INTRODUCTION: Investigators are approaching consensus that the enigmatic hollows (Fig. 1) observed by MESSENGER in and around some Mercurian craters result from the relatively recent, perhaps ongoing, release of volatiles from within the impact melts associated with each structure [1,2]. The identities and origins of those volatiles, however, remain a mystery. Some work [2-5] suggests that immiscible sulfides residing in the melts, especially CaS and MgS, might decompose during daytime heating or be released by interactions with the solar wind [1]. Although the absence of direct evidence for either the process or those species in the melts may be a matter of instrumentation [4, 5], such hypotheses do not account for some fundamental aspects of the occurrence and distribution of hollows. If impact melting of calcium, magnesium, and sulfur-rich crust commonly produces unstable sulfides, similar to the troilite and pyrrhotite that are ubiquitous in impact melts formed from more iron-rich crust, then why do we not observe hollows at all Mercurian craters? And as the distribution of those sulfides should be random in each melt, why are hollows concentrated in particular areas, most commonly along annular regions of crater floors or walls, and even along ray-like lineaments within proximal fall-out ejecta?

Many hollows exhibit distributions reminiscent of the dissemination of meteoritic contamination experimentally predicted and observed in the ejecta and melt sheets of some impact structures [e.g., 6, 7]. But what volatile component of common bolides could survive impact and be sequestered for later release? We propose a simple answer: Water.

THE FATE OF WATER IN IMPACTS: The hypothesis that frequent collisions between Mercury and comets, or volatile-bearing asteroids, might give rise to abundant water vapor capable of freezing in the polar shadows now seems uncontroversial and can be modeled [8]. Nevertheless, the potential role of water in the formation of hollows seems to have been ignored. This follows the typical trend to assume that the ultra-high temperature and pressure conditions responsible for the production of impact melts preclude the survival of all but trivial water concentrations. Yet most impact melts on Earth contain a few percent by weight, as a combination of dissolved hydroxyls and molecular species. And, as previously reported [e.g., 9-11], melts produced by natural and experimental hypervelocity collisions into porous targets can trap substantial concentrations of water. Moreover, melts produced by natural impacts into wet regolith can contain abundant hydrous inclusions (Fig. 2), with OH + H2O concentrations ranging between approximately 5 and 20 wt%, embedded within nominally anhydrous glassy breccias.

Figure 1. MESSENGER narrow-angle MDIS images (Johns Hopkins University/Applied Physics Laboratory) of (A) Warhol, a complex crater, and (B) a fresh simple crater on Mercury. High-albedo hollows have developed in particular areas on the floor and walls of some complex craters while they appear to have formed in the ejecta field of the smaller structure. We suggest that the occurrences reflect the distribution of impactor-derived water in the melt ejecta.
Hydrous melts that remain inside the crater may coat crater walls, cover the surface of melts sheets, and mix in a layered stratigraphy with melt sheets. The distribution depends on the velocity, size, and angle of each event, in addition to the mechanical properties of the target and bolide.

We are examining the conditions under which hydrous melts may persist in large melt pools and the residence times of volatiles in cold quenched ejecta layered within the pools.

The trapped water may leak out as vapor over lengthy intervals of time, subsequently contributing to the shadowed cold traps adding to the volume of ice found there.

We propose that hollows reflect water trapped within melts from lower speed melts, thereby accounting for the absence of hollows in all craters. Water derived from cometary and hydrous asteroids cannot be ignored when considering the volatile history of impact melt deposits on Mercury or any other body. Moreover, this process at basin scales (although not necessarily cometary) may play a role in trapping water at depth.

Alternatively, some hollows may result from exca-vation of water-bearing materials in the mantle, which likewise were derived from sequestered hydrous melts formed during early large basin forming impacts. Such processes may be important in the formation of all the terrestrial planets and the Moon.