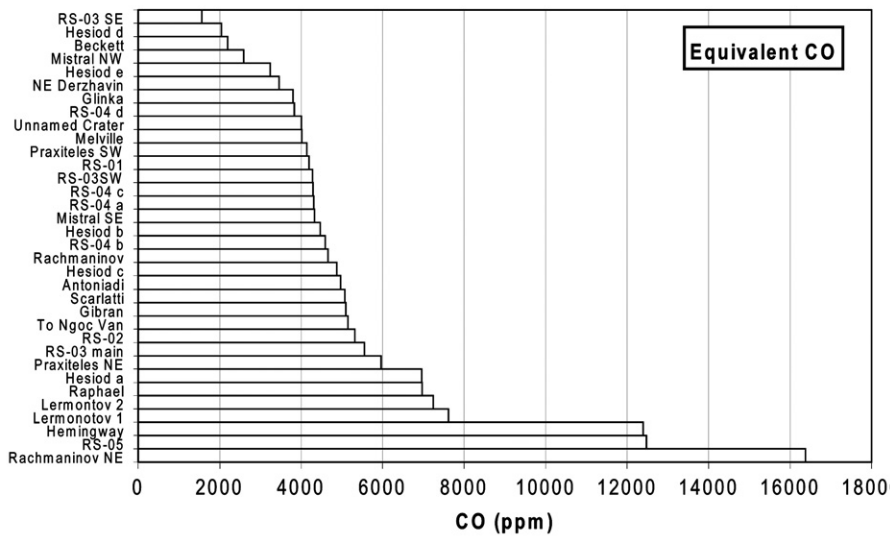

Fig. 7. Magmatic content of CO needed to propel pyroclasts to the measured radius for each deposit, under the assumption that CO was the only driving volatile. Results for other volatiles are shown in Table 2. Hemingway and RS-05 both lack a discernible vent, meaning that the calculations for these deposits may yield an erroneously large result. NE Rachmaninoff has an irregular central depression and fairly well-defined edges, but the deposit's large radius would require an extremely high volatile content. This result suggests that the NE Rachmaninoff deposits may not be completely composed of pyroclastic material, that there are additional vents within the area of the deposit, or that volatiles were concentrated below the surface prior to eruption (as in vulcanian eruptions); images at higher resolution will allow these possibilities to be evaluated.

It is possible, especially in the case of vulcanian eruptions, to concentrate a volatile-rich magmatic foam at the tip of a propagating dike or below a plug blocking the vent mouth. In such a situation, magma containing a moderate amount of volatiles can eventually lead to an energetic eruption composed of mostly gas and fragmented foam (Wilson, 1980; Wilson and Head, 1981; Fagents and Wilson, 1993).

The majority of the newly recognized pyroclastic deposits on Mercury are smaller in size than the original deposit analyzed by Kerber et al. (2009). Of the four deposits that are larger than RS-03 in areal extent, only one (NE Rachmaninoff; Fig. 1a) has well-defined edges and a prominent central irregular depression. However, with a radius almost three times that of RS-03, the proportion of volatiles needed to emplace pyroclasts to that distance is almost three times as great. For comparison, measurements made from eruptions of Kilauea volcano in Hawaii implied volatile abundances in the hotspot mantle source of ~3000 ppm H_2O, ~6500 ppm CO_2, and ~1300 ppm S (Gerlach, 1986). If the NE Rachmaninoff deposit was formed through a fire-fountaining, hawaiian-like explosive eruption, where calculated volatile contents would be similar to those found in the mantle source, the deposit dimensions would imply volatile contents in the source region of up to 11,000 ppm H_2O, 26,000 ppm CO_2, 13,000 ppm SO_2, or a combination of these or other volatiles (see Zolotov, 2011). If the volcanic gas was created through the oxidation of carbon, nitrogen, or similar species, a somewhat oxidizing crust would be required in order to supply oxygen for the process (Zolotov, 2011). It is possible that these high volatile abundances could be achieved through concentration of gas in a vulcanian eruption, as discussed above. The NE Rachmaninoff deposit currently lies at the edge of the usable MESSENGER WAC color data and will be an important target during the orbital phase of the mission.

The presence of large pyroclastic deposits on Mercury and the implied amount of volatile species needed to create them suggests that Mercury may be more volatile-rich than previously thought. The observation that there appears to be a greater proportion of large pyroclastic deposits on Mercury than there is on the Moon may yield clues to the relative abundances of interior volatiles or solid phases of C, S, N, or Cl present in the two bodies when they formed.

4. Future analyses

Mercury and the Moon are similar in that they are both small, airless bodies with generally ancient silicate surfaces. Both bodies have similar dominant surface processes: impact cratering, volcanism, structural deformation, and space weathering (e.g., Hiesinger and Head, 2006). However, Mercury differs from the Moon in its surface area (~2 times that of the Moon), the radius of its core (at least ~5 times that of the Moon), the composition of its crust (silicates with very low FeO content), and the distribution and expression of its volcanic output.

The Moon, because it is closer to Earth, better studied, and sampled, provides an excellent framework for an increased understanding of Mercury. Conversely, Mercury, lacking the complicating factors of the Moon's proximity to (and likely origin from) the Earth (e.g., Hartmann and Davis, 1975; Cameron and Ward, 1976; Benz et al., 1986), provides a good context through which we may better understand the Moon. New data currently being acquired by missions to the Moon will provide a wealth of information about that body. The concurrent exploration of Mercury will provide a rich context that will lead to a substantial and synergistic increase in understanding of both bodies.

The MESSENGER mission and the upcoming BepiColombo mission provide an opportunity to begin to understand Mercury's surface processes in ways that were first possible on the Moon almost a half-century ago. Several techniques may be used to better understand pyroclastic deposits, each contributing to progress on the outstanding issues discussed above. First, MESSENGER NAC images have made it possible to view large portions of the planet in much greater detail than was previously available. This improved resolution allows for the careful inventory and characterization of the morphologies of possible pyroclastic deposits, including their shapes and dimensions and characteristics of their central vents (e.g., Figs. 2 and 5, Table 1). On the Moon, morphological studies have allowed the classification of