FROM POINT SOURCE TO PARTICLE: A GIS TO MAP A SAMPLE TO AN OBJECT MILLIONS OF KILOMETERS FROM EARTH.

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Introduction: After the OSIRIS-REx sample return in September 2023 an unprecedently comprehensive dataset will exist for asteroid (101955) Bennu [1]. This dataset will include point-source observations from Earth-based telescopes [2], high resolution, in-situ global and local maps generated from observations during OSIRIS-REx proximity operations, and finally detailed sample analysis conducted in the world's best laboratories. The data will be co-registered and integrated into a single Geographic Information System (GIS), allowing one to view Bennu from point source through a global dataset at a variety of resolutions.

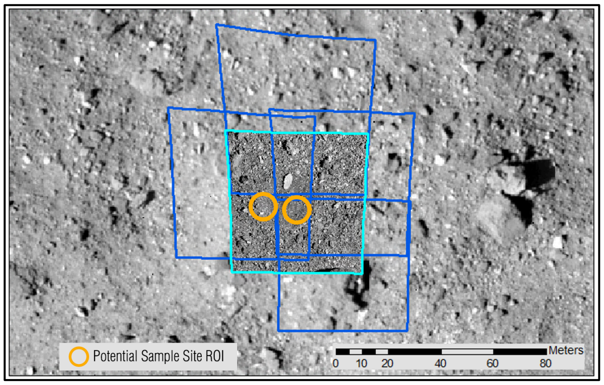

Figure 1: A closeup of the global map of Bennu created from Approach data showing image footprints from the Detailed Survey phase (blue) and two potential sample sites (orange) where the returned particles could originate from.

Geographic Information Systems: GIS is well established in Earth and planetary science to organize, analyze, and visualize geographic data. These data include, but are not limited to, images, terrain feature maps, and spectral and thermal data, that are presented within the framework of a single, spatially aware set of software applications. We expand on these capabilities to utilize commercially available GIS tools to spatially map data to the scale of a returned sample.

Traditionally, when a terrestrial or meteorite sample is analyzed through microscopy and other lab-based methods, the acquired information is manually mapped to scanned photos of thin sections. These images and data are organized and stored without an industry-wide set of standards or best practices. Here, we use standard GIS tools and established methods to store and process the sample data. We do this by assigning thin sections, slabs, and other sample types a unique coordinate reference system (CRS). All data subsequently collected from that sample can be spatially linked to the sample's CRS [3]. These data, in turn, can also be linked to the remotely sensed global and local data of asteroid Bennu. By using a GIS, data in a wide variety of formats and at vastly varying resolutions can be analyzed and visualized within the same system.

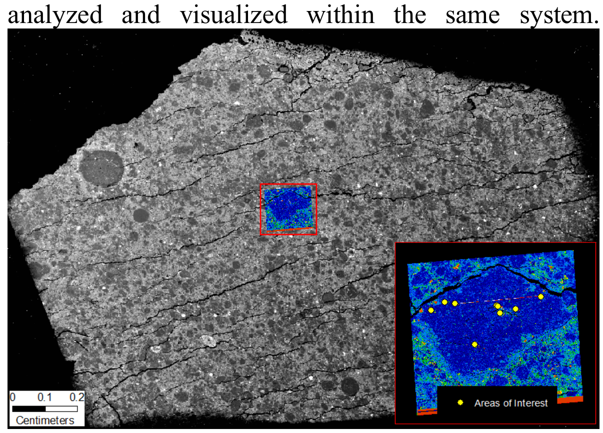

Figure 2: A thin section of the Moapa Valley meteorite shown in ArcMap. A high-resolution image (inset) has been co-registered and a shapefile shows specific TS2 point locations.

Tools: The entirety of the Bennu-resolved OSIRIS-REx OCAMS dataset is stored in a Postgres geospatial database [4]. The same database will be used to store digitized images, rasters, shapefiles (standard vector files), and tabular output from sample analysis. Additionally, the database will store data from other OSIRIS-REx payloads such as the OVIRS and OTES spectrometers. All data within the database are spatially connected to each other via geo-referencing and/or table keys. Using standard SQL commands, the data are easily queried to perform simple and complicated spatial data analysis. Data within a Postgres geospatial database is also easily accessible through most commercial and open-source GIS software, such as ArcMap and QGIS, where all data can be visualized, layered, and further queried and manipulated to produce insightful rasters, shapefiles, and ultimately maps. The outputs of data manipulation will also be stored within the database for future reference and use. The final system will enable the end-to-end mapping of sample data—from a thin section to an image, global spectral map, shape model or other datasets—enabling data querying and manipulation in unified environment.

Conclusion: Using the same GIS for remotely-sensed and sample datasets allows the returned material to be studied in the global context of asteroid Bennu. Additionally, by utilizing a GIS the analysis performed will be reproducible and available in an industry standard format opening research capabilities up to the wider scientific community and seamlessly incorporating new analysis in the future. As sample return missions like OSIRIS-REx and Hayabusa2 become more common, a standard method to organize the sample information alongside other datasets acquired throughout the mission will be extremely valuable in advancing asteroid and planetary science.

References: [1] Lauretta, D. S., et al. (2017) Space Science Reviews, 212, 925–984. [2] Nolan, M. C., et al. (2013) Icarus, 226, 629-640. [3] S. Tarquini, S. and Favalli, M. (2010) Computers and Geosciences, 36, 665-674. [4] DellaGiustina, D.N. et al. (2018) Earth and Space Science,5, 929–949.

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