FOUR TYPES OF IMPACT BASINS AND ITS IMPLICATIONS FOR THE FORMATION AND EVOLUTION OF MASCON ON THE MOON. Jinzhu Ji[1,2], Jianzhong. Liu[1], Li Zhang[1], Dijun Guo[1,2,3], Jingwen Liu[1,2], Juntao Wang[1,2], Lin Luo[1,2], Jingyi Zhang[1,2], [1]Center for Lunar and Planetary Science, Institute of Geochemistry, Chinese Academy of Sciences, 99 Lincheng West Road, Guiyang 550051, China, [2]University of Chinese Academy of Sciences, Beijing 100049, China, [3]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI 02912 USA. Email: jijinzhu@mail.gyig.ac.cn.

Introduction: Large impact basins, the comprehensive results of external and subsequently internal dynamic geological processes, are the principal topographic features on the Moon. Study on evolution of those large impact basins provides important clues for understanding early history of the Moon. And, many large basins display mass concentration or mascon characteristic, which is the "by-product" of impact process [1-5], providing lots of clues for the formation and evolution of mascons. However, to classify the impact basins before anyone can link their characteristics to basin evolution, discrepancies occur among different classification systems, of which some did not to consider the effect of filled basalt [6] or some did not to consider the category of non-mascon basins [1, 2]. In order to clarify the ambiguous basin types caused by different classifications, we re-examined impact basins ⩾ 200 km in diameter.

Methods and data: We made measurements free-air gravity anomalies, bouguer gravity anomalies, topography and FeO content of 66 basins, excluding SPA basin. Free-air gravity was measured using GRAIL 16ppd GRGM660PRIM data [7], which was truncated to degree and order 320 for the expansion in the spatial domain, to reduce remaining artifacts. Bouguer gravity was measured using GRAIL 64ppd GRGM900C data [8], which was truncated to degree and order 600 for the expansion in the spatial domain. FeO content was measured using the released FeO map from LP gamma-ray and neutron spectrometers [9].

Relative Mascon: From the gravity profiles, 48 of 66 basins show a "bulls-eye" gravity pattern (central high anomaly and rim low anomaly). For the 48 basins, the values of central high anomaly (C) minus rim low anomaly (R) increase rapidly with the basin diameter between 200km and 500km, while increase slowly when the basin diameter larger than 500km (Fig. 1a). And the value of (C-R)/C trend to a constant value of 2 when the basin diameter is larger than 300km (Fig. 1b), which may be used to describe the inherent attribute of mascons, like the value of Body Mass Index.

Some basins show positive central with an annulus of negative anomalies, which are the traditional characteristic of mascon [2, 3, 4, 10]. However, some basins, such as Korolev, Mendeleev, show negative central with an annulus of more negative gravity anomalies, also considered as mascons [2, 6]. This may not be able to fully understand the masons. Here we propose to understand the mascons with a relative concept, which means that the "relative mascon" shows a "bulls-eye" gravity pattern and an approximate constant value of 2, (C-R)/R.

Basalt or basaltic materials in basins: Mare basalts or basaltic materials are extrusive igneous rocks. Thus, Basalt flooding or not is of great significance for the mascon and basin evolution. The iron-rich composition of mare basalts not only gives rise to their low albedo but also result in their density to be considerably higher than the anorthositic highlands [11-13]. Many basins flooded by basalt or basaltic materials, with high iron contents larger than 15wt% [14]. And the bouguer gravity anomalies of basalt flooded basins are obviously larger than the unflooded basins (Fig.2).

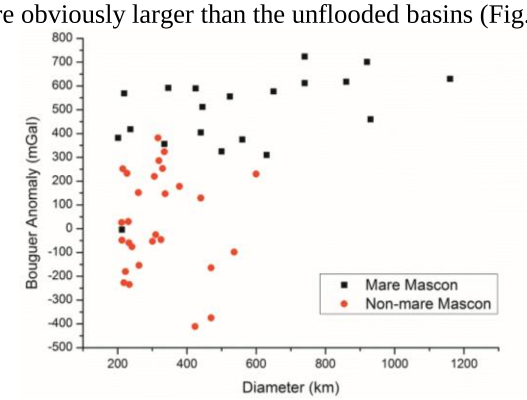

Fig. 2. Trends in central bouguer gravity anomaly characteristics within mare mascons and non-mare mascons.

Classification of impact basins: We chose two major category labels: mascon or not [1, 2, 6] and the basin floor is covered by basalt/basaltic materials or not [3]; plus, we considered topographic signatures as the clue of timescale. As a result, the 66 impact basins were classified into four categories: Type I (20, M-M), mascon basins with basalt or basaltic materials and most of them show well-preserved topography signature; Type II (28, NM-M), mascon basins without basalt or basaltic materials, most of them are located on the farside with preserved topography signature; Type III (11, M-NM), non-mascon basins with basalt or basaltic materials, most basins of this type are dated as Pre-Nectarian except for Van de Graaff basin and showing severely degraded topography; Type IV (7, NM-NM), non-mascon basins without basalt or basaltic materials, all basins of this type are dated as Pre-Nectarian with severely degraded topography. This new classification scheme can be easily applied to various lunar basins and help us to locate important information about early environment or thermal state of the Moon by comparison study of regional geological evolution of different basin types.

Implications for the formation and evolution of mascon: We have made a statistics about the relationship of 66 basins' age [15] and diameter (Fig. 3), we can find that: 1) the diameters of almost mascon basins are larger than 300km, which is the basic formation condition; 2) Most of the mare mascons are on the nearside and their ages are distributed in late Pre-Ne to Lower-Im; 3) The non-mare mascons are all on the farside and their ages are distributed in Pre-Ne to Lowr-Im; 4) The ages of mare non-mascons basins are almost in the early Pre-Ne with diameters larger than 500km, which infer that the long-time subsequently igneous processes and isostatic adjustment lead to the disappearance of mascons [2, 16, 17]; 5) The ages of non-mare non-mascon basins are all in the early Pre-Ne, which infer that the long-time subsequently isostatic adjustment lead to the disappearance of mascons.

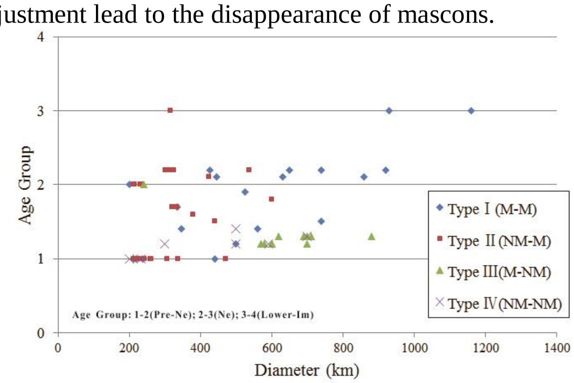

Fig. 3. The distribution of different types basin within age group and basin size.

Conclusion: We propose to understand the mascons with a relative concept, which means that the "relative mascon" shows a "bulls-eye" gravity pattern and an approximate constant value of 2, (C-R)/R. For types of impact basins can be easily applied to various lunar basins and help us to study the geological evolution of different basin types by comparison. We also suggest that mascon formation is the by-product of large impacts on the Moon, and the mascons characteristics of some very ancient basins disappeared because of the subsequently geologic processes.

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Fig. 1. Trends in gravity anomaly within "bulls-eye" gravity pattern basins: a) the relationship between the values of (C-R) and basin size; b) the relationship between the values of (C-R)/C and basin size.