INITIAL DEVELOPMENT OF THE PLANETARY GEOSCIENCE MAP GATEWAY. C. H. Okubo, M. A. Hunter, S. W. Akins, M. S. Bailen, G. E. Cushing, C. M. Fortezzo, T. A. Gaither, A. L. Gullikson, T. M. Hare, J. R. Laura, J. A. Skinner, Jr, and T. N. Titus, US Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001, cokubo@usgs.gov.

Introduction: Over the past year, we began development of a new data portal, the Planetary Geoscience Map Gateway (PGMG). Once fully functional, the goal of the PGMG is to provide on-line access to thematic data for all solid-surface bodies in the solar system except for the Earth. The PGMG is similar in concept to the USGS' National Geologic Map Database (NGMDB) [1], but is planned to have data discovery and serving capabilities far beyond those of the current NGMDB.

Motivation: A semantic, geospatially-aware method of locating geoscience maps and thematic data is a major Planetary Spatial Data Infrastructure (PSDI) component that is very much needed by the planetary science community–a need reiterated in the results of the recent MAPSIT Geoscience Mapping Survey [2]. The PGMG will fill this need by enabling the scientific community to easily find and utilize planetary geoscience map data for all solid-surface bodies in the solar system except for the Earth.

Vision: Key capabilities of the PGMG under development include (1) search options tailored to the needs of planetary scientists, (2) the ability for users to contribute data (e.g., non-standard maps funded by NASA R&A programs) to the PGMG's archives, (3) the ability to search the PGMG and pull data into third-party GIS applications, (4) the ability to discover complementary data provided by other Astrogeology and NASA services (e.g., Astropedia, IAU Nomenclature, PDS) and external data providers.

To keep the project tractable, the PGMG is initially limited to thematic data; that is, data derived through mapping and other geospatial analysis of spacecraft images. However, our long-term goal is to develop a larger, more comprehensive data portal analogous to the USGS National Map [3], wherein multiple planetary databases and data services (e.g., PGMG, Astropedia, PDS, RPIF, non-USGS/non-NASA data portals) can be linked to and interacted with. In this future data portal, the PGMG and other planetary data portals would be accessible as layers that can be activated as needed to suit the requirements of the user.

The PGMG will leverage best practices developed for the NGMDB, the USGS National Map, and other data services currently provided by the USGS Astrogeology Science Center, as appropriate, with enhancements made as needed to serve the needs of the planetary science community.

Implementation: We are currently developing draft PSDI metadata and content standards and requirements that leverage existing SDI standards for Earth, specifically Federal Geographic Data Committee (FGDC) metadata standards, as a basic framework. Subject matter experts from the USGS Planetary Geologic Mapping (PGM) group, USGS Mars Global Digital Dune Database (MGD^3) [4], the USGS Mars Global Candidate Cave Catalog (MGC^3) [5], and the IAU planetary nomenclature database [6] are helping to improve our nascent PSDI metadata standards by specifying metadata standards required by their specialized datasets. The intent of this work is to develop PSDI metadata standards that are robust enough to describe specialized datasets, yet flexible enough to adapt to the needs of datasets that will be added in the future. We expect the PSDI metadata standards to evolve and adapt to the needs of other specialized planetary datasets provided by the broader scientific community.

Just as standardized metadata enable automated discovery at the dataset level, content standards are needed to support that same capability at the data level. These are codified as schemas, which define the required fields and data types allowed for each dataset. Reconciling information in maps produced over several decades into a database format is a significant challenge, but can serve as the basis for an more general data model, such as GeoSciML.

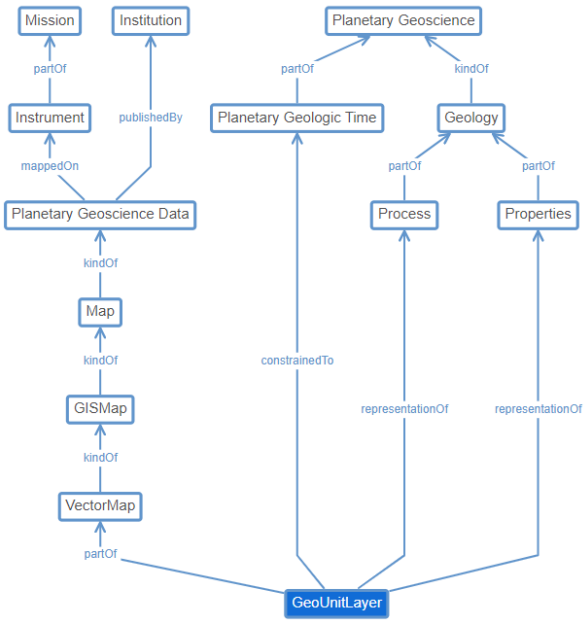

Figure 1. This graphical view from the ontology illustrates the different avenues through which users can discover the same dataset.

We have also developed nascent ontologies for planetary geologic maps (Figure 1), Mars dunes, Mars caves, and planetary nomenclature. Ontologies are object-based models of phenomena that use hierarchical structure to infer relationships between classes and subclasses of objects, and custom predicates to explicitly define relationships across classes. These relationships can then be queried, and when mapped to a database, can support more abstract semantics than querying a database alone. These ontologies are, and will always be, a work in progress. We also expect that our ontologies will evolve and adapt to the concepts pertinent to the broader scientific community.

Based on our draft PSDI metadata standards, schemas and ontologies, we have set up a testbed for the PGMG [7]. This proof-of-concept testbed server is capable of processing semantic queries using our planetary ontologies and test databases. We are currently working to enhance the capabilities of this testbed to include larger and more diverse datasets and to process increasingly complex semantic queries.

Near-term activities: In the coming year, we plan to pursue the following activities:

1. Enable community use and exchange of thematic data through the PGMG by completing our initial draft of the PSDI thematic metadata standards and distributing these draft standards for public review and eventual adoption by GeoSciML

2. Enable testing of the PGMG with larger databases by formatting the entire MGD^3 and MGC^3 databases to PSDI thematic metadata standards. These complete databases, plus the IAU planetary nomenclature and USGS geologic map databases will be incorporated into the PGMG testbed.

3. Enable broader semantic queries by generating production versions of the PSDI ontologies for planetary geologic maps, IAU planetary nomenclature, Mars dunes and Mars caves and incorporating these ontologies into the PGMG testbed.

4. Enable database queries based on geospatial criteria by testing candidates for geospatial-enabled repositories (e.g., GeoNetwork, GeoBlackLight, GeoPortal, extended Alfresco) using a subset of existing Astropedia metadata.

5. Enable the display of planetary geospatial data in a web browser by developing an OpenLayers3 extension to handle planetary body and coordinate reference system definitions (e.g., planetary radii, ocentric/ographic, east/west conventions). The resulting OpenLayers3 planetary extension will be released to the public through GitHub. We will also implement our OpenLayers3 planetary extension in the PGMG testbed.

Long-term plans: Implementation of the PGMG and any successor data portals is a long-term endeavor. Funding for the PGMG is currently provided by the NASA-USGS PSDI inter-agency agreement (IAA) [8]. Future funding for the PGMG is not guaranteed, and we plan to propose to this IAA for funding on an annual basis to sustain the PGMG and any succeeding data portals that it may evolve into.

Feedback from and participation by the scientific community is a fundamental principle of the PGMG project. Although we would prefer to involve the community in testing the PGMG within the next year, the PGMG testbed will not be ready for external review until at least 2020. This long development timeline is due to limited personnel availability, rather than technical challenges.

In a few years, we intend to establish inter-organizational memorandums of understanding (MOUs) with data providers. MOUs are necessary to enable data providers to submit data the PGMG, and to enable users to discover complementary data services hosted outside of, but linked through the PGMG (i.e., fully realize the benefits of an SDI). Similarly, we will need to create translations between existing, non-PSDI metadata standards and the PSDI metadata standards that the PGMG is based upon. For example, to allow PDS data to be discoverable through the PGMG (or its successor data portal), an interface between the PDS metadata standards and the PSDI metadata standards will be required.

References: [1] https://ngmdb.usgs.gov [2] Skinner J. A. et al. (2019) *USGS OFR 2019-1012*. [3] https://nationalmap.gov [4] Gullikson A. L. (2018) USGS Open-File Report 2018-1164. [5] https://astrogeology.usgs.gov/search/map/Mars/MarsCaveCatalog/mars_cave_catalog [6] https://planetarynames.wr.usgs.gov [7] Hunter M. A. et al. (2019) *LPS L*, Abstract #1107. [8] Keszthelyi L. P. et al. (2018) *Planetary Science Informatics and Data Analytics International Conference*, Abstract #6054.