993, LSAPT changed its charter and name to the Lunar and Planetary Sample Team (LAPST) to incorporate the growing collections in Houston. At the advent of the first Discovery program sample return missions, Stardust and Genesis, the charter and name changed again in 1994 to the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM). Today, CAPTEM is one of NASA's oldest analysis committees stemming from the Apollo program.

Curation Management: The NASA JSC Curation Office was managed by the Apollo Lunar Curator position from 1968 to 1998. In 1998, as the organization grew, Carl Agee, Chief Scientist appointed to JSC Center Director George Abbey's staff, created the position of Astromaterials Curator to manage and lead all JSC Curation activities. Carl Allen served as the Astromaterials Curator from 2000 to 2015, and that position is currently held by Francis McCubbin. In 2014, the Astromaterials Curator position was split into two positions: Astromaterials Curator and Curation manager. Cynthia Evans served as manager from 2014 to 2016 and Ryan Zeigler is the current manager.

Future and Advanced Curation: For over 50 years, JSC Curation has honed its craft of curating astromaterials from other worlds grounded in the legacy of Apollo. JSC Curation is currently constructing new collection cleanroom facilities for the Hayabusa2 and OSIRIS-REx missions returning asteroidal material to Earth in 2020 and 2023 respectively. JSC Curation is also collecting contamination knowledge samples from the Mars 2020 mission intended to be the first leg of a Mars Sample Return campaign. In addition, advanced curation efforts are expanding to enable future sample return missions that will require preservation and processing of frozen material, robotic and micro sample handling, and further reduction of terrestrial organic and biological contamination. Today, JSC Curation is posed to write the continuing chapters in astromaterials curation for the next 50 years while continuing to build upon the legacy of Apollo.

Reference: [1] McCall et al. (Eds.). (2006). The history of meteoritics and key meteorite collections: fireballs, falls and finds. Geo. Soc. of London. [2] Allen et al. (2011). *Chemie der Erde-Geochemistry*, 71(1), 1-20. [3] Righter et al. (Eds.). (2014). 35 seasons of US Antarctic meteorites (1976-2010). John Wiley & Sons. [4] Calaway et al. (2017) *LPSC XLVIII*:1224.