Features and Genesis of the Impact Crater and accumulation of Sinus Iridum Area of the Moon

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1 Introduction

Based on morphological features of craters, quantity and preserving status of fillings of craters, the lunar impact craters can be divided into 7 types and 11 subtypes, and accumulative materials of craters are divided into 6 types and 9 accumulative formations. The Early Imbrian bedrock accumulate groups in the northern terra plateau area consists of crater ejecta plagioclasite accumulative materials, which experienced violent reworking of subsequent impact of craters such as Mare Imbrium and are extensively covered. Such accumulation can also be found around the first ring structure in the southeastern, northeastern and western parts of the Imbrian Basin. The Early Imbrian craters are generally large in size with extensively distributed accumulations, which can be accordingly further divided into three formations: the accumulative group in Mare Imbrium at the early stage of the Early Imbrian, the accumulative group in Sinus Iridum at the middle stage of the Early Imbrian and the accumulative group in Crater Plato at the late stage of the Early Imbrian. This implies the intense impact-magmatism taking place in the study area in the Early Imbrian.

2 Types of impact craters

Impact craters are one of the major ring structures on the Moon, the study of the development, distribution, size, form and structure of the impact craters are of the important significance for the lunar original and evolutional history (Jin et al., 2009; Yue et al., 2006). The craters in this mapping quadrangle can be basically divided into 7 type and 11 subtypes according to their forms, quantity and preservation status of filling materials.

(1) **Bowl-shaped crater:** Small and very small bowl-shaped craters with a diameter ranging from 15 to 20 km, formed mainly from the Copernican to the present.

(2) **Central peak crater**: Craters with a small peak at the center, which have the following groups in consideration of the rocky types constituting the peaks.

(a) Fallback accumulative central peak crater.

(b) Meteorite relict central peak crater.

(3) **Multi-ring crater**: These craters are composed of two ring-like fault zones. They are mostly huge "ancient lunar craters" formed in the Imbrian or earlier with a diameter larger than 300 km. Mare Imbrium can be an example of such huge craters.

(4) **Radial crater:** Craters with evident radial ejecta outside. They were mostly "new lunar craters" formed in the Copernican or later.

(5) **Filled crater:** Craters intruded by or filled up with late-stage basalt or plagioclase magma. They are basically divided into the following groups according to the quantity of the fillings.

(a) Full-filled crater.

(b) Nearly full-filled crater.

(c) Half-filled crater.

(d) No-filled crater.

(6) **Incomplete crater:** Crater partially altered or assimilated by basalt magma with incomplete shape.

(7) **Residual crater**: Craters largely altered or assimilated by basalt magma with features of relicts .

3 Features and genesis of crater accumulation

3.1 Classification of crater accumulation

Analysis of accumulations in craters shows that accumulative materials of impact craters can be divided into 6 types and 9 accumulative formations from the center outwards. (1) *cp*—formation of central peak meteorite relict accumulation or central peak fallback accumulation ("central peak accumulative formation" for short); (2) *ba*—formation of fallback and slump accumulation at the center of a crater ("basin accumulative formation" for short); (3) *fb*—formation of step accumulation of arcuate fault blocks inside craters ("fault block accumulative formation" for short); (4) *db*—formation of dike-like coarse brecciated accumulation outside the crater ("dike-like accumulative formation" for short); (5) *br*—formation of dike-like fine brecciform accumulative outside the crater ("fine brecciated accumulation formation" for short); (6) *ra*—formation of radial accumulatione outside the crater ("radial accumulation formation" for short); (7) *ci*—formation of accumulation inside the crater ("inside accumulation formation" for short); (8) *co*—formation of accumulation outside the crater ("outside accumulation formation" for short); (9) *cr*—formation of crater accumulation, referring to small craters and undividable accumulations ("crater" for short); in addition to secondary craters and accumulation (*sc*) and small crater chains and accumulation (*cc*).

It should be explained that lunar craters tend to have more complex structure when their diameters are increased, and those formed in different times would have varying degrees of subsequent disruption. Therefore, it should be taken into account the particular form and preservation status of a crater for classifying its ejecta materials. During the geological mapping at a scale of 1:2.5 M, for craters that have a diameter < 5 km (pixel size: 2 mm or area: 2–4 mm^2) and are undividable in detail, it is enough to outline craters and accumulative materials (*cr*); for craters with a diameter > 5 km or < 20 km, it is needed to identify accumulative materials inside craters (*ci*) and materials outside craters (*co*); for craters with a diameter > 20 km or <100 km, it is the best to identify all accumulative formations from the center outwards: the central peak accumulative formation, the central accumulative formation, the fault block accumulative formation, the dike-like accumulative formation, the fine breccia accumulative formation and the radial accumulative formation.

3.2 Features and genesis of crater accumulations

Based on the features of accumulative materials formed during impact-ejection process and in consideration of the classification schemes proposed by previous researchers, we unitively named the accumulative materials of craters "crater accumulative group", and the different types of crater accumulative materials are named different "formations". The accumulative materials in the study area are divided into 9 accumulative formations from the center outwards.

(1) Central peak accumulative formation

As for the genesis of central peaks, most of the researchers hold meteorite impact, which will generate intensive downward compression to bedrock in the central crater and make the bedrock respond back upwards. However, we consider that the central peaks might not be formed due to upward response of bedrock since such back response could cause only gentle upheavals instead of local high mountains, and this hypothesis is also supported by analysis of the texture, forms and characteristics of the rocks forming the central peaks.

(2) Basin accumulative formation

As for the genesis of the central accumulation of the basin, we think the accumulation here was mainly generated by the accumulate of ejecta debris and fallback materials at the time when craters were formed. Moreover, the study of the central accumulation of Crater Tycho shows that within craters there are accumulative materials formed due to collapse or slump along crater walls and in areas of accumulative blocks; whereas late-stage filling of basalt and plagioclase magma does not belong to accumulation any longer.

(3) Fault block accumulative formation

(4) Dike-like breccia accumulative formation

(5) Fine breccia accumulative formation

The ejecta materials of this accumulative formation are obviously finer compared with dike-like accumulative blocks, but numerous salient rays are visible. The accumulation becomes thinner from the crater's center towards the edges and meanwhile some small and short radial valleys and gullies can be seen.

(6) Radial accumulative formation

The radial accumulation generally has small thickness and is not evenly distributed. The rays are varied greatly in length: dozens of kilometers, tens or hundreds of kilometers, and are even as long as thousands of kilometers, mainly depending upon the size of crates.

(7) Crater inside accumulative formation

(8) Crater outside accumulative formation

(9) Crater accumulative formation

4 Stratigraphic division

Based on the analyzing results of the samples directly collected in the study area and neighboring regions, especially Montes Apenninus and Montes Carpatus, we preliminarily divide the bedrock and crater accumulation of the study area into five accumulative series in stratigraphy: pre-Imbrian bedrock accumulative group, Early Imbrian crater accumulative group, Late Imbrian crater accumulative group, Eratosthenian crater accumulative group and Copernican crater accumulative group.

Main references

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