Bridging the Gap between Two Methods of Measuring Impact Features, Charles J. Byrne, Image Again, charles.byrne@verizon.net.

Introduction: Measurements of lunar craters and basins based on topographic information from Apollo [*Pike*, 1976], Lunar Reconnaissance Orbiter (LRO) [*Kalynn et al.*, 2013a, 2013b, *Mahanti et al*., 2013], and Kaguya, [*Byrne*, 2013] are now available, covering the entire range of diameters from 20 meters to the largest impact events on the Moon. Two types of measurement systems have been used (see figure 1).

1. Based on the apparent crater, the parameters are Apparent Diameter, Apparent Depth, and Fill Depth.

2. Based on the rim, the parameters are the Rim Crest Diameter and the Rim Crest-to-Floor Depth.

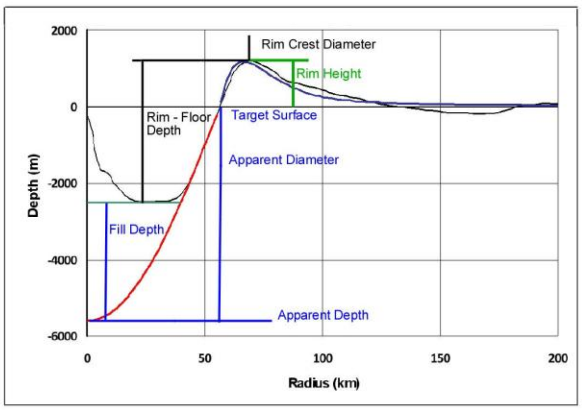

Figure 1: The two measurement systems are shown as applied to the complex crater Pythagoras. The irregular line is a radial elevation profile of the crater, after the target surface has been estimated and subtracted from a 1/16 degree Digital Elevation Map (DEM) from the Kaguya project. The red line is a model of an excavation cavity before formation of the central peak and the flat floor. A smooth blue line models the rim and ejecta field, scaled according to the Apparent Diameter and Apparent Depth [*Byrne*, 2007, 2013]. The Rim Crest Diameter and Rim-to-Floor Depth measurements are shown in black and the Apparent Diameter, Apparent Depth, and Fill Depth are shown in blue. Rim Height is shown in Green.

Measurements based on the apparent crater are discussed in [*Turtle et al.* 2004, 2005, *Byrne* 2007, 2013, *Croft* 1980, *Housen et al.* 1983] and measurements based on Rim Crest Diameter and the Rim-to-Floor Depth are discussed in [*Pike* 1976, *Kalynn et al.* 2013, *Mahanti* 2013]. The parameters based on the apparent crater are referenced to the pre-impact target surface and are used in experiments, simulations, and theoretical studies. The parameters based on the rim are used for studies of natural craters, where the pre-impact target surface is difficult to estimate. Rim Height is sometimes measured in each system and is very useful (but not always required) in cross-correlating data sets measured with the two systems.

Here, we examine a data set of natural lunar craters that is based on Apparent Diameter, Apparent Depth, and Fill Depth but also includes Rim Crest Diameter and the Rim-to-Floor Depth in order to explore relationships among the parameter sets. The intent is to make it possible to combine data from multiple studies.

Method of the data set reported here: The data set of 90 lunar impact features discussed here covers all lunar impact features with Rim Crest Diameters of 200 km or more that are not too degraded to model. Measurements have been made even on severely degraded craters or basins as long as the rim is exposed in at least one 90 degree segment. Nearly all of the features are listed in [*Byrne* 2013]. In addition, a few selected smaller young features are included. All measurements are made by the methods of [*Byrne* 2007 and 2013]: selecting the latitude and longitude of the center, estimating the target surface, deriving a radial elevation profile relative to the target surface, and determining both the crater-based and rim -based parameters shown in Figure 1.

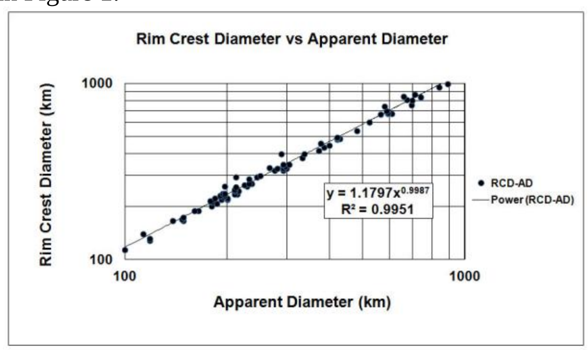

Figure 2: Rim Crest Diameter is seen to be strongly correlated with Apparent Diameter.

Comparison of parameters: As shown in Figure 2, Rim Crest Diameter and Apparent Diameter are closely correlated: the cross-correlation value $R^2$of the trend line is 0.9951.

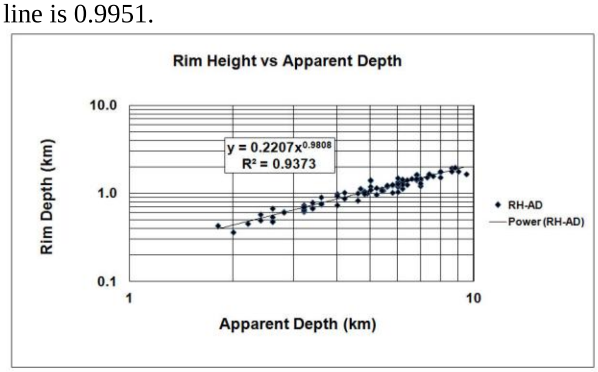

Figure 3: Rim Height is strongly correlated with Apparent Depth.

If Apparent Diameter is measured, Rim Crest Diameter can be calculated and if Rim Crest Diameter is measured, Apparent Diameter can be calculated by inverting the formula shown in Figure 2.

As can be seen in Figure 3, Rim Height and Apparent Depth can each be calculated if the other is measured. In some studies [*Pike* 1980], Rim Height is measured along with Rim Crest-to-Floor Depth.

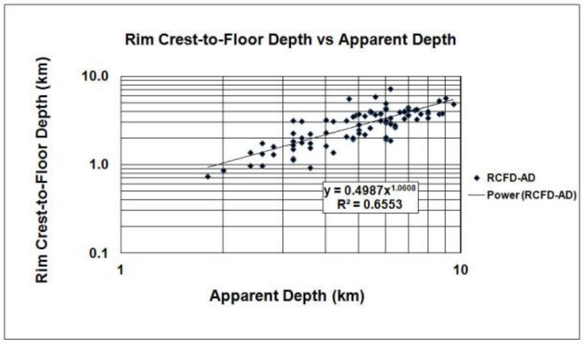

Figure 4: Rim Crest-to Floor Depth is seen to be less well correlated with Apparent Depth than Rim Height.
For craters that are selected to be free of mare or debris, the Rim Crest-to-Floor Depth can be used to estimate Apparent Depth.

As shown in Figure 4, Rim Crest-to-Floor Depth measurements do not correlate well with Apparent Depth. The reason is that deposits on the crater floor such as mare flows and debris ejected from neighboring impact features reduce the Rim Crest-to-Floor Depth, diminishing its value as a measure of the initial impact phenomenon. However, for craters that are carefully selected to be free of mare or debris, Rim Crest-to-Floor Depth can be used to estimate Apparent Depth, especially if a set of such selected craters are calibrated by comparing measurements of sample features made with both methods.

Figure 5 shows the relation between Rim Crest-to-Floor Depth and Apparent Depth for the Eratosthenian and Copernican craters from the data set in the Supplement.

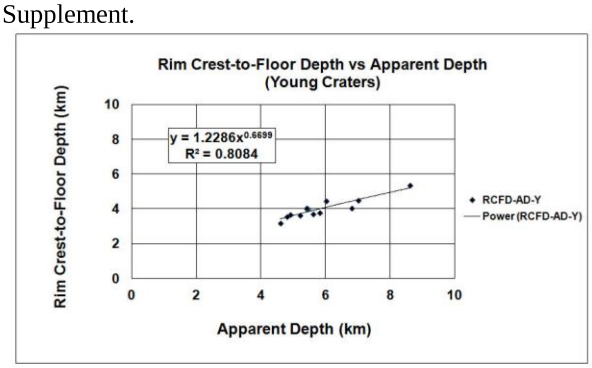

Figure 5: This graph of Rim Crest-to-Floor Depth against Apparent Depth shows only the young craters (Eratosthenian or Copernican periods). These craters are free of mare flooding or debris. The scale has been changed from Figure 4 to show a narrower range of data. The trend line is still a power law.

Conversion of measurement systems: The power laws relating parameters, shown in the figures, are of the form $Y=aX^b$, where X is a crater-based parameter and Y is a rim-based parameter.

Solving for the crater-based case, $X = (Y/a)^{(1/b)}$. Applying this formula to the rim-based parameters of a study provides an estimate of the crater-based parameters. A test of this principle has been successfullly performed by converting rim-based parameters of [Kaylynn 2013] to crater-based parameters measured for the same features in [Byrne 2013].

Conclusions: A method has been presented to convert rim-based parameters to crater-based parameters and successfully applied to compare converted parameters. This prepares the way to merge large datasets to extend the range of consistently measured impact features.

References: Byrne, C. J., 2007: A large basin on the near side of the Moon, Earth, Moon and Planets (2007) 101 pp153-188. **Byrne, C. J., 2013:** The Near Side Megabasin and the Far Side Bulge of the Moon, Springer, doi 10.1007/978-1-4614-6949-0 (2013). **Croft, S. K., 1980:** Cratering flow fields: Implications for the excavation and transient expansion stages of crater formation, Lunar Planet. Sci. Conf., p. 2347-2376, 1980. **Housen, K. R., Schmidt, R. M., and Holsapple, K. A., 1983,** Crater ejecta scaling laws: fundamental forms based on dimensional analysis, JGR, 88 (B3), 1983: p. 2485-2499. **Kalynn, J. D., C. L. Johnson, G. Osinski, and O. S. Barnuin, 2013a:** Topographic characterization of lunar complex craters, AGU: Geophysical Research Letters, Vol. 40, Issue 1, 16 January 2013, doi: 10.1029/2012GL0 53608. **Kalynn, J. D., C. L. Johnson, G. Osinski, and O. S. Barnuin, 2013b:** Lunar complex craters: revisiting depth-diameter and central peak height-diameter relationships, LPSC 2013 Abstract 1309. **Mahanti, P., M. S. Robinson, R. Stelling, S. J.Lawrence, and J. Stopar, 2013:** A probabilistic model to explore depth-diameter dependencies for lunar craters, LPSC 2013 Abstract 1215. **Pike, R. J., 1976:** Crater dimensions from Apollo data and supplemental sources, The Moon, vol. 15 (1976) pp.463-477. **Pike, R. J., 1980:** Target-Dependence of crater depth of the Moon, LPSC XII, pp. 845-847. **Turtle, E. P., E. Pierazzo, G. S.Collins, G. R. Osinski, H. J. Melosh, J. V. Morgan, W. U. Reimold, and J. G. Spray, 2004:** Impact structures: what does crater diameter mean?, LPSC 2004, Abstract 1772.d. **Turtle, E. P., E. Pierazzo, G. S.Collins, G. R. Osinski, H. J. Melosh, J. V. Morgan, W.U. Reimold, and J. G. Spray, 2005:** Impact structures: what does crater diameter mean?, Geological Society of America, Special Paper 384, 2005.