Science Objective Summary and **Science Weekly Debrief**

DOY 315–322: MapCam, OTES, OVIRS, and REXIS will globally map the asteroid surface from the Recon safe home orbit. NavCam 1 will collect images every 2 hours for particle monitoring.

Science Weekly Debrief

For slides and the WebEx recording on ODOCS, click here then follow the path: Folders \ Documents and Drawings \ OSIRIS-REx Bennu Proximity Operations \ Science Status \ Science Weekly \ 2019-11-14.

Recon A data & site selection inputs

- SAWG – Vicky Hamilton, Amy Simon

N.B. Issues have been identified with the photometric model applied to OVIRS data and with the propagation of errors to L3e; PMWG and SAWG are working to correct these but will revert to L3c if needed.

In OTES Recon A data, Sandpiper and Osprey appear to have a mix of type 1 (coarser) and type 2 (finer) materials, with more of the latter than was identified in Detailed Survey data. At Osprey, distinctions are evident between texturally different areas and correspond to variations in thermal inertia (TI). In OVIRS Recon A data, both sites are brighter than the global average and have 3.4-micron band depths of about 2%. Sandpiper's slope is similar to the global average but its hydration band is deeper, whereas Osprey has a redder slope but a similar hydration band.

Quick previews of the remaining two sites indicate that Kingfisher leans toward type 1 material, whereas Nightingale leans toward type 2, and Nightingale has the deepest 3.4-micron feature of any site. Once all four sites have maps, the maps will be regenerated with consistent scales for more straightforward comparison. See the slides for more detail on methods and mapped spectral parameters.

- IPWG – Dathon Golish, Carina Bennett

See the slides/WebEx for maps of dispersion, tilt, backaway (discussed below), and texture for Sandpiper and Nightingale. Spectrally, Sandpiper, Osprey, and Kingfisher look mostly like the global average Bennu, but Nightingale looks spectrally flatter, more like DL08 or a Mickey Mouse ear at Kingfisher, which may be indicative of better sampleability (finer particles). Beth Clark noted that OVIRS data supports this interpretation.

Rock counts were shown for each site with a 5-m-diameter circle for visual comparison. Some of the areas that look unresolved are on slopes, which is not always clear in nadir images. Although

tilt (surface orientation relative to a reference) has been the focus for sampleability and spacecraft orientation, slope (gravity-based) is important to where material settles.

- RDWG – Kevin Walsh

Movies are available on the wiki that show imagery laid over DTMs for each of the candidate sample sites (note: these should not be shared outside the team). See the slides/WebEx for detailed geologic settings of each site, summarized below, and for sampleability maps.

At Nightingale, slopes are significant in the northern area, and three perched boulders sit at a local minimum, suggesting downslope movement. Two circular depressions adjacent to the site have been mapped as craters. They may be younger than Nightingale based on their smaller size; however, ejecta flow observed by the PI and the intactness of the Nightingale crater rim suggest that they are in fact older. The dominant rock texture at Nightingale is cauliflower-like.

Sandpiper also has steep slopes, with boulders clustered where they shallow. Fines are observed running up on boulders (moving downhill) and forming a skirt on a boulder's downslope side. The dominant rock texture is bacon-like.

Osprey has more moderate slopes. The dark mound at the center is part of a ridge that snakes through the crater. Buried flat rocks, perched rocks, and possibly some small craters are observed. The dominant rock texture is shaley. Osprey is a classical bowl-shaped crater, unlike many of the other craters observed on Bennu. It may represent cratering into the strength regime as opposed to the gravity regime. The crater catalog and depth/diameter ratios will help capture the distinction.

Kingfisher has minimal slopes, a mix of rock textures, and an average abundance of space weathering phases. The Mickey Mouse ear craters are smooth and presumably young.

Terrestrial field observations suggest that fines should be settling between larger clasts, or perched (as in the skirts) where boulders act as catchments.

The percentages of unresolved material at each site are about 50–60% when using a 16-cm particle limit and 3-sigma delivery radius; when considering all particles, the percentages decrease to more like 30–40%.

- Backaway hazard maps – Mike Nolan

A "backaway" hazard is an object that puts the spacecraft at risk of tipping over. The spacecraft is able to wave off the approach to TAG if the place that it is going to touch has been marked as hazardous. All four sites are reachable with a nonzero but reasonable probability of wave off. The probability of success on the first attempt across the four sites ranges from about 80 to 95% (maybe better). Osprey has the highest chance of success on first attempt, but the bottom line is that deliverability is not a major discriminator between sites.

- AltWG – Olivier Barnouin

The cleaned-up OLA products do not resolve rocks smaller than 15 cm, but OLA does capture amalgams of multiple smaller rocks. The overall uncertainty for each site's OLA DTM ranges from 2.25 to 2.75 cm, with 1 to 1.5 cm contributed from registration errors. Tilt deviation and maximum height were calculated over a 20-cm-diameter region centered on each facet to give a sense roughness and where the biggest obstacles are. Nightingale and Sandpiper are relatively smooth based on these metrics.

The SPC v50 2-cm products, which have been pushed to the SPOC, generally match the OLA products within 4.5 to 6 cm (but 9 cm in the case of Nightingale, which has artifacts). These products also show that Nightingale and Sandpiper are the smoother two sites. Large rocks are not captured correctly in these products, but they add relief that OLA does not see. Cobbles 10–20 cm are captured; pebbles <6 cm are not, and dark pebbles are particularly poorly represented. See the slides for details of each product.

- TAWG – Ben Rozitis

With single time-of-day measurements, TI cannot be separated from roughness in the Recon A data. The preliminary TI maps used roughness data from Detailed Survey. OLA DTMs were used to compute higher-resolution roughness for all four sites. Orbital A and B data can also offer additional times of day, although data are sparse. Uncertainties from the data and model are estimated to be about 20 J m–2 K–1 s–1/2. See the slides for degeneracy between TI and roughness.

The higher-resolution Recon A data reveal more TI variation at the four sites than observed in Detailed Survey. Apparent correlations with rock type continue to be observed, but no lunar-like TI that would unequivocally indicates fines. The lowest TI values observed might indicate particles smaller than the thermal skin depth of 2 cm, but these values do not occur in the sampling ellipses. Large dark rocks tend to have lower TIs than the sampling ellipses. Nightingale has the lowest TI, and Kingfisher has the highest. See the slides for temperature maps, TI maps, and interesting TI features for each site.

The low TI of the boulders relative to the finer regolith remains a puzzle. One possibility is that brecciated boulders have an extremely porous matrix that is removed during breakdown, leaving behind higher-TI clasts. Alternatively, a surficial feature such as entrainment of fines could be responsible.

- G-mode statistics – Antonella Barucci

Multivariate statistical ("G-mode") analyses suggest that Nightingale is the largest contiguous site with red spectra (interpreted as indicative of fines), dark albedo, and organics (less space weathering). Sandpiper also has these three features. The four candidate sites are all redder than the global average.

Other updates

- Publications status – Cat Wolner

"Outgassing from the OSIRIS-REx sample return capsule: characterization and mitigation" by Sandford et al. was recently published in Acta Astronautica. The global Bennu basemap (Bennett et al.) and TAGCAMS in-flight calibration (Bos et al.) manuscripts were recently submitted to Icarus and Space Science Reviews, respectively. See the slides for further manuscript status.

Slides and posters presented at the Asteroid Science workshop should be sent to Nancy Ramos (nramos@orex.lpl.arizona.edu) for archiving. The files will be stored on ODOCS [04.0 Science and Technology \ Science Team Meetings-OPEN TO ALL (US and NON-US) \ STM 16 Nov '19 – Asteroid Science workshop Tucson \ OREX presentations] and eventually on the Science Team Wiki.

A "Bennu at the macroscale" special issue is under development, targeting Science. The journal expressed provisional interest in a set of ~5 such papers. This limited size means that the special issue is not intended to comprehensively cover all aspects of the mission, but rather to opportunistically package a manageable, balanced set of already-planned papers with high-impact potential that are developing on roughly similar timelines. See the slides for the list of paper topics. Next steps will be to try to obtain a commitment from the journal. Drafts are targeted for PI Office review in mid-January.

Upcoming meetings

The next two meetings are canceled: 21 November (for the SSB meeting) and 28 November (for the Thanksgiving holiday). The meeting in the first week of December might be canceled as well, and the second week of December is AGU; it is possible that 19 December will be the only meeting before the end of the year. Meetings will resume in earnest in January to discuss Recon B data.