RESTORATION OF APOLLO MAGNETIC FIELD DATA: A PROGRESS REPORT.
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Introduction: The Apollo missions at the close of the 1960s and beginning of the 1970s generated a unique collection of lunar magnetic field measurements. The data set has been the only one to date that contains simultaneous magnetic field observations at the lunar surface as well as in the near-Moon space, providing useful reference for scientific studies and future lunar exploration plans in today's environment.

The Apollo magnetic field data were examined in earnest in the 1970's, but since then they have not been widely used. The major obstacle to study these data at the present time is that the digital data are stored in obsolete forms which make them inaccessible to most users.

In 2008 we began an effort to restore this valuable data set under the support by NASA's Lunar Advanced Science and Exploration Research (LASER) Program. In this paper we outline the progress of data restoration and our plan for data archiving.

Apollo Magnetic Field Experiments: The magnetic field experiments conducted by the Apollo missions started with, as a part of the Apollo Lunar Surface Experiment Packages (ALSEPs), a Lunar Surface Magnetometer (LSM) installed by Apollo 12 astronauts on November 19, 1969, marking the first ever magnetic field measurements on the surface of the Moon. Later, Apollo 14 astronauts used the Lunar Portable Magnetometer (LPM) to measure the magnetic vector field at various positions near the landing site. Apollo 15 added a biaxial magnetometer aboard the subsatellite orbiting the Moon, making joint observations with an LSM on the lunar surface. The Apollo 16 had all three magnetic field experiments: LSM, LPM, and a subsatellite biaxial magnetometer (SBM). Figure 1 summarizes the available data sets resulting from these experiments.

The LSM measured the magnetic field on the lunar surface and determined from these measurements some of the deep-interior electrical properties of the Moon, such as magnetic permeability, electrical conductivity, and temperature. The SBM experiments extended the measurements of the lunar magnetic field (the permanent as well as the induced components) and were used to study the interaction of the Moon with the field and charged particles in the near-Moon space. These two data sets have been shown valuable for studying, for example, (1) internal structure of the Moon, (2) crustal magnetic fields and their origins, (3) heliophysics science, and (4) space weather for human exploration.

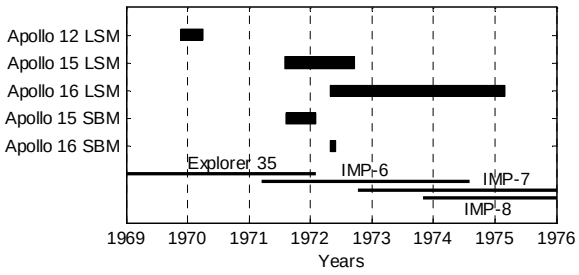

Figure 1. Coverage of magnetic field observations from various Apollo missions and other concurrent NASA satellites.

Data Restoration: The deep archive of Apollo magnetic field data consists of 44 magnetic tapes residing at the National Space Science Data Center (NSSDC). We have retrieved from NSSDC all the digital data with the highest temporal resolution, including the 0.3-sec LSM data and the 24-sec SBM data that exceed 3 Gigabytes in volume.

The data descriptions written by the original instrument teams are vital to properly decoding the source data. Also essential is the knowledge about the computer environment during the Apollo era and the history of data archiving since then. Both LSM and SBM data were originally written on computers with 6-bit bytes (that is compatible with the 36-bit word format). At a later time each 6-bit byte was padded with two extra bits of zero so that the data could reside in an 8-bit byte frame. Another source of complications comes from the fact that the data format was machine dependent in the early years. LSM data (mostly written by IBM 7090/7094) has a different definition of alphanumeric characters, integers, and floating point numbers than that for SBM data (written by Unisys UNIVAC), and both definitions are obsolete in today's computing environment.

We have devised a set of computer routines in Matlab to decode the Apollo LSM and SBM data at the bit level. Some of these programs also help display the data or organize them in a modern form convenient for data analysis (Figure 2).

Data Archiving Plan: The Apollo magnetic field data will be stored in several popular formats, includ-

ing ASCII tables, Common Data Format (CDF) files, and IGPP flat files. The data files will contain values in different coordinate systems for the convenience of future users of these data. The calibration of the LSM and SBM data sets will either be included in the restored data set or stated in the documentation.

Within two years the restored Apollo magnetic field data can be accessible through three different channels. First, we will build a dedicated online data server for these data, which allows data users to quickly access and view the data through an easy-to-use web interface. Second, the restored data will be available at the Planetary Plasma Interactions (PPI) Node of the PDS for archiving. Our efforts include recasting the data in a PDS-compliant form and writing detailed documentation for the data set. Third, a copy of the restored data will be submitted to the NSSDC through an agreement involving the PDS Lunar Data Node and NSSDC. The CDF data sets will also be made available through NSSDC's online CDAWeb system.

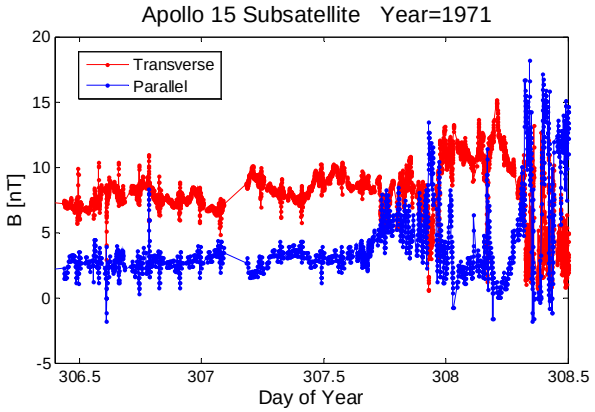

Figure 2. An example of the magnetic field measurements made by the Apollo 15 subsatellite.