terrain, and infilling of the crater interior can occur, raising the elevation of the crater above that of the pedestal surface (Kadish et al., 2009).

It should be noted that other models for Pd formation have been proposed (e.g. Arvidson et al., 1976; McCauley, 1973). These studies suggested that Pd resulted from impacts into dry, fine-grained material. An armoring mechanism indurated the proximal surface, allowing eolian deflation to remove the nonarmored intercrater terrain while preserving the pedestal material. This left the Pd perched above the surrounding plains (Arvidson et al., 1976; McCauley, 1973). In both the ice-rich and dry models, a host of armoring mechanisms have been proposed. These include increased ejecta mobilization caused by volatile substrates (e.g. Osinski, 2006), a coarse lag deposit (Arvidson et al., 1976), a veneer of impact melt (Schultz and Mustard, 2004), dust insulation (Skorov et al., 2001), or a thermally indurated soil consisting of a layer of fine-grained, volatile-poor dust and/or salts (Wrobel et al., 2006). For a discussion of these armoring mechanisms, see Kadish et al. (2009).

In comparing this range of characteristics and these proposed formation mechanisms, it is clear that the processes may be similar, particularly between EE and Pr. In both of these cases, the initial impact excavates the underlying regolith, and the distributed ejecta is primarily responsible for inhibiting the sublimation of the proximal volatiles during erosion of the intercrater terrain, leading to the anomalously large ejecta volumes. The only significant distinction between the geomorphological outputs identified in the process models is the infilling of the crater interiors; all EE are necessarily fresh, having deep crater cavities, whereas Pr have always undergone extensive infilling, yielding shallow crater interiors. Pr are also more likely to show modification of their ejecta deposits, possibly due to eolian deflation (Meresse et al., 2006). As will be discussed later, this may imply that Pr are simply modified EE which have been degraded and/or covered by post-emplacement deposits.

Based on the limited extent of Pd ejecta deposits, which are not always present on the pedestal, it is very likely that Pd have experienced a different process by which the ice-rich material becomes preserved. As previously mentioned, several mechanisms have been proposed that could be capable of armoring such a large surface area relative to the size of the crater interior, but none have been proven (Arvidson et al., 1976; Osinski, 2006; Schultz and Mustard, 2004; Skorov et al., 2001; Wrobel et al., 2006). The absence of ejecta associated with many Pd supports the interpretation that the impacts that form Pd, unlike EE and Pr, do not excavate a significant volume of the underlying silicate regolith. As such, the ejecta would consist primarily of the ice-rich layer, making it easily erodible, and would have a very small rock fraction. This observation argues against armoring mechanisms that rely on rocky ejecta to armor the pedestal surface, which include the hypotheses of ejecta mobilization (Osinski, 2006), lag deposits (Arvidson et al., 1976), and impact melt (Schultz and Mustard, 2004).

Using the depth-diameter relationship for simple craters of $d = 0.21D^{0.81}$, where d is the transient depth and D is the diameter (Garvin et al., 2003), and the approximation that excavation depth is one-third of the transient depth (Melosh, 1989), it is clear that the impacts resulting in Pd (1–3 km diameter craters) tend to excavate only 70–170 m. This produces transient crater depths from 200 to 500 m below the rim crest. These depths will vary due to the strength of the impact target material (Garvin et al., 2000). Because the impact excavation depth is comparable to the thickness of material that is eventually removed due to sublimation and deflation, most Pd have their crater basins and any detectable ejecta perched above the elevation of the intercrater plains. By strict definition, this would allow them to be classified as Pr. However, as we will emphasize in the following section, while some Pd may technically qualify as Pr, the two morphologies are not identical, having several distinguishing physical and topographic features.

4. Physical attribute comparison

4.1. Crater diameter and ejecta/pedestal thickness

One of the significant physical distinctions between these crater types is the variation in diameter ranges (Fig. 9). As previously mentioned, the initial studies of EE and Pr revealed that they tend to be approximately the same size range. Although these studies did not survey craters of all diameters, the distribution of sizes in confirmed examples suggests that the majority of EE and Pr are between 4 and 10 km in diameter, with extreme cases extending the range from 2 to 23 km (Black and Stewart, 2008; Boyce et al., 2005; Meresse et al., 2006). Conversely, Pd typically range from <0.5 to 6 km in diameter, with a median of 1.2 km (Kadish et al., 2009). These distributions show that the lower size limit for EE and Pr overlaps only slightly with the upper size limit of Pd (Fig. 9). As such, if all three crater types form from impacts into the same icy paleodeposits, then this distinction in crater sizes suggests that the primary factor influencing the initial morphology of the observed craters is the excavation depth (Barlow et al., 2001), which scales with the total impact energy based on the size and velocity of the impactor.

The validity of the above assumption relies on the notion that each crater type results from distinct impacts into the same thickness of ice-rich paleodeposits, rather than being produced by impacts into deposits of different thicknesses that were present at different times. To assess this, we can compare the thicknesses of the excess ejecta, perched ejecta, and pedestals (Fig. 9). If these morphologies do form from the same icy layers of the same thickness, then their proposed formation mechanisms predict that the ejecta/pedestals will have similar thicknesses.

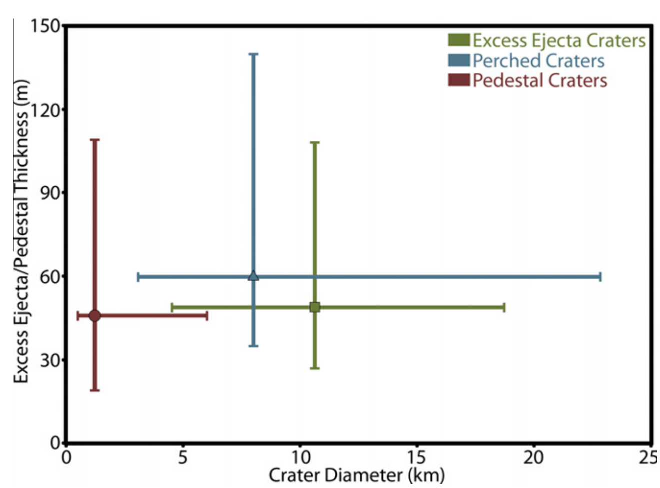

Fig. 9. A graph of the crater diameter and thickness values for EE (green square), Pr (blue triangle), and Pd (red circle). Locations of the data points show the approximate average values for each crater population while the error bars indicate the range of values, as identified by Black and Stewart (2008), Boyce et al. (2005), Meresse et al. (2006), and Kadish et al. (2009). These data exclude extreme cases – for example, the new EE found in this study show that some examples can be much smaller in diameter than the population identified by Black and Stewart (2008). This visualization of the typical physical characteristics the crater morphologies clearly shows the similarity between their thicknesses (vertical error bars). The diameters (horizontal error bars) show that there is an overlap between larger Pd and smaller EE and Pr, but Pd tend to be smaller while EE and Pr are similar in size. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).