Re-examination of Excavation Cavity of the Impact Basins of the Moon based on GRAIL based Crustal Thickness Model. Y. Ishihara[1], R. Nakamura[2], [1]JSPEC/JAXA, (3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510, Japan; ishihara.yoshiaki@jaxa.jp), [2]National Institute of Advanced Industrial Science and Technology (Umezono 1-1-1, Tsukuba, Ibaraki 305-8568, Japan, r.nakamura@aist.go.jp).

Introduction: Impact cratering is one of the major geologic processes that operated on planets and small bodies early in their evolution. For the tectonically active planets (e. g., Earth and Venus) , much of the early cratering records have been eliminated by tectonic and erosional processes. In contrast, for non-active planets such as the Moon, much of the early cratering record still exists. So, for the Moon, large impact features called "impact basin" are the most important geologic clues when investigating the lunar evolution.

Large impact features, whose diameters are more than hundreds of kilometers, are called impact basins. Large impact basins can provide comparatively clear information of the cratering process and/or constrain the lunar thermal history. The internal or subsurface structures of basins can be assessed through an analysis of their associated gravitational and topographic signatures. Using this approach, the subsurface structure of the basin is modeled. For instance, it has been concluded from previous studies that the lunar Moho (i.e. crust–mantle interface) is substantially uplifted beneath the large basins (e.g., [1][2][3][4][5]) This uplift is commonly interpreted as resulting from the excavation of large amounts of lunar crustal materials and the subsequent rebound of the crust and mantle materials beneath the basin floor. Using rebound (or a mantle plug) calculated from these studies, we are able to obtain first order estimates of the volume of materials that was excavated from impact basins. These kind of studies were first done by Bratt and colleagues [5]. These early studies were hampered by the limited coverage of the gravity and topography data set. Follow-on studies were done after the availability of Clementine topography and Lunar Prospector gravity data set [6]. Their study also suffered from the lack of far side gravity data, so they estimated excavation depth and diameter of nearside large impact basins and farside South Pole-Aitken basin, using a crustal thickness model based on Clementine topography and Lunar Prospector gravity [7].

The recently Kaguya/SELENE mission has improved the crustal thickness model not only for the nearside but also for the farside [8] based on the first direct farside gravity [9][10] and global topography mapping [11]. Moreover most recent GRAIL mission vastry improved spatial resolution and overall accuracy of the lunar gravity models [12] and lunar crustal thickness models [13] The GRAIL crustal thickness model [13] gives us the opportunity to re-analyse excavation depth and diameter of basin forming impact processes anywhere on the Moon with improved accuracy. This study uses the GRAIL crustal thickness model [13], to reconstruct the excavation cavity geometry of large impact basins on the Moon.

Excavation Cavity Reconstruction: In this study, we have used the GRAIL crustal thickness model [13].

Our method of reconstructing the excavation cavity of large impact basins is fairly simple. We assume that the thinned crust and uplifted Moho beneath features is a direct consequence of (1) the amount of crustal material excavated during the cratering process and (2) the subsequent rebound of the crater (basin) floor. We first construct azimuthally averaged profiles for the surface topography [Fig. 1(A)], mare thickness and subsurface structure of the Moho [Fig. 1(B)] for each basin [Fig. 1(C)]. Next, we restored the uplifted Moho and overlying crust to its "pre-impact" position. Estimating procedures of "pre-impact" position is almost the same as previous analysis [6]. After removing mare fill, this process resulted in a roughly parabolic surface depression, that we interpret as being the first-order representation of the basin's excavation cavity [Fig. 1(D)]. We measured diameter and depth from this depression. This approach neglects many processes that may have modified the shape of the original excavation cavity, and the first-order excavation cavity is highly likely to be affected by post-impact modifications (e.g., such as isostatic adjustment, viscoelastic modification, and brittle deformation etc.). The magnitude of post-impact modification of each basin can be assessed using the depth-to-diameter ratio of the reconstructed cavity.

Results and Discussions: One of the most important values of understanding the large impact basin is the depth-to-diameter ratio of the excavation cavity. Theoretical considerations such as Z-model, hypervelocity impact experiments, numerical simulations of impact cratering, and empirical evidence of small lunar craters all suggest that the depth-to-diameter ratio is approximately 0.1 for craters ranging in size from centimeters to a few tens of kilometers.

In Fig. 2 we plot the depth versus the diameter of our reconstructed excavation cavities (excluding the Imbrium Basin and the South Pole-Aitken Basin). It seems that up to 400 km cavity diameter, the depth (hex) and diameter (Dex) are linearly related. Further more, the linear relationship (hex/Dex=0.079+/-0.006) is almost consistent with, though slightly smaller than, the value for craters orders of magnitude smaller in size (hex/Dex=0.1), suggesting that proportional scaling is valid for basin scale impact structures except the largest impact structures on the Moon. One of the reasons of smaller depth-to-diameter ratio are probably effects due to the post impact modifications. Impact basins which has excavation cavity diameter larger than 400 km show the different state. The average crustal thickness of GRAIL lunar crustal thickness model is 34 to 43 km [13]. So excavation cavity diameter of 400 km is located the ragime boundary between the excavation/melting cavity within crust ragime and the excavation/melting cavity exeed the Moho interface ragime.

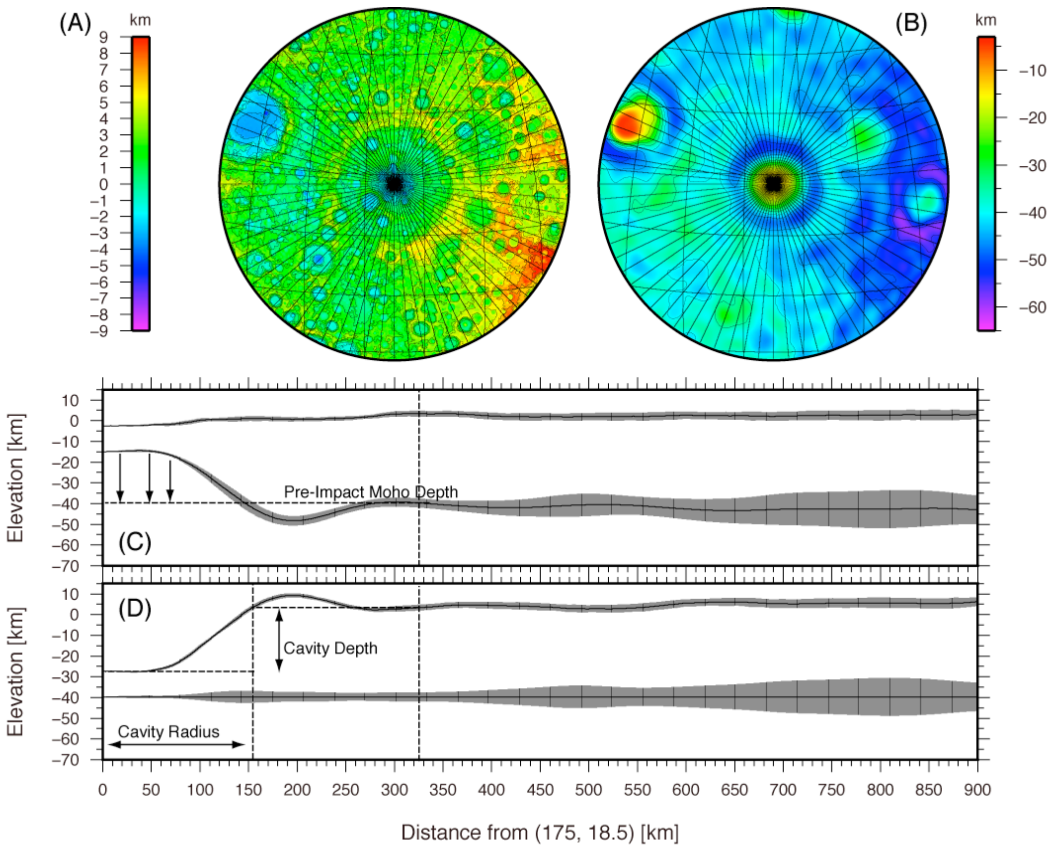

Fig. 1 Schematics of excavation cavity reconstruction. (A)Topographic figure of the Freundlich-Sharonov basin. (B)Moho undulation beneath the Freundlich-Sharonov basin. (C) Azimuthally averaged (every five degrees) profile of the Freundlich-Sharonov basin. (D) Azimuthally averaged reconstructed cavity profile of the Freundlich-Sharonov basin.

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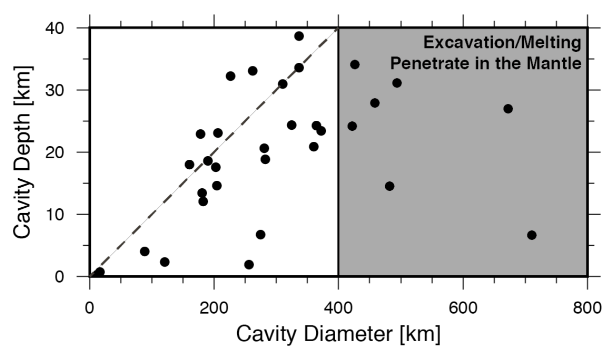

Fig. 2 Depth versus diameter of the reconstructed excavation cavity.