THE BIG SCIENCE QUESTIONS ABOUT MERCURY'S ICE-BEARING POLAR DEPOSITS AFTER MESSENGER. Nancy L. Chabot[1] and David J. Lawrence[1], [1]Johns Hopkins Applied Physics Laboratory, 11100 Johns Hopkins Rd, Laurel, MD, 20723, USA. (Nancy.Chabot@jhuapl.edu).

Introduction: Earth-based radar observations [e.g, 1] and MESSENGER measurements [e.g., 2–7] have provided multiple lines of evidence that Mercury's polar deposits are dominantly composed of water ice, answering a fundamental question about the distribution of water ice in the Solar System. BepiColombo [8] is positioned to provide the first in-depth exploration of water ice near Mercury's south pole when it orbits Mercury in 2025. With our new understanding from extensive orbital datasets, now is the time to ask new questions – What are the big open science questions about Mercury's ice-bearing polar deposits?

Open Science Questions: MESSENGER datasets have fully revealed Mercury's polar regions for the first time and led to substantial new knowledge about Mercury's polar deposits, enabling a new set of fundamental science questions:

- ***What is the origin of Mercury's water ice?*** Do the ice deposits represent ancient reservoirs, as they are located in regions where ice is stable for billions of years? Or did the ice deposits result from a recent or ongoing process, as supported by their fresh-looking appearances?
- ***What other volatiles are trapped at Mercury's poles?*** MESSENGER provided strong evidence that Mercury's polar deposits contain large amounts of water ice but that there are other volatile materials too. Do Mercury's polar deposits preserve organic-rich volatile compounds that were perhaps delivered to all of the inner planets?
- ***How do Mercury's polar deposits relate to the inventory of inner Solar System volatiles?*** Why does Mercury have extensive polar water ice deposits but the Moon does not [9]? What processes act in permanently shadowed regions to produce or to destroy water ice? What are the implications of Mercury's water ice deposits for water ice in the inner Solar System and on Earth and the other terrestrial planets?

Future Exploration Potential: Mercury's polar deposits provide many well-characterized locations for *in situ* landed investigations – locations that are known to have large expanses of exposed water ice and/or other volatile materials (**Fig. 1**). A landed science mission could determine the composition, age, heterogeneity, and physical properties of these deposits, answering big open science questions about the delivery, evolution, and retention of water and organics to the terrestrial planets, with comparisons to lunar polar cold traps and potential implications for early Earth.

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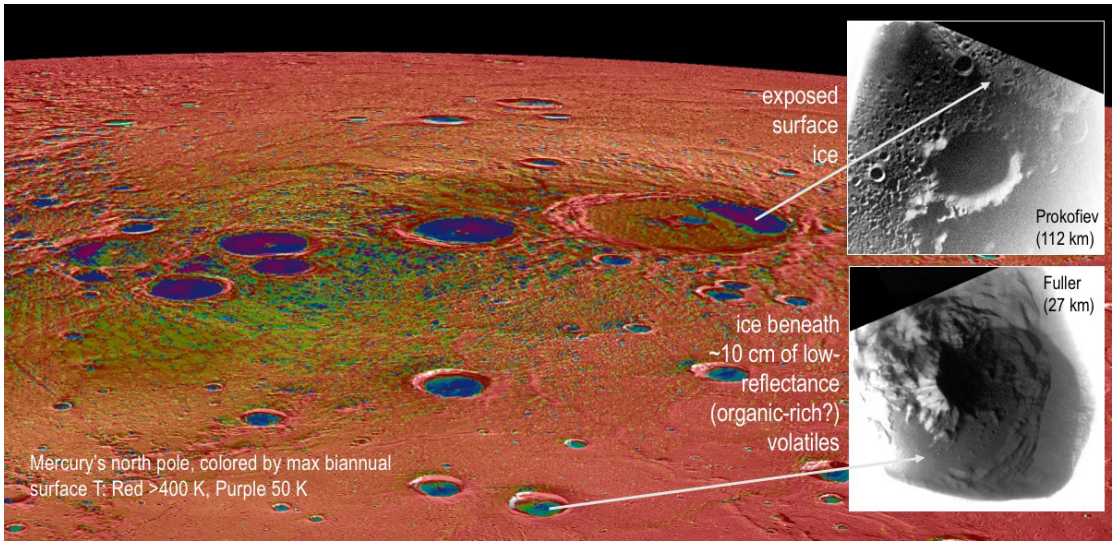

Figure 1. Mercury's north polar region, colored by the maximum biannual surface temperature [5].