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AUDIT REPORT

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OFFICE OF AUDITS

NASA'S MANAGEMENT OF MOON ROCKS AND OTHER  
ASTROMATERIALS LOANED FOR RESEARCH,  
EDUCATION, AND PUBLIC DISPLAY

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OFFICE OF INSPECTOR GENERAL

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National Aeronautics and  
Space Administration

REPORT No. IG-12-007 (ASSIGNMENT No. A-11-015-00)

Final report released by:



Paul K. Martin  
Inspector General

## Acronyms

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ARES	Astromaterials Research and Exploration Science
CAPTEM	Curation and Analysis Planning Team for Extraterrestrial Materials
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
OIG	Office of Inspector General
µm	Micrometers

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## OVERVIEW

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# NASA'S MANAGEMENT OF MOON ROCKS AND OTHER ASTROMATERIALS LOANED FOR RESEARCH, EDUCATION, AND PUBLIC DISPLAY

## The Issue

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Materials originating from extraterrestrial environments, commonly referred to as astromaterials, are a rare and limited resource that serve an important role for research, education, and as a legacy for future generations. NASA's collection of astromaterials includes lunar rock and soil samples; meteorites from asteroids, Mars, and the Moon; ions from the outer layers of the Sun (Genesis); dust from comets and interstellar space (Stardust); and cosmic dust from Earth's stratosphere.<sup>1</sup> To promote investigation of the origin and evolution of the solar system and the nature and distribution of life, NASA both studies these materials itself and loans astromaterial samples to researchers



**Figure 1.** ALH84001 weighs about 4 pounds and at 4.1 billion-years-old is NASA's oldest Martian meteorite.

Source: NASA

astromaterials and distributes samples for scientific study. In addition, the Office makes lunar and meteorite samples available to exhibitors, educators, and institutions of higher learning through NASA's Exhibits and Education Programs. The Office manages about 140,000 lunar samples, 18,000 meteorite samples, and about 5,000 solar wind, comet, and cosmic dust samples. As of March 2011, over 26,000 of these samples were on loan for scientific study, educational pursuits, and public outreach purposes.

worldwide. For example, NASA-sponsored research on a 4.1-billion-year-old meteorite has provided evidence that life may have once existed on Mars (see Figure 1). To inspire the next generation of explorers, enhance the nation's education system, and inform the public about NASA's space programs, the Agency also loans lunar and meteorite displays to schools, libraries, museums, and planetariums.

Johnson Space Center's Astromaterials Acquisition and Curation Office (Curation Office) maintains NASA's collection of

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<sup>1</sup> The origins of NASA's astromaterial collection are varied. Lunar samples were returned to Earth during the 1969–1972 Apollo missions; meteorites were obtained as a result of the Antarctic Search for Meteorites Program begun in 1977; solar wind was collected during the 2001 Genesis mission; NASA's Stardust spacecraft – launched in 1999 – collected cometary and interstellar dust particles; and cosmic grains and orbital debris from the stratosphere have been collected by high-flying aircraft since 1981.

The Johnson Exhibits Manager, a member of the Johnson Public Affairs Office, is responsible for tracking astromaterials loaned for public display. In June 2010, he notified NASA Security and the Office of Inspector General (OIG) that a lunar sample disk, similar to the one in Figure 2, on loan to the Mount Cuba Astronomical Observatory in Greenville, Delaware, was missing.

NASA had loaned the sample disk to the Observatory in 1978, and the loan agreement between the two organizations had expired in June 2008. However, due to an administrative oversight and the lack of a system to adequately track renewal dates for long-term loans, the Exhibits Manager did not contact Mount Cuba regarding the loan until February 2010. At that time, the Exhibits Manager learned that the responsible Mount Cuba employee had died the previous year and that the Observatory could not locate the sample. As of December 2011, the disk still has not been found.



**Figure 2.** Example of a lunar sample disk. The six-inch diameter disk contains three soil and three rock materials encapsulated in clear acrylic.

Source: NASA

NASA has been experiencing loss of astromaterials since lunar samples were first returned by Apollo missions. In addition to the Mount Cuba disk, NASA confirmed that 516 other loaned astromaterials have been lost or stolen between 1970 and June 2010, including 18 lunar samples reported lost by a researcher in 2010 and 218 lunar and meteorite samples stolen from a researcher at Johnson in 2002, but since recovered.<sup>2</sup> As a result of the Mount Cuba incident and concerns about additional unknown losses, the OIG initiated an audit to assess NASA's controls over loans of astromaterials. The number of astromaterial samples NASA has loaned to researchers has increased by more than 60 percent over the last decade. Additionally, NASA is planning new missions intended to collect more samples from across the solar system. Accordingly, NASA's control of and accountability for these rare and valuable materials must be reliable. Details of the audit's scope and methodology are in Appendix A.

## Results

NASA lacks sufficient controls over its loans of moon rocks and other astromaterials, which increases the risk that these unique resources may be lost. Specifically, we found that Curation Office records were inaccurate, researchers could not account for all samples loaned to them, and researchers held samples for extended periods without performing research or returning the samples to NASA. In addition, although NASA

<sup>2</sup> As of December 2011, the Curation Office was still searching for the 18 lost lunar samples.

recently improved controls over loans to educators, we identified additional opportunities for NASA to strengthen its practices and update its policies for loans of astromaterials for education and public display purposes.

**NASA’s Controls over Research Loans of Astromaterials Are Inadequate.** The Curation Office does not exercise sufficient controls over the astromaterials NASA loans for scientific study. Using NASA records, we performed an inventory of astromaterial samples on loan to 59 of the 377 U.S. researchers. This group represented 16 percent of U.S. researchers with loaned materials and 23 percent of all NASA astromaterial samples on loan as of March 30, 2011.<sup>3</sup> In examining this group of 59 researchers, we found that:

- Eleven of the 59 researchers (19 percent) could not account for all samples NASA records indicated had been loaned to them or possessed samples that, according to NASA records, had been destroyed or loaned to other individuals.
- Curation Office records included (1) hundreds of samples that no longer exist and (2) loans to 12 researchers who had died, retired, or relocated, in some cases without the Office’s knowledge and without returning samples.
- The Curation Office did not ensure that these loaned research samples were efficiently used and promptly returned to NASA. For example, we learned of one researcher who still had lunar samples he had borrowed 35 years ago on which he had never conducted research.

These conditions occurred for several reasons. First, the Curation Office did not require loan agreements or have in place other internal procedures for safeguarding loans of meteorites and cosmic dust samples. Loan agreements specify the conditions for the loan and include security plans prescribing precautions for guarding against theft or unauthorized use of astromaterial samples. NASA requires loan agreements for lunar, Genesis, and Stardust samples but does not require such agreements for meteorites or cosmic dust samples. Moreover, the Office maintains guidebooks and internal procedures to help ensure lunar, Genesis, and Stardust samples are adequately controlled and properly accounted for but has never established similar controls over meteorites and cosmic dust samples.<sup>4</sup>

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<sup>3</sup> Details of our methodology and sampling plan are in Appendix A and Appendix B.

<sup>4</sup> NASA Policy Directive (NPD) 7100.10E, “Curation of Extraterrestrial Materials (Revalidated 01/10/2008).”

Even in those instances when NASA has required researchers to sign loan agreements, the agreements have not consistently specified:

- that researchers must independently provide NASA with an annual inventory of all samples in their custody;<sup>5</sup>
- an agreed-upon timeframe for conducting research on and returning samples to NASA;
- procedures for notifying and returning samples to NASA upon the researcher's death, retirement, or other change in status or place of employment; or
- that researchers must obtain NASA's permission to perform destructive analysis on loaned samples.

In addition, NASA's loan agreements do not contain enforceable sanctions for noncompliance with the terms of the agreement.

Second, the Office did not consistently follow its inventory procedures for astromaterial samples. For example, we found that although NASA policy required an annual inventory from holders of loaned materials, the Curation Office did not consistently request these inventories. In fact, the Office had never requested inventories of Stardust samples and, prior to our audit, had not requested inventories of lunar samples held at locations other than Johnson since 2008. Additionally, we found that the Office's inventory practices depend on (1) the type of sample in question and (2) whether borrowers store samples at Johnson.

Third, the Curation Office's annual inventory procedures are inadequate and do not account for all loaned samples. Specifically, to have researchers verify the samples they hold, the Office provides them with a list based on its records and requests they confirm its accuracy. We believe that an example of a more reliable inventory method would be to request that researchers provide the Office with a list of the samples in their possession and then reconcile the researchers' lists with Agency records. In addition, the Curation Office said that due to funding constraints it has not performed a complete physical inventory of all lunar samples loaned to researchers since the 1980s.

**NASA's Controls over Educator and Public Display Loans Need Strengthening.** At the time of our fieldwork, NASA had 455 astromaterial sample disks available for education purposes and 94 lunar exhibits on long-term public display. We found that the Agency's controls over these samples need improvement. For example, the Johnson Exhibits Manager who tracks long-term loans (loans that exceed 1 year) of lunar material, like the loan to the Mount Cuba Astronomical Observatory, does not have an adequate system to track loaned exhibits and ensure loan agreements are up-to-date. In addition,

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<sup>5</sup> Loan agreements for lunar samples only require researchers to respond if NASA requests an annual inventory.

NASA's policies do not require, and the Exhibits Manager does not conduct, an annual inventory of these exhibits.

Furthermore, although NASA has taken some steps over the last 2 years to improve controls over loans of lunar and meteorite samples for use in classrooms, related Agency policies are out of date and do not accurately reflect current practices and organizational responsibilities.<sup>6</sup>

NASA has strengthened the Curation Office's role in educator and public display loans and has begun the process of updating the relevant policy, which expired in June 2011.<sup>7</sup> However, NASA needs to continue improving its oversight over materials loaned for education and public display by updating all relevant policies, ensuring that all long-term loan agreements are up-to-date, and obtaining an accurate inventory of long-term loans. With lunar and meteorite samples loaned to classrooms around the country and exhibits disbursed across 25 states, the District of Columbia, and 13 foreign countries, NASA must ensure these materials are properly protected and accounted for.

**Conclusion.** For over 40 years, NASA has loaned astromaterial samples to researchers and shared lunar and meteorite exhibits with educators and the public. However, the materials remain the property of the U.S. Government and may only be borrowed for approved research, educational pursuits, and public display.<sup>8</sup> Additionally, while loan periods may range from days to years, these transfers are not intended to be permanent, and NASA retains the right to recall its samples and exhibits at any time. Because NASA does not have adequate controls in place, the Agency cannot be sure of the location and security of all of its loaned astromaterials and therefore is at risk of losing these unique and limited resources.

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<sup>6</sup> NPD 1387.1G, "NASA Exhibits Program (Revalidated 3/17/10)," November 15, 1999; NASA Procedural Requirements (NPR) 1387.1, "NASA Exhibits Program w/Change 2 (Revalidated 3/17/10);" NPD 1387.2F "Use, Control, and Loan of Lunar Samples for Public and Educational Purposes (Revalidated 2/28/05);" and NPD 7100.10E, "Curation of Extraterrestrial Materials (Revalidated 01/10/2008)."

<sup>7</sup> During the audit, NASA extended the expiration date of NPD 1387.2F from June 28, 2011, to December 29, 2011. The OIG provided suggested changes to ensure that the update includes accurate and necessary information. As of December 2011, NASA had not finalized the update.

<sup>8</sup> Lunar material retrieved from the Moon during the Apollo Program is U.S. Government property. Lunar material may also be present in some meteorites that fall to Earth, but this lunar material is not necessarily regulated or U.S. Government property.

## Management Action

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To strengthen internal controls and ensure efficient use and proper protection of loaned astromaterials, we recommended that NASA (1) establish detailed procedures for safeguarding loaned materials; (2) require loan agreements for all types of materials and strengthen the agreements currently in use; (3) establish procedures for tracking retention periods and ensure that researchers timely use and, when required, promptly return loaned samples; (4) evaluate practices for ensuring inventory procedures are effectively implemented and consistently followed; and (5) strengthen the inventory verification process. To further improve controls over astromaterials loaned for education and public display purposes, we also recommended that NASA (1) establish an effective tracking system and annual inventory requirements for long-term loans; (2) review all long-term loan agreements to identify expired agreements and either renew the agreements or recall the exhibits; and (3) review and update all relevant policies.

In response to a draft of our report, the Acting Associate Administrator for the Science Mission Directorate concurred with our recommendations. We consider the Acting Associate Administrator's comments and proposed actions to be responsive to our recommendations. The recommendations will be closed upon completion and verification of the proposed actions. The full text of his comments are provided in Appendix C.



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## INTRODUCTION

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### Background

Materials originating from extraterrestrial environments, commonly referred to as astromaterials, are a rare and limited resource for research, education, and as a legacy for future generations. NASA's collection of astromaterials includes lunar rock and soil samples; meteorites from asteroids, Mars, and the Moon; ions from the outer layers of the Sun (Genesis); dust from comets and interstellar space (Stardust); and cosmic dust from Earth's stratosphere. To promote investigation of the origin and evolution of the solar system and the nature and distribution of life, NASA loans astromaterial samples to researchers worldwide. To inspire the next generation of explorers and inform the public about NASA's space programs, the Agency also loans lunar and meteorite displays to schools, libraries, museums, and planetariums. However, NASA does not consider requests for loans of these samples from individuals acting on their own behalf.

NASA's Astromaterials Acquisition and Curation Office (Curation Office), managed by the Agency's Astromaterials Curator, is located within the Astromaterials Research and Exploration Science (ARES) Directorate at Johnson Space Center. The mission of the Office is to support the international planetary science community through curation of NASA's collection of astromaterials. NASA defines curation as the documentation, preservation, preparation, and distribution of samples for research, education, and public outreach. In addition to the Astromaterials Curator, the Office employs curators dedicated to each type of astromaterial.

As described below, NASA's current astromaterials collection includes approximately 140,000 lunar samples, 18,000 meteorite samples, and over 1,000 samples each of Genesis, Stardust, and cosmic dust.

**Apollo Lunar (Lunar) and Antarctic Meteorite (Meteorite) Samples.** Between 1969 and 1972, the six Apollo missions returned 842 pounds of lunar material (2,196 individual rock, soil, and core samples) that subsequently have been split into about 140,000 subsamples. Since 1977, the Antarctic Search for Meteorites Program – a cooperative effort among NASA, the National Science Foundation, and the Smithsonian Institution – has recovered over 18,000 meteorites that originated from asteroids, Mars, and the Moon. Lunar and meteorite samples are measured in grams (1 gram =  $\approx$  0.035 ounce). Many lunar and



**Figure 3.** Lunar sample compared to a dime weighing 2.3 grams.

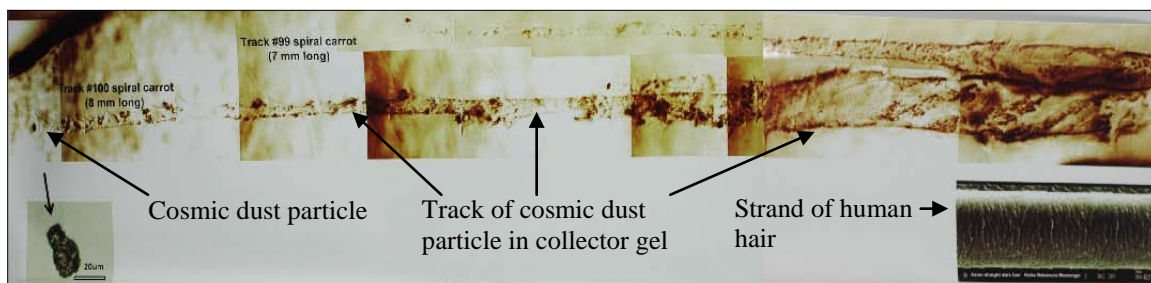
Source: NASA

meteorite samples loaned to researchers are 1 gram or less in weight. In comparison, the weight of a dime is 2.3 grams. Figure 3 shows the size of a lunar sample compared to the size of a dime.

**Genesis Solar Wind Atoms (Genesis).** Launched in 2001, NASA's Genesis spacecraft captured solar wind – a stream of ions ejected from the outer layers of the Sun, composed mostly of electrons and protons. Since 2004, NASA has cataloged 1,500 Genesis collector fragments. Because of their extremely small size, the Curation Office does not measure the samples in terms of weight or size.

**Comet and Interstellar Dust Particles (Stardust) and Cosmic Dust Samples.**

Launched in 1999, NASA's Stardust spacecraft collected over 1,200 grains of cometary dust particles and approximately 135 grains of interstellar dust particles as it passed the comet Wild-2. Cosmic dust grains and orbital debris are collected in the stratosphere by high-flying aircraft. Currently, Johnson has over 2,000 cosmic dust particles in its collection. Stardust particles and cosmic dust are measured in micrometers ( $\mu\text{m}$ ) ( $1 \mu\text{m} = \approx 0.000039$  inch). Stardust grains generally measure less than  $1 \mu\text{m}$  in diameter and cosmic dust particles are approximately  $5\text{--}10 \mu\text{m}$  in diameter. By comparison, the diameter of an average human hair is approximately  $100 \mu\text{m}$  (see Figure 4).



**Figure 4.** Cosmic dust particle compared to a strand of human hair.

Source: NASA

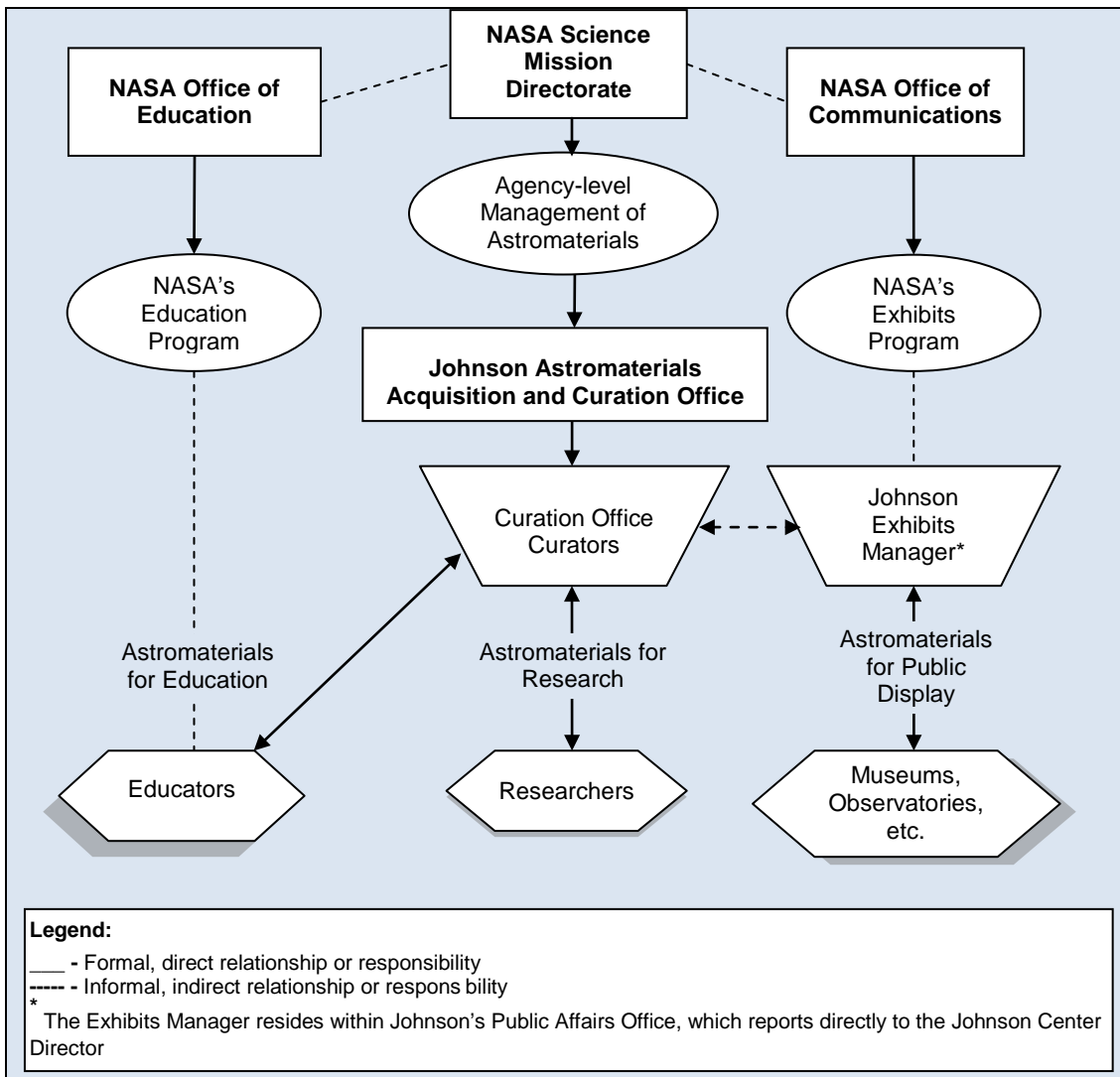
NASA's collection of astromaterials is the property of the U.S. Government and loans are permitted for research, education, and public display only. NASA's collection is slated to grow in December of this year when the Japan Aerospace Exploration Agency plans to transfer to NASA 10 percent of the asteroid samples collected by the Hayabusa spacecraft.<sup>9</sup>

As shown in Figure 5, NASA's Science Mission Directorate is responsible for approving allocations of astromaterials for scientific research, education, and public display. However, the Curation Office assists the Science Mission Directorate in NASA's outreach efforts by ensuring astromaterials are available and distributing the appropriate sample. Thus, for each samples collection, the Astromaterials Curator has assigned a curator within the Curation Office to be the dedicated manager of that collection.

<sup>9</sup> Launched in 2003 by Japan, Hayabusa collected about 1,500 grains of particles from the asteroid Itokawa.

NASA’s Office of Education implements the Agency’s Education Program and through the Aerospace Education Services Project, provides certification courses required for teachers who want to apply for loans of astromaterials for classroom examination and study. The Curation Office manages the loans and makes lunar and meteorite education disks available to teachers.<sup>10</sup> NASA’s Office of Communications is responsible for the Exhibits Program, which provides a limited number of lunar displays managed and approved by the Exhibits Manager through Johnson’s Public Affairs Office.

**Figure 5.** Management and Distribution of Astromaterials for Research, Education, and Public Display



The Curation Office uses a database to track NASA’s inventory of astromaterial samples. The database contains information on each sample’s weight, whether it has been split into

<sup>10</sup> The disks contain six small samples of lunar rocks and soils or meteorites embedded in acrylic.

smaller subsamples, and whether the samples and subsamples have been loaned to researchers for scientific study or included as part of an educational or public display. The database also contains information about loan agreements and loan expiration dates for researcher and educator loans, but the Johnson Exhibits Manager is responsible for tracking similar information for public display loans.

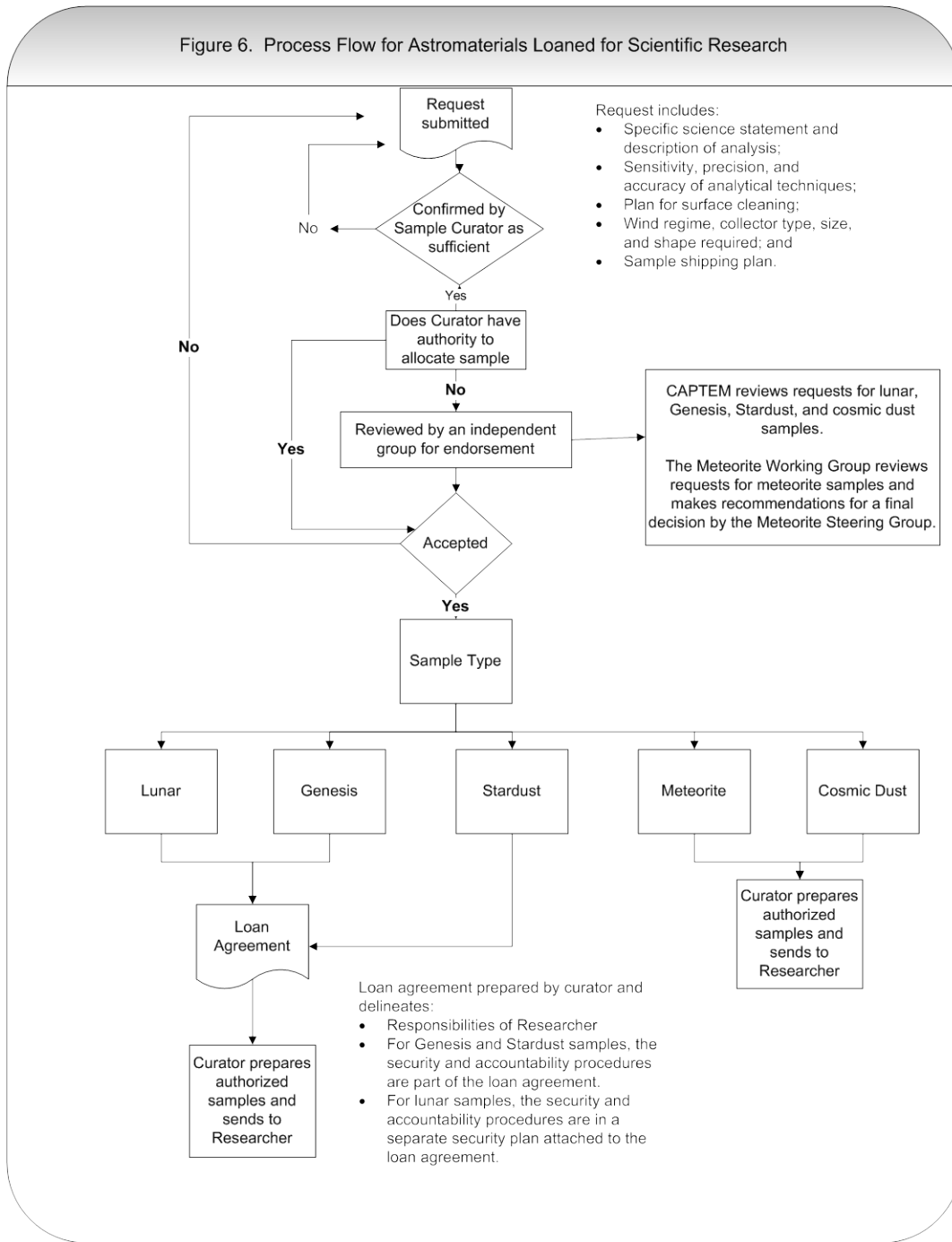
**Scientific Research Loans.** NASA's policy is to encourage scientific research on natural materials returned from extraterrestrial environments to derive maximum scientific and technological information. In accordance with this policy, NASA loans astromaterial samples to researchers who demonstrate that their proposed research has received a favorable scientific peer review.<sup>11</sup> Researchers submit research requests that include the justification, methods, and benefits of the planned research to the appropriate material curator within the Curation Office. The curator reviews requests and assesses the scientific content of the proposal, capability of the proposer, and availability of requested samples. The curator then decides whether he or she is required to request an additional outside review. For all requests except those involving meteorite samples, outside reviews are performed by the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM), a standing committee of scientists who advise NASA on the care and use of all astromaterial samples except Antarctic meteorites. CAPTEM ensures that appropriate samples have been selected and performs a peer review.<sup>12</sup> For Antarctic meteorites, NASA, the National Science Foundation, and the Smithsonian Institution signed a trilateral agreement and formed a Meteorite Steering Group to manage and control the meteorites. The Steering Group has its Meteorite Working Group perform the outside reviews and make recommendations back to the Steering Group for allocation of samples.

Upon approval of a request, the curator prepares the appropriate sample, establishes a loan agreement between NASA and the borrower (unless the loan involves meteorites or cosmic dust samples for which NASA does not require a loan agreement), and distributes the sample. Unless NASA has given prior approval to perform destructive analysis, NASA expects borrowers to return all lunar, Genesis, and Stardust samples as soon as their research is completed. NASA requires the return of meteorite samples only when they originate from rare meteorites, which make up approximately 25 percent of the Agency's meteorite collection. Because of their small size – only 5–10  $\mu\text{m}$  in diameter (approximately one-tenth the width of a human hair) – NASA does not expect researchers to return cosmic dust samples. Figure 6 illustrates the process flow for scientific research loans of astromaterials.

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<sup>11</sup> The peer review may include determining if the proposal has been: (1) recommended by any NASA program needing a planetary or scientific study within the past 3 years; (2) recommended and funded by any foreign or domestic government or non-profit agency; or (3) supported by reprints of scientific articles published in peer-reviewed professional journals and pertaining directly to the specific research methods to be applied.


<sup>12</sup> For example, outside reviews are required of all lunar researchers unless requested samples have already been used for research purposes.



As of March 2011, NASA had 10,293 lunar, 11,955 meteorite, 418 Genesis, 1,266 Stardust, and 2,670 cosmic dust samples on loan to 595 researchers worldwide. As shown in Table 1, the number of samples loaned by the Agency to researchers increased by 62 percent over the last decade.

**Table 1. Number of Astromaterial Samples Loaned to Researchers by Fiscal Year**

Collection	Fiscal Year									
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Lunar	426	232	152	221	199	261	252	218	264	436
Meteorites	340	194	503	503	693	495	520	702	771	571
Genesis					87	106	85	53	62	50
Stardust						450	339	210	78	217
Cosmic Dust	122	46	29	69	57		194	121	109	167
<b>Total</b>	<b>888</b>	<b>472</b>	<b>684</b>	<b>793</b>	<b>1,036</b>	<b>1,312</b>	<b>1,390</b>	<b>1,304</b>	<b>1,284</b>	<b>1,441</b>

Increase In Total Number of Samples Loaned Between 2001 and 2010  62 percent

Source: Report to CAPTEM, "Astromaterials Acquisition and Curation at JSC: November 2009 - November 2010."

**Educator and Public Display Loans.** NASA provides opportunities for people in the United States and around the world to view and study lunar and meteorite samples by loaning samples for educational purposes and public display. To that end, the Curation Office has 455 lunar and meteorite education disks similar to those pictured in Figure 7 available for K-12 classroom examination via short-term loans (usually 2 weeks) to qualified U.S. schoolteachers.<sup>13</sup>



**Figure 7.** Examples of lunar and meteorite education disks used for K-12 classroom study.

Source: NASA

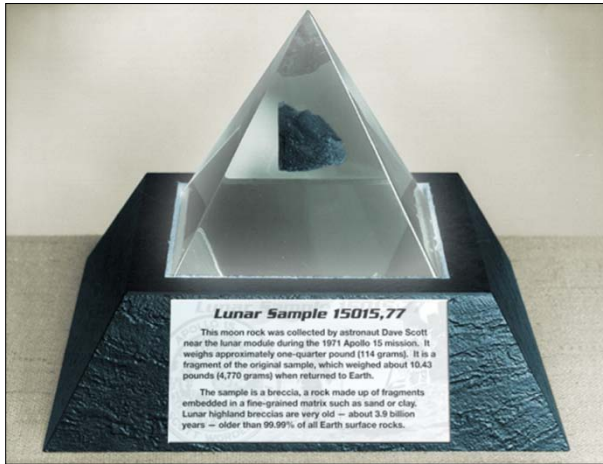
professional events open to the public. Currently, NASA has 94 lunar exhibits on long-term display worldwide. For example, the Exhibits Program has provided long-term displays to the visitor facilities at or associated with the NASA Centers and to the Smithsonian Institution's National Air and Space Museum as well as to institutions in 25 states, the District of Columbia, and 13 foreign countries.

As with loans to researchers, loans of lunar and meteorite education disks require an application, loan agreement, and security plan approved by the Curation Office. Educators are also required to attend a training course that includes, but is not limited to, security requirements and proper handling procedures before being allowed to use an education disk in their classroom.

NASA's Exhibits Program provides several different types of displays (see Figure 8) for use on a short- or long-term basis at museums, planetariums, expositions, or

<sup>13</sup> In addition to kindergarten-12th grade (K-12) disks, NASA also prepares thin sections of lunar rocks on rectangular 1 x 2-inch glass slides that are suitable for use in U.S. colleges and universities.





**Figure 8.** Apollo 15 lunar sample exhibit.

Source: NASA

included in exhibits for public display, the only means the Exhibits Manager has for tracking loan expiration dates is to review his paper files.

**Goodwill Moon Rocks and Ambassador of Exploration Awards.** In addition to the astromaterial samples available for scientific research, education, and public display loans, in 1973 President Nixon gave fragments from one of the last rocks collected from the Moon to foreign heads of state and each of the 50 U.S. states as a symbol of goodwill. During the final moonwalk of the Apollo missions, Apollo 17 astronauts Eugene Cernan and Harrison Schmitt picked up the rock— known as the “Goodwill Rock” – and stated that they would like to share pieces of it with the children of the world. Though NASA still has about 80 percent of the original rock, the hundreds of fragments that were given to countries around the world and each U.S. state are not tracked by NASA.

In addition, over the years NASA has awarded lunar samples to individuals the Agency has named “Ambassadors of Exploration” in recognition of the contributions of the astronauts and other individuals who were part of the Mercury, Gemini, and Apollo programs. To date, NASA has named over 30 Ambassadors of Exploration, including astronauts Alan Shepard and Neil Armstrong and former U.S. Senator and astronaut John Glenn. NASA presents each honoree with a lunar sample that remains the property of NASA but may be publicly displayed in the honoree’s name at the museum or educational institution of their choice. Since these lunar samples remain NASA property, the Exhibits Manager tracks their location.

**Confirmed Losses of Astromaterials.** NASA has confirmed that 517 astromaterial samples have been lost or stolen between 1970 and June 2010, including 218 lunar and meteorite samples stolen during a single theft from a researcher at Johnson in 2002 (with all of the material subsequently recovered), and 18 lunar samples reported lost by one researcher in 2010.<sup>14</sup> In June 2010, the Johnson Exhibits Manager notified NASA

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<sup>14</sup> As of December 2011, the Curation Office was still searching for the 18 lost lunar samples.

Security and the Office of Inspector General that a disk containing lunar samples was missing from the Mount Cuba Astronomical Observatory in Greenville, Delaware. NASA loaned the disk to the Observatory in 1978 and the loan agreement between the two organizations expired in June 2008. However, due to an administrative oversight and the lack of a system to adequately track renewal dates for exhibits on long-term loan, the Exhibits Manager did not contact Mount Cuba to renew the loan until February 2010. At that time, the Exhibits Manager learned that the responsible Mount Cuba employee had died the previous year and that the Observatory could not locate the exhibit. As of December 2011, the disk still had not been found.

## **Objectives**

Our audit assessed NASA's controls over astromaterial samples loaned for research, education, and public display. See Appendix A for details of the audit's scope and methodology, our review of internal controls, and a list of prior coverage.

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## **NASA'S CONTROLS OVER RESEARCH LOANS OF ASTROMATERIALS ARE INADEQUATE**

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To test NASA's controls, we used Agency records to verify the existence and location of astromaterial samples loaned to selected researchers. We reviewed 4,991 samples on loan to 59 researchers in the Houston and Washington, D.C., areas as of March 30, 2011.<sup>15</sup> According to Agency records, these individuals represented 16 percent of the U.S. researchers with loaned materials and the group possessed 23 percent of the samples loaned to researchers across the country.

We found that NASA is fulfilling its mission to distribute astromaterials for scientific study. However, we also found that the Agency lacks sufficient controls over its loans of moon rocks and other astromaterials once they have been transferred to borrowers. Specifically, we found that some researchers could not account for all samples NASA records indicated had been loaned to them, or possessed samples that, according to NASA records, had been destroyed or loaned to other individuals. In addition, Curation Office records included hundreds of samples that no longer exist and loans to researchers who had died, retired, or relocated, in some cases without the Office's knowledge. Finally, the Curation Office had not ensured that loaned samples were used for agreed upon research purposes and promptly returned to NASA.

These conditions occurred because the Curation Office had not established procedures – including requiring loan agreements – to manage meteorites and cosmic dust samples. Further, the loan agreements the Agency required for lunar, Genesis, and Stardust samples did not contain basic elements necessary to protect the loaned materials. Finally, inventory procedures are not consistently followed and need improvement. As a result of these deficiencies, NASA does not properly safeguard loaned materials, has little assurance of the location or continued existence of the loaned materials, and is at risk of losing more of these unique and limited resources.

**Researchers Could Not Account for All Samples Loaned to Them and Agency Records Did Not Contain Accurate Information Regarding Loaned Samples.** We found that 11 of the 59 researchers in our sample (19 percent) could not account for all samples Agency records indicated had been loaned to them or had in their custody samples that, according to Agency records, did not exist or had been loaned to other individuals. Specifically, 7 researchers could not account for 22 meteorites and

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<sup>15</sup> The Houston group included researchers at the Johnson Space Center, the Lunar and Planetary Institute, University of Houston, Rice University, and Texas A&M University. The Washington, D.C., group included researchers at NASA Headquarters, Goddard Space Flight Center, Carnegie Institution of Washington, and U.S. Department of Interior (U.S. Geological Survey). See Appendix B for details of our sampling approach.

2 Stardust samples. When questioned, the researchers either (1) speculated that the samples must have been destroyed during research or (2) after searching admitted that the samples had been lost, and we reported the loss to the appropriate NASA curator. Of the 24 missing samples, NASA expected that 11 of the meteorite samples and both Stardust samples would be returned to the Agency at the completion of approved research. Of the 11 meteorite samples, 5 have been reported lost, 5 were reported destroyed during testing, and the Meteorite Curator continues to investigate the status of the remaining sample.<sup>16</sup> During our audit fieldwork, we notified the Stardust Curator about the two missing Stardust samples and he initiated an investigation.<sup>17</sup>

Additionally, we found that 3 researchers possessed 20 samples that, according to Curation Office records, had either been destroyed or were on loan to other researchers. Because research is often collaborative, NASA permits researchers who have obtained prior approval to share samples with other researchers. However, 18 of the 20 samples had been reported lost or destroyed by the original borrower. For example, we found one researcher with nine meteorites that the researcher of record told us had been destroyed during his research. Further, two samples (one lunar and one meteorite) with the same sample identification number were simultaneously held by two researchers. It appears that the researcher of record of the lunar sample split off a piece of the sample and gave it to the other individual. This practice was inconsistent with the Lunar Sample Allocation Guidebook, which required the researcher of record to return the sample to the Curation Office to request splitting. If approved, the Office would have given the subsample a new number before providing it to the second researcher. Because NASA was not aware that these 20 samples existed, their loss or theft could be overlooked.

**NASA Records Included Loans of Samples That No Longer Exist and Loans to Researchers Who Had Died, Retired, or Relocated.** We found that the Curation Office's inventory records contained inaccurate information for hundreds of samples that had been destroyed through research. For example, the Office's records indicated that one researcher should have had in his custody 199 cosmic dust samples loaned to him by NASA; however, the samples were destroyed as a result of approved research. Additionally, the Office's records indicated that another researcher should have had 88 meteorite samples, although these samples had also undergone destructive analysis and, therefore, no longer exist.

Overall, the Curation Office's inventory records contained inaccurate information for 12 of 59 researchers (20 percent) in our sample. Specifically, NASA had loaned these researchers 94 meteorites and cosmic dust samples and, since obtaining the materials, 3 of the researchers had died as long as 9 years ago, 4 had changed locations/employers

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<sup>16</sup> A researcher told us that five of the meteorites that NASA expected to be returned were destroyed during research. When we informed the Meteorite Curator, he said he did not believe the meteorites were destroyed based on information he obtained in a corresponding published research paper. The Meteorite Curator is addressing this situation with the Meteorite Working Group and the Astromaterials Curator.

<sup>17</sup> The Curator's investigation disclosed that the samples were lost in 2006 while the samples were being prepared for study.

as long as 21 years ago, and the remaining 5 had retired as long as 17 years ago. Although NASA was aware of most of these events, the Curation Office had not updated its records to reflect the status of the samples. Of the 94 samples, 7 of the meteorites were expected to be returned to NASA. As of December 2011, NASA had retrieved 4 of the 7 meteorites, provided permission for a researcher to keep 1 sample for further study, and as a result of our audit determined 1 sample is lost and was attempting to locate the remaining sample.

**Researchers Had Not Efficiently Used and Returned to NASA Valuable Lunar and Meteorite Samples.** To determine whether researchers efficiently used and promptly returned loaned astromaterials, we asked 25 of the 59 researchers in our sample when they last performed research using the lunar or meteorite samples in their possession.<sup>18</sup> Three of the researchers did not provide the requested information. The remaining 22 indicated that, on average, they had not used the meteorite samples for at least 5 years and the lunar samples for at least 15 years. Additionally, one researcher had in his possession nine lunar samples borrowed from NASA 35 years earlier on which he had never conducted research. Another researcher had never conducted research on ten meteorite samples he kept for an average of 14 years. Still another researcher retained 36 lunar samples for an average of 16 years after he had completed his research. When we asked these individuals why they kept materials they were not using for research purposes, some said they had requested the samples in anticipation of planned research only to encounter delays such as obtaining funding for their research. Others told us that it never occurred to them to return the samples after they had conducted their research. Still others stated that they held the samples in anticipation of needing them “some day.”

### **Curation Office Had Not Established Adequate Controls over Astromaterials**

The control weaknesses identified during our review occurred because:

- the Curation Office had not established procedures to maintain control over meteorites and cosmic dust and did not require loan agreements for these materials;
- loan agreements pertaining to lunar, Genesis, and Stardust samples did not contain basic elements necessary to protect loaned materials; and
- the Office did not consistently follow inventory procedures or ensure that the procedures were adequate.

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<sup>18</sup> We excluded Genesis and Stardust samples because all loans of these materials were made less than 5 years ago. We also excluded cosmic dust samples because NASA does not require return of these samples. Based on this methodology, we determined that 25 of the 59 researchers were in possession of lunar and/or meteorite samples they had been loaned at least 5 years ago. See Appendix B for our sampling approach.

**Required Procedures for Managing Meteorites and Cosmic Dust Samples Did Not Exist.** Although NASA policy requires the Astromaterials Curator to develop detailed procedures relating to curation of astromaterials, the Curation Office had not established such procedures for meteorites and cosmic dust samples.<sup>19</sup> The Office maintains guidebooks and other internal procedures intended to ensure lunar, Genesis, and Stardust samples are adequately controlled and properly accounted for but has not produced similar materials pertaining to meteorite and cosmic dust samples. In fact, the Office does not even require loan agreements – the only binding contractual document between NASA, the borrower, and the borrower’s employing institution – for these materials. Generally, NASA does not expect researchers to return most meteorites or cosmic dust samples; however, NASA does consider about 25 percent of all loaned meteorites to be sufficiently rare and valuable to require they be returned after the borrower completes his or her research.<sup>20</sup> However, without proper procedures including binding loan agreements NASA cannot properly manage these assets. For example, during our review the Meteorite Curator requested that we interview a researcher holding 13 meteorite samples who had been unresponsive to the Curator’s repeated requests that he return 3 of the samples to NASA.<sup>21</sup>

Most of the weaknesses we observed in NASA’s procedures were associated with loans of meteorites and cosmic dust. Furthermore, the Astromaterials Curator acknowledged that meteorites are at particular risk of theft because, unlike other types of materials, they can be collected on Earth and legally owned by private citizens. Therefore, an offer to sell a stolen meteorite would draw less attention from authorities than an offer to sell Apollo lunar samples or other astromaterials that NASA has collected in space and, as a result, are the legal property of the U.S. Government.

To improve NASA’s controls over the loans of meteorite and cosmic dust samples and reduce the risk that these assets may be lost or stolen, the Curation Office should establish procedures, including requiring that borrowers sign loan agreements prior to receiving the materials.

**Loan Agreements Lack Basic Elements.** As noted above, the Curation Office requires researchers to sign loan agreements to obtain lunar, Genesis, and Stardust samples. However, the agreements the Office was using were not adequate to ensure loaned astromaterial samples were properly safeguarded. As shown in Table 2, depending on the type of astromaterials being loaned, loan agreements did not always include the following basic controls:

- a requirement that researchers independently provide NASA with an annual inventory of all samples in their custody;

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<sup>19</sup> NASA Policy Directive (NPD) 7100.10E, “Curation of Extraterrestrial Materials (Revalidated 01/10/2008).”

<sup>20</sup> Cosmic dust samples are usually destroyed during research.

<sup>21</sup> We verified that the researcher had all 13 samples and arrangements were made for return of the 3 samples to the Curation Office.

- an agreed-upon timeframe for using samples and, when applicable, returning them to the Agency;
- procedures for immediately notifying NASA and returning samples upon a researcher’s death, retirement, or other change in status/place of employment;
- a requirement to obtain NASA’s permission to perform destructive analysis using loaned samples; or
- enforceable sanctions for noncompliance with the agreement.

<b>Table 2. Elements of Loan Agreements by Type of Astromaterials</b>				
<b>Element</b>	<b>Lunar</b>	<b>Genesis</b>	<b>Stardust</b>	<b>Meteorites and Cosmic Dust<sup>a</sup></b>
Samples identified as property of the U.S. Government	Yes	Yes	Yes	N/A
Requirement to report annual inventory	Yes <sup>b</sup>	No	No	N/A
Requirement that samples be stored in a safe or secured storage cabinet	Yes	Yes	Yes	N/A
Designated timeframe for samples to be returned	No	No	No	N/A
Notification procedure for when researcher’s employment status changes	No	No	No	N/A
Explicit permission for destructive analysis on the sample	Yes	No	No	N/A
Sanctions for failure to comply with loan agreement	No	No	No	N/A

<sup>a</sup> The Curation Office does not require researchers to sign loan agreements for meteorites and cosmic dust samples.

<sup>b</sup> Per the lunar loan agreement, researchers are only required to report annual inventories of loaned lunar samples if NASA specifically requests them.

Without these essential elements, NASA has little assurance that the loaned astromaterials will be properly safeguarded and accounted for or that researchers will follow NASA policy. For example, although the Curation Office’s internal procedures state that researchers will complete annual inventories of Genesis and Stardust samples, the loan agreements make no reference to such inventories and therefore the borrowers are not legally obligated to complete them. In addition, in the absence of specific sanctions laid out in the agreement, NASA has little recourse if a researcher chooses not to comply. For example, although the lunar sample loan agreement requires researchers to perform an annual inventory of loaned samples and report the results to NASA, the agreement does not provide a mechanism for enforcement of this requirement. In fact, according to the Lunar Sample Curator, NASA received only about 70 percent of

requested inventories in 2008 (its most recent completed inventory request prior to our audit) and all but 5 responses the previous year.<sup>22</sup> To further illustrate, one researcher did not respond to NASA's repeated requests for an inventory for 9 years. This researcher died prior to May 2010, and the 18 lunar samples that NASA had loaned him are now missing.

The only recourse for non-compliance with the loan agreements currently available to NASA requires the Agency to prove that a borrower willfully lost or damaged the samples. In addition, the Curation Office can refuse requests for additional samples from researchers who have lost or damaged loaned samples. Loan agreements that clearly spell out what is expected of researchers and the consequences of non-compliance would help ensure that loaned samples are used, safeguarded, and returned as intended.

**Inventory Procedures Are Not Consistently Followed and Need Improvement.** The Curation Office did not consistently follow its inventory procedures for astromaterial samples. The Office's internal policies state that the Office will annually request researchers to verify that inventories of Stardust, lunar, and Genesis samples in their custody match NASA's records.<sup>23</sup> However, we found that the Office had never requested an inventory of Stardust samples and, prior to our audit, had not requested an inventory since 2008 of lunar samples maintained outside Johnson property.<sup>24</sup> Additionally, the Curation Office did not request an inventory of Genesis samples in 2009. Moreover, the Office's inventory practices depend on (1) the type of sample in question and (2) whether borrowers store samples at Johnson.<sup>25</sup>

Moreover, the Curation Office's inventory procedures are weak and do not ensure that all loaned samples are accounted for. Specifically, the Office provides researchers a list of the astromaterial samples NASA records indicate have been loaned to them and requests that the borrower review the list, annotate any discrepancies, and sign and date the list verifying the samples that are in their custody.<sup>26</sup> This inventory method allows the possibility that borrowers can simply sign the form without actually verifying that their inventory matches the Office's records. Since the Curation Office does not have the resources to physically verify samples on loan, we believe an example of a more reliable

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<sup>22</sup> The Lunar Sample Curator started the 2011 inventory verification in February 2011. As of the date of this report, it was not complete.

<sup>23</sup> The inventory verifications are called for in the Curation Office's Lunar Sample Allocation Guidebook, June 2007; Genesis Research Sample Investigator's Guidebook, May 2006; and Stardust Sample Investigator's Guidebook, August 2006.

<sup>24</sup> The Stardust Curator stated that since loans of Stardust samples began in 2006 he had never requested a complete inventory of researchers with loaned materials. However, in January 2011 the Curator began performing random spot checks and verified the inventory of the researcher who possessed the most loaned Stardust samples. The Curator told us that he is considering performing more inventory checks in the future.

<sup>25</sup> Approximately 15 percent of all astromaterial samples on loan are located at Johnson.

<sup>26</sup> Sample Control and Data Procedure 43 states that for researchers located at Johnson with lunar samples, the Curator provides the inventory listing to Johnson Security Office. Security then performs a physical verification of the accuracy of the listing.



method would entail requesting each researcher to provide the Office with a list of the samples in the researcher's custody so that NASA officials can reconcile reported inventories with Agency records and take action when the two lists do not match.<sup>27</sup>

## **NASA Risks Losing Its Unique and Limited Resources**

For over 40 years, NASA has loaned astromaterials to researchers. The materials, which are highly sought after and vulnerable to theft, remain the property of the U.S. Government, and NASA retains the right to recall loaned samples at any time. However, because NASA does not have adequate controls over its loans, the Curation Office cannot be assured of the security, location, or even the continued existence of loaned samples. Consequently, NASA is at risk of losing samples distributed to researchers.

It is imperative that NASA ensure that its curation procedures evolve to meet the challenges of a growing and diverse collection of extraterrestrial samples. For example, in December 2011 the Japan Aerospace Exploration Agency plans to transfer to NASA 10 percent of the particles it collected from the Asteroid Itokawa. Also, in May 2011 NASA announced plans to launch its own spacecraft that will one day return samples from an asteroid, thereby enabling research to better explain our solar system's formation and how life began.<sup>28</sup> Until NASA improves controls of astromaterials loaned to researchers, the Agency risks failing to fulfill its mission to preserve samples for research and future study.

## **Recommendations, Management's Response, and Evaluation of Management's Response**

To strengthen internal controls for the efficient use and proper protection of NASA's irreplaceable astromaterials collection, the Astromaterials Curator, in conjunction with the Johnson Space Center Director, should:

1. Establish procedures for controlling loaned meteorite and cosmic dust samples to include guidebooks, internal procedures, and loan agreements.

**Management's Response.** Concur. The Acting Associate Administrator for the Science Mission Directorate stated that the Curation Office will develop guidebooks and loan agreements for Antarctic meteorites and cosmic dust. The meteorite guidebook and loan agreement will be developed in consultation with the Meteorite

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<sup>27</sup> Curation Office officials said they has not performed a complete physical inventory of their collection of lunar samples loaned to researchers since the 1980s due to funding constraints.

<sup>28</sup> The mission, Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-Rex), will launch in 2016, use a robotic arm to collect samples, and be the first U.S. mission to carry samples from an asteroid back to Earth.

Working Group while CAPTEM will be consulted on the cosmic dust guidebook and loan agreement. In addition, the Office of General Counsel will review the loan agreements prior to their finalization. Existing borrowers will transition to the new loan agreements at the time of their next annual inventory. Finally, the Curation Office will review current internal procedures and update or develop new procedures for loans of meteorite and cosmic dust samples.

**Estimated Completion Date:** October 1, 2012

**Evaluation of Management's Response.** Management's proposed actions are responsive; therefore, the recommendation is resolved and will be closed upon completion and verification of the corrective actions.

2. Require that loan agreements include essential elements necessary to ensure that NASA's materials are safeguarded, used, and, when applicable, returned to NASA. At a minimum, the loan agreements should contain:
  - a requirement that researchers provide an annual inventory, including the status of research completed and any samples consumed;
  - the maximum time period a researcher may retain any sample before returning the sample or requesting an extension;
  - procedures for immediate notification of changes in researcher status (i.e., employment changes, relocation, etc.), and changes in the custody of a loaned sample;
  - a requirement for explicit permission to perform destructive analysis using a loaned sample; and
  - a detailed description of actions NASA will take if researchers fail to comply with any element of the loan agreement.

**Management's Response.** Concur. The Acting Associate Administrator stated that existing loan agreements will be revised and that loan agreements for meteorites and cosmic dust samples will be developed. The loan agreements will require sample recipients to perform annual inventories, provide immediate notification of changes in researcher status, request explicit permission for destructive analysis, identify specific actions NASA will take if researchers fail to comply, and require that samples be returned or loans renewed by the expiration of the loan period. In addition, NASA will draft policies for the duration of all types of loans.

**Estimated Completion Date:** March 2012

**Evaluation of Management's Response.** Management's proposed actions are responsive; therefore, the recommendation is resolved and will be closed upon completion and verification of the corrective actions.

3. Establish procedures for tracking loaned astromaterial sample retention periods and ensure that researchers efficiently use and, when required, promptly return loaned samples.

**Management's Response.** Concur. The Acting Associate Administrator stated that the date of loan, expiration date, and any relevant renewal periods specific to each sample will be tracked in the curatorial databases along with critical loan information such as permission for destructive analysis. The procedure for tracking and requesting return of samples will be tied to annual inventories. In addition, the Curation Office will develop procedures for following up on cases of noncompliance and document those procedures in the guidebooks for each type of sample. Moreover, when a loan period expires, the borrower will be required to request renewal and provide justification for the request. Finally, the Office, in conjunction with CAPTEM and the Working Group, will evaluate whether it is in NASA's best interest to approve a borrower's loan application renewal request or deny it and request return of a sample.

**Estimated Completion Date:** October 1, 2012

**Evaluation of Management's Response.** Management's proposed actions are responsive; therefore, the recommendation is resolved and will be closed upon completion and verification of the corrective actions.

4. Evaluate the Curation Office's practices for ensuring that established inventory procedures have been effectively implemented, are consistently followed, and are applicable to all researchers.

**Management's Response.** Concur. The Acting Associate Administrator stated that annual inventories will be required of all scientists who receive astromaterial loans and that this requirement will be communicated in the loan agreements.

**Estimated Completion Date:** March 2012

**Evaluation of Management's Response.** Management's proposed actions are responsive; therefore, the recommendation is resolved and will be closed upon completion and verification of the corrective actions.

5. Strengthen the current annual inventory verification procedure to improve NASA's assurance that all applicable astromaterial samples are accounted for. At a minimum, NASA should consider requiring researchers to maintain a record of samples in their custody and supply NASA the inventory for reconciliation with the Curation Office's records. In addition, NASA's internal procedures should provide detailed steps to correct any deficiencies noted and NASA should adjust and update its inventory records accordingly, including removing from its records any samples that have been destroyed or returned.

**Management's Response.** Concur. The Acting Associate Administrator agreed that researchers must maintain a record of the samples in their custody and stated that the revised guidebooks and loan agreements will remind researchers of this requirement. In addition, the Curation Office will review current procedures and update or develop new procedures as needed. As part of this process, NASA will evaluate the procedure suggested in the recommendation along with a variety of alternate procedures.

**Estimated Completion Date:** October 1, 2012

**Evaluation of Management's Response.** Management's proposed actions are responsive; therefore, the recommendation is resolved and will be closed upon completion and verification of the corrective actions.

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## **NASA'S CONTROLS OVER EDUCATOR AND PUBLIC DISPLAY LOANS NEED STRENGTHENING**

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In May 2009, NASA's Science Mission Directorate and Office of Education implemented new procedures governing loans of lunar and meteorite education disks to U.S. educators. Pursuant to these procedures, most existing education disks were collected from the various NASA Centers and centralized at the Johnson Curation Office for distribution. In addition, in February 2010 the NASA Administrator created executive-level offices of Education and Communications responsible for implementing NASA's Education Program and managing the exhibits that inform the public about the Agency's aeronautics and space programs, respectively. Although these changes have improved NASA's controls over loans, NASA needs to take additional steps, including establishing an effective tracking system for long-term loans of lunar exhibits and requiring annual inventories of loaned materials. Moreover, NASA has not updated its policies to reflect these organizational changes.

**Management of Long-term Loans of Lunar Exhibits Is Inadequate.** NASA's management of long-term loans of lunar exhibits is inadequate and needs improvement. Specifically, the Johnson Exhibits Manager, who at the time of our fieldwork was responsible for 94 long-term loans of lunar exhibits worldwide, does not have an adequate system to effectively track the renewal dates of the loans. Moreover, NASA's policies do not require, and the Exhibits Manager does not conduct, an annual inventory of these loaned exhibits.

As previously discussed, the loan agreement for the Mount Cuba loan expired in June 2008. In 2010, the Exhibits Manager was reviewing display loan files when he realized the Mount Cuba loan was almost 2 years past due. The Exhibits Manager contacted Mount Cuba to renew the loan, at which time he learned that the Mount Cuba employee responsible for the display had died the previous year. Despite what Mount Cuba officials characterized as an exhaustive search, the Mount Cuba display was still missing as of December 2011. As a result of this incident, the Exhibits Manager said he realized he needed a better system to track expiration dates on the long-term loans for which he is responsible.

When loans are due to expire, the Exhibits Manager should promptly contact the institution and renew the loan or recall the exhibit. The Exhibits Manager acknowledged that he did not contact borrowers in a timely manner and that a tracking system was needed. He also told us that there could be other loan agreements that have not been renewed on a timely basis. Reliance on the Exhibits Manager's review of files on an ad hoc basis does not ensure long-term loans are timely renewed. The lack of a tracking system – particularly when coupled with a lack of annual inventories – does not promote proper management of NASA's long-term loans of lunar exhibits or succession planning in the event the current Exhibits Manager retires or changes jobs. Specifically, his

successor may be unaware of the status of NASA's loans since relevant information is not contained in a manner that comprehensively tracks the loans.

If the Exhibits Manager had a tracking system and had annually contacted those institutions with exhibits on long-term loan to conduct an inventory, NASA might have earlier discovered that the Mount Cuba exhibit was missing and had a better chance of recovering it.

**Agency-wide Policies Had Not Been Updated to Reflect New Procedures, Responsibilities, and Organizational Changes.** In accordance with NASA Procedural Requirements (NPR) 1400.1E, "NASA Directives and Charters Procedural Requirements," July 15, 2011, NASA directives are effective for 5 years. When a directive is about to expire, the Agency can choose to revalidate it for an additional 5 years if "the directive is current, necessary, and requires no changes" or if only minor administrative changes are needed.

In March 2010, NASA revalidated its policies governing the Exhibits Program.<sup>29</sup> However, NASA did not ensure that these and related policies reflected the procedural and organizational changes the Agency implemented between 2009 and 2010 (see Table 3). For example, the policies do not explain that the Johnson Exhibits Manager is responsible for managing all exhibits that contain a lunar sample. Similarly, NASA's policy on the use of lunar samples for public and educational purposes (NPD 1387.2F) does not reflect that as of May 2009 the Curation Office is responsible for managing the lunar and meteorite education disk program. During the audit, NASA acknowledged that this policy was out of date and began the process of updating the policy. During the audit, NASA extended the NPD's expiration date from June 28, 2011 until December 29, 2011. We provided suggested changes to ensure that the update includes accurate and necessary information; however, as of early December 2011 NASA had not finalized the revised policy.

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<sup>29</sup> NPD 1387.1G, "NASA Exhibits Program" (effective, November 15, 1999; revalidated March 17, 2010; expiration, November 15, 2015); and NPR 1387.1, "NASA Exhibits Program w/Change 2" (effective, January 9, 1999; revalidated, March 17, 2010; expiration, March 17, 2015).

<b>Table 3. Revalidation Dates of Policies Governing NASA’s Exhibits Program and Use of Lunar Samples for Public and Educational Purposes.</b>			
<b>Policy</b>	<b>Effective Date</b>	<b>Date Revalidated</b>	<b>Expiration Date</b>
NPD 1387.1G, “NASA Exhibits Program”	November 15, 1999	March 17, 2010	November 15, 2015
NPR 1387.1, “NASA Exhibits Program w/Change 2”	January 9, 1999	March 17, 2010	March 17, 2015
NPD 1387.2F, “Use, Control, and Loan of Lunar Samples for Public and Educational Purposes”	February 29, 2000	February 28, 2005	December 29, 2011 <sup>a</sup>
NPD 7100.10E, “Curation of Extraterrestrial Materials”	February 11, 2003	January 10, 2008	February 11, 2013

<sup>a</sup>During the audit, NASA extended the expiration date from June 28, 2011 until December 29, 2011.

**Conclusion.** While NASA has taken the first steps toward strengthening controls over loans of lunar and meteorite samples for education and public display, the Agency needs to maintain an accurate inventory of exhibits on long-term loan, ensure all loan agreements are current, and update its policies associated with these loans. With lunar and meteorite samples loaned to classrooms around the country and exhibits disbursed across 25 states, the District of Columbia, and 13 foreign countries, NASA must ensure that its limited number of astromaterials available for educational use and public display are properly protected and accounted for.

## **Recommendations, Management’s Response, and Evaluation of Management’s Response**

To strengthen NASA’s controls over astromaterials loaned for education and public display purpose, we recommended the following:

6. The Johnson Center Director should establish a comprehensive tracking system and annual inventory requirements for long-term loans of lunar exhibits.

**Management’s Response.** Concur. The Acting Associate Administrator for the Science Mission Directorate stated that during the audit the Johnson Exhibits Manager developed a prototype system to track loan and renewal dates for all institutions. NASA will evaluate this system and make adjustments as necessary. The Exhibits Manager will use the Long-Term Lunar Sample Display Annual Survey to determine how borrowers are using loaned displays.

**Estimated Completion Date:** September 30, 2012

**Evaluation of Management's Response.** Management's proposed actions are responsive; therefore, the recommendation is resolved and will be closed upon completion and verification of the corrective actions.

7. The Johnson Exhibits Manager should review all agreements for long-term loans of lunar exhibits, identify any expired agreements, and either renew the agreements or recall the exhibits, as necessary.

**Management's Response.** Concur. The Acting Associate Administrator stated that all agreements for long-term loans of lunar exhibits will be reviewed. Any expired agreements will be reevaluated and agreements either will be renewed or the sample(s) recalled as appropriate.

**Estimated Completion Date:** September 30, 2012

**Evaluation of Management's Response.** Management's proposed actions are responsive; therefore, the recommendation is resolved and will be closed upon completion and verification of the corrective actions.

8. The Associate Administrators for Education and Communications, and the Acting Associate Administrator for the Science Mission Directorate should review and update Agency policies governing loans of astromaterial samples for education and public display purposes to reflect current processes and organizational responsibilities.

**Management's Response.** Concur. The Acting Associate Administrator stated that NASA is updating NPD 1387.2G to reflect the current process and organizational responsibilities for educational and public display loans. NASA will also review NPD 1387.1G and NPR 1387.1 and update them as necessary. The Acting Associate Administrator also stated that while the Associate Administrator for Education does not have a role in governing such loans, Education remains a stakeholder in the process and will be asked to review and concur with the polices before they are finalized.

**Estimated Completion Date:** Spring 2012

**Evaluation of Management's Response.** Management's proposed actions are responsive; therefore, the recommendation is resolved and will be closed upon completion and verification of the corrective actions.



## Scope and Methodology

We performed this audit from March 2011 through November 2011 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

The scope of our audit was controls over astromaterials loaned for research, education, and public display purposes within the United States. Our review included lunar, meteorite, Genesis, Stardust, and cosmic dust samples loaned for research purposes; lunar and meteorite samples loaned for education purposes; and lunar samples loaned for public display.<sup>30</sup> We reviewed each type of loan separately because the Agency uses different processes and controls for each type. We focused primarily on loans for research purposes because they account for most loans made by the Curation Office and have a higher risk of sample loss than loans for education or public display purposes. See Appendix B for the sampling approach we used to review astromaterials loaned to researchers.

**Researcher Loans.** NASA has 10,293 lunar, 11,955 meteorite, 418 Genesis, 1,266 Stardust, and 2,670 cosmic dust samples on loan to 595 researchers worldwide. We reviewed 4,991 astromaterials on loan to 52 researchers in the Houston, Texas, area and 7 researchers in the Washington, D.C., area as of March 30, 2011. The Houston group included researchers at the Johnson Space Center, the Lunar and Planetary Institute, University of Houston, Rice University, and Texas A&M University. The Washington, D.C., group included researchers at NASA Headquarters, Goddard Space Flight Center, Carnegie Institution of Washington, and U.S. Department of Interior (U.S. Geological Survey).

To accomplish the review, we identified and reviewed policies, processes, and controls pertaining to the loans. To understand the Agency's basic policy for the curation of astromaterials, we interviewed NASA's Astromaterials Curator and reviewed NPD 7100.10E, "Curation of Extraterrestrial Materials." To identify and understand the processes and controls, we interviewed the curators and reviewed Curation Office guidebooks. The interviewed curators included the Lunar Sample Curator, Meteorite Curator, Genesis Sample Curator, and Stardust/Cosmic Dust Curator. The guidebooks

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<sup>30</sup> The Curation Office also loans space exposed hardware samples to researchers. We did not review these loans because the loans are an informal activity and average about one loan per year.

included the Lunar Sample Allocation Guidebook, Stardust Sample Investigator's Guidebook, and Genesis Research Sample Investigator's Guidebook. To verify and test the processes and controls, we interviewed the selected researchers; conducted physical inventories of astromaterials in their possession; and reviewed the Office's files on each researcher, including loan agreements, security plans, sample assignment acknowledgements, and the researcher's verifications of inventories. We also reviewed researchers' use of astromaterials by asking researchers to provide dates they last used judgmentally selected lunar and meteorite samples.<sup>31</sup> We used the dates the researcher provided to calculate the average length of time the researchers held the samples without using them for research.

**Educator Loans.** NASA has a total of 455 lunar and meteorite education disks available for loan for education purposes. To verify and test controls over the Education Disk Program, we reviewed and accounted for 70 percent (320 out of 455) of the education disks managed by Johnson's Educational Sample Center. To understand the relevant procedures, requirements, and controls we interviewed the Education Curator and reviewed NPD 1387.2F, "Use, Control, and Loan of Lunar Samples for Public and Educational Purposes." We conducted a physical inventory and observed 78 percent (248 out of 320) of the education disks available. We did not physically observe the remaining 72 disks because they were on loan to various education facilities around the nation. To account for the 72 education disks that were on loan, we reviewed related records, including lunar/meteorite sample disk certification forms, loan agreements, and security plans.

**Public Display Loans.** NASA has 94 lunar sample displays on exhibit worldwide. We reviewed two displays on loan to exhibitors in Houston, Texas, as of March 30, 2011: the Houston Museum of Natural Science and Space Center Houston. We limited our review to the loans in Houston due to limited audit resources and because astromaterials loaned for public display have a relatively low risk of loss. To accomplish the review, we identified and reviewed requirements, procedures, and controls pertaining to NASA's Exhibits Program. We interviewed the Johnson Exhibit Manager and reviewed NPD 1387.1G, "NASA Exhibit Program," and NPR 1387.1, "NASA Exhibits Program w/Change 2." To verify and test controls, we interviewed officials with the Houston Museum of Natural Science and Space Center Houston, and conducted physical inventories of astromaterials in the exhibitors' possession. We also reviewed related records including the exhibitors' Lunar Sample Display Agreements for Long-Term Display, security plans, and sample assignment acknowledgements.

**Use of Computer-Processed Data.** We used computer-processed data provided by the Astromaterials Acquisition and Curation Office in order to select our samples to perform this audit. Specifically, we used computer-generated lists of astromaterials loaned to researchers in the Houston, Texas, and Washington, D.C., areas. However, because we identified several internal control weaknesses with NASA's inventory records, as

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<sup>31</sup> See Appendix B for the sampling approach we used to select the samples for the review.

described in this report, we could not rely on the computer-processed data. As a result, we compared the appropriate source documents to what we observed in the inventory to verify whether the astromaterials at the various locations and records were accurate and complete.

### **Review of Internal Controls**

We examined NASA's internal controls over loans of astromaterial samples, to include the use and control of the samples on loan. We determined that the internal controls over astromaterials loaned to researchers need improvement to minimize risk of loss. Additionally, practices and policies over astromaterials loaned for education and public display need strengthening. See the "Results" section of the report for details.

### **Prior Coverage**

During the last 5 years, the NASA Office of Inspector General (OIG) and the Government Accountability Office (GAO) have not issued any reports of relevance to the subject of this report. However, the NASA OIG issued Report Number A-JS-86-04, "Final Report on the Management and Control of Lunar Materials Program," dated October 22, 1987. The report examined, but was not limited to, reviews of lunar samples loaned to domestic researchers and lunar samples under the control of the Public Affairs Office. The review of loans to domestic researchers disclosed problems concerning the performance of annual inventories and proper execution of lunar sample loan agreements. The review of samples under control of the Public Affairs Office disclosed that the Office had not established adequate procedures and controls for safeguarding the samples for public display and educational activities.

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## SAMPLING APPROACH FOR REVIEW OF ASTROMATERIALS LOANED TO RESEARCHERS

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As of March 31, 2011, NASA had loaned 21,580 astromaterial samples to 377 researchers located throughout the United States. To best utilize our audit resources, we limited our review to astromaterials loaned to researchers located in the Houston, Texas, and the Washington, D.C., areas. We reviewed all astromaterials loaned to researchers in the Houston area and lunar samples loaned to researchers in the Washington, D.C., area.<sup>32</sup> As shown in Table 4, our review covered 23 percent of the astromaterial samples loaned to 16 percent of the researchers in the United States.

<b>Table 4. Number of Astromaterial Samples on Loan and Number of Samples Reviewed</b>							
Location	Number of Researchers	Number of Samples by Type					Total
		Lunar	Meteorite	Genesis	Stardust	Cosmic Dust	
United States	377	8,827	9,426	277	929	2,121	21,580
Houston, Texas	52	2,039	1,281	12	97	826	4,255
Washington, D.C.	<u>7</u>	<u>657</u>	<u>79</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>736</u>
<b>Total</b>	<b>59</b>	<b>2,696</b>	<b>1,360</b>	<b>12</b>	<b>97</b>	<b>826</b>	<b>4,991</b>
Percentage Reviewed	16%	31%	14%	4%	10%	39%	23%

To determine whether researchers kept samples for extended periods either before or after conducting research, we asked researchers to provide the dates they last used specific lunar and meteorite samples we judgmentally selected.<sup>33</sup> Because researchers at Johnson generally had more samples than researchers located elsewhere, we used two approaches to select samples for review

- 1. Researchers Located at Johnson.** We used the number of samples held by the researchers as the basis for selecting samples for review. If a researcher had 50 or fewer samples of a particular astromaterial, we asked for the last used date for all samples. If a research had more than 50 samples, we requested last use dates for 10 percent of randomly selected samples. For example, if a researcher had 45 lunar samples and 90 meteorite samples, we asked for the last use dates for all 45 of the lunar samples and 9 (10 percent of 90) of the meteorite samples.

<sup>32</sup> At the request of the Meteorite Curator, we also interviewed a researcher with meteorite samples because the researcher had been nonresponsive to NASA's repeated attempts to contact him.

<sup>33</sup> We excluded Genesis and Stardust samples because all of the allocations were made less than 5 years ago. We also excluded cosmic dust because they are not returned to NASA at the end of the loan period.

2. **Researchers Located Elsewhere.** We used the number of years that researchers had samples in their custody as the basis for selecting samples for review. Because NASA had not established reasonable timeframes for sample use and return, we judgmentally considered 5 years a reasonable period for researchers to use and return samples. Consequently, we asked researchers to provide the date they last used any lunar or meteorite sample held for more than 5 years.

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## MANAGEMENT COMMENTS

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National Aeronautics and  
Space Administration  
**Headquarters**  
Washington, DC 20546-0001



DEC - 7 2011

Reply to Attn of: SMD/Strategic Integration and Management Division

**TO:** Assistant Inspector General for Auditing  
**FROM:** Associate Administrator for Science Mission Directorate (Acting)  
**SUBJECT:** Response to OIG Draft Report, "NASA's Management of Moon Rocks and Other Astromaterials Loaned for Research, Education, and Public Display" (Assignment No. A-11-015-00)

The Science Mission Directorate (SMD) appreciates the opportunity to review your draft audit report entitled "NASA's Management of Moon Rocks and Other Astromaterials Loaned for Research, Education, and Public Display."

In the draft report, the Office of the Inspector General (OIG) outlines several findings and communicates eight recommendations. The first five recommendations are directed to the Astromaterials Curator, in conjunction with the Johnson Space Center Director, and are designed to strengthen internal controls for the efficient use and proper protection of NASA's irreplaceable astromaterials collection. The final three recommendations are directed to multiple offices and are designed to strengthen NASA's controls over astromaterials loaned for education and public display purpose. NASA's response to the recommendations, including planned corrective actions, follows:

**Recommendation 1:** Establish procedures for controlling loaned meteorite and cosmic dust samples to include guidebooks, internal procedures, and loan agreements.

**Management's Response:** Concur. The following actions will be taken in response to this recommendation:

- a. An investigator's guidebook for Antarctic meteorites will be developed. A draft document will be completed and submitted for approval by July 1, 2012. This document will be produced by the Curation Office, in consultation with the Meteorite Working Group (MWG). The target date for approval by the Director, Astromaterials Research and Exploration Science at Johnson Space Center (JSC) will be Oct 1, 2012. Due to the nature of the three-party agreement between NASA, NSF, and the Smithsonian concerning Antarctic meteorites, approval must also be sought from the interagency

Meteorite Steering Group (MSG). SMD/NASA Headquarters appoints one of the three members of MSG (currently, Dr. Jeffrey N. Grossman).

- b. An investigator's guidebook for cosmic dust will be drafted. The draft document will be completed by July 1, 2012. This document will be produced by the Curation Office, in consultation with the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM). The target date for final approval by the Director, Astromaterials Research and Exploration Science will be Oct. 1, 2012.
- c. Loan agreements for Antarctic meteorites and cosmic dust will be developed, as specified in recommendation 2 below. Draft language will be developed by the JSC Curation Office by Feb. 15, 2012 and submitted for review by MWG (meteorites) and CAPTEM (dust) at their respective meetings in March 2012. Immediately upon acceptance by MWG/CAPTEM and with concurrence from the NASA Office of General Counsel, these loan agreements will become part of all new sample allocations. In addition, existing holders of loans of meteorite and cosmic dust samples will be required to accept the new loan agreements at the time of their next annual inventory, or upon requesting extension of an existing loan.
- d. Current internal curation procedures will be reviewed and either updated or new procedures developed as necessary to clearly identify applicability to the meteorite and cosmic dust collections. The review to identify updates and gaps will be completed by May 4, 2012, with documents developed or updated as necessary and approved by Oct. 1, 2012.

**Recommendation 2:** Require that loan agreements include essential elements necessary to ensure that NASA's materials are safeguarded, used, and, when applicable, returned to NASA. At a minimum, the loan agreements should contain:

- a requirement that researchers provide an annual inventory, including the status of research completed and any samples consumed.
- the maximum time period a researcher may retain any sample before returning the sample or requesting an extension.
- procedures for immediate notification of changes in researcher status (i.e., employment changes, relocation, etc.), and changes in the custody of a loaned sample.
- a requirement for explicit permission to perform destructive analysis using a loaned sample.
- a detailed description of actions NASA will take if researchers fail to comply with any element of the loan agreement.

**Management's Response:** Concur. The review process and timeframe for actions relevant to Antarctic meteorites and cosmic dust loan agreements are outlined under recommendation 1, response (c). The review process and timeframe for revisions to

lunar, Stardust, and Genesis agreements will be identical to that specified above for cosmic dust agreements.

- a. Existing templates for loan agreements for lunar, Stardust, and Genesis samples will be revised, and new templates for agreements for Antarctic meteorites and cosmic dust samples will be drafted, to require performance of annual inventories, immediate notification of changes in researcher status, explicit permission for destructive analyses (note: the lunar sample agreements already specify the requirement to obtain permission for destructive analysis). All agreements will also be modified, as necessary, to specify actions NASA will take if researchers fail to comply with any element of the loan agreement.
- b. Policies for the duration of all types of loans will be drafted. Existing templates for loan agreements for lunar, Stardust, and Genesis samples will be revised, and new templates for agreements for Antarctic meteorites and cosmic dust samples will be drafted, requiring that samples be returned or loans renewed by the expiration of the loan period. Both the new policies and the revised templates for loan agreements will be reviewed by CAPTEM/MWG.

**Recommendation 3:** Establish procedures for tracking loaned astromaterial sample retention periods and ensure that researchers efficiently use and, when required, promptly return loaned samples.

**Management's Response:** Concur. Loan periods specific to each specimen (date of loan, expiration date, and any relevant renewal periods) will be tracked in curatorial databases, along with other critical loan information (including whether permission has been granted for destructive analysis). Any programming changes needed to implement this will be completed by Oct. 1, 2012. The procedure for tracking and requesting return of loaned samples will be tied to the performance of annual inventories (see below). Procedures for following up in cases of noncompliance will be developed by the Curation Office and documented in revisions to the investigator guidebooks for each collection. Drafts will be completed and submitted for approval by July 1, 2012.

NASA already has procedures in place to assess whether researchers efficiently use samples. The sample-allocation procedure currently involves a peer review process that evaluates whether a scientist has reasonable plans to conduct their research. When a loan period expires, the scientist will have to request a renewal with a justification. At that point, the Curation Office – in consultation with the CAPTEM/MWG as appropriate – will evaluate whether it is in NASA's best interest to approve the renewal application or to deny it and request return of the sample.

**Recommendation 4:** Evaluate the Curation Office's practices for ensuring that established inventory procedures have been effectively implemented, are consistently followed, and are applicable to all researchers.



**Management's Response:** Concur. As stated in recommendation 2, response (a), NASA concurs that annual inventories will be required for all scientists who receive astromaterials loans. This policy will be communicated to scientists in their loan agreements.

**Recommendation 5:** Strengthen the current annual inventory verification procedure to improve NASA's assurance that all applicable astromaterial samples are accounted for. At a minimum, NASA should consider requiring researchers to maintain a record of samples in their custody and supply NASA the inventory for reconciliation with the Curation Office's records. In addition, NASA's internal procedures should provide detailed steps to correct any deficiencies noted, and NASA should adjust and update its inventory records accordingly, including removing from its records any samples that have been destroyed or returned.

**Management's Response:** Concur. NASA concurs that researchers must maintain a record of samples in their custody. In revising the investigator guidebooks, as described in NASA's response to recommendation 1, the Curation Office will assure that appropriate language is included. In addition, language will be added to new loan agreements reminding researchers of this requirement.

NASA believes it would be in the Agency's best interest for the Curation Office to develop an inventory process that makes efficient use of staff and resources and does not place an undue burden on the scientific community. To this end, current internal curation procedures documenting the conduct of sample inventories will be reviewed and either updated or new procedures developed as necessary to clearly identify applicability to the meteorite and cosmic dust collections. In doing so, NASA will evaluate the procedure suggested in recommendation 5, in which researchers supply NASA with their inventory for reconciliation with the curator's records, along with a variety of alternate procedures. The review to identify updates and gaps will be completed by May 4, 2012, with documents developed or updated as necessary and approved by Oct. 1, 2012.

**Recommendation 6:** The JSC Director establish a comprehensive tracking system and annual inventory requirements for long-term loans of lunar exhibits.

**Management's Response:** Concur. The JSC Exhibits Manager has developed a prototype system that enables the tracking of loan and renewal dates for all institutions that have long-term loans. This prototype was developed during the course of the audit in response to findings from the Office of the Inspector General. Evaluation and improvement recommendations will be completed by June 30, 2012. The full system will be completed by Sept. 30, 2012. As part of this process, the Exhibits Manager will consistently use the Long-Term Lunar Sample Display Annual Survey to get information on how the displays are being used.

**Recommendation 7:** The JSC Exhibits Manager review all agreements for long-term loans of lunar exhibits, identify any expired agreements, and either renew the agreements

or recall the exhibits, as necessary.

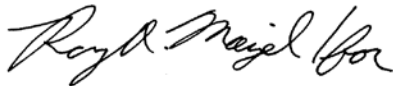
**Management's Response:** Concur. All agreements for long-term loans of lunar exhibits will be reviewed by the JSC Exhibits Manager by Sept. 30, 2012. Any expired agreements will be evaluated, and either the agreement will be renewed or the sample(s) will be recalled.

**Recommendation 8:** The Associate Administrators (AA) for Education, Communications, and the Science Mission Directorate review and update Agency policies governing loans of astromaterial samples for education and public display purposes to reflect current processes and organizational responsibilities.

**Management's Response:** Concur. NASA, through the Office of Communications, is in the process of updating NPD 1387.2G – Use, Control, and Loan of Lunar Samples for Public and Educational Purposes, to reflect the current processes and organizational responsibilities. The final version of the NPD is expected to be released no later than spring 2012. NASA will also review NPD 1387.1G and NPR 1387.1 and revise them if necessary.

Because the SMD's budget supports the educator loans through the Curation Office at JSC, the AA for Education does not have a role in governing such loans and the NPD is being updated accordingly. The AA for Education, however, remains a stakeholder in the process, and the Education AA's concurrence will be necessary on the revised NPD.

Thank you for the opportunity to review and comment on the subject draft audit report. If you have further questions or require additional information on the NASA response to the draft report, please contact Ellen Cohen at 202-358-0812.



Charles Gay

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DECEMBER 8, 2011

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