

Groups of meteorite-producing meteoroids containing carbonaceous chondrite meteorites

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Abstract

The possibility of existence of groups of meteorite-producing meteoroids which contain meteorites Maribo, Murchison, Shutter's Mill, classified as carbonaceous chondrites and ungrouped carbonaceous chondrite Tagish Lake was analyzed. The main argument for existence of groups of meteorite-producing bodies is the existence of bolides and meteorites with similar orbits and time-correlated meteorite falls. The IAU Meteor Database of Photographic orbits and the other published sources were used to bright sporadic fireballs with currently similar orbits to orbits of analyzed meteorites. The analysis used known and widely used similarity functions – the orbital D_{SH} criterion of Southworth and Hawkins and D_D criterion of Drummond. As a result, some meteorite-dropping sporadic fireballs as possible members of the studied meteorite groups were found and possible regions of origin were considered. Especially the small bodies (50 – 100 m in size) with Earth-crossing orbits on the timescale of human civilization represent natural hazards because of the greatest probability of risk of collision with the Earth. Purposeful monitoring of these bodies in the identified periods of increased fireball and meteorite activity by the means of both land fireball network and space equipment installed in orbital satellites is important to prevent the danger of such impacts.

1. Introduction

Meteorites are very valuable samples coming from different objects in the Solar system that contain records of processes occurring at an early stage of formation of Solar system. Research focused on establishing links between meteorite-producing meteoroids, rare and primitive meteorites and their parent asteroids is very important to understand the origin and evolution of primitive Solar System

materials. The Chelyabinsk meteorite incident [1] has shown that potentially dangerous Near Earth objects (NEOs) of 50-100 m in size and within the timeline of a human civilization can present the greatest threat to Earth because of their higher occurrence among the NEOs than that of bodies in with more than half kilometer in size. Here, we consider the possibility of existence of groups of meteorite-producing meteoroids that can generate carbonaceous chondrite meteorites falling on Earth at present time.

2. Groups of meteorite-producing meteoroids and carbonaceous chondrite meteorites

In this study, we investigate the feasibility of a connection between carbonaceous chondrite meteorites and meteorite-producing meteoroids which form groups of bodies with similar orbits. Groups of meteorite-producing meteoroids crossing the Earth's orbit are defined as the subset of linked orbits of meteoroids and meteorites on the basis of observed photographic data. At present, 4 orbits of carbonaceous chondrites have been published: Tagish Lake [2], Maribo [3], Murchison [4] and Shutter's Mill [5] meteorites. The incidents of these meteorites were observed during the periods of increased meteorite-dropping fireballs activity: January, April-May and September-October [6]. Within the time intervals adjoining the periods of increased activity of meteorite-dropping fireballs, a search for orbits similar to those deduced for the carbonaceous chondrites Tagish Lake, Maribo, Murchison, and Shutter's Mill was carried out. In this connection, the international meteor database IAU MDC_2003, as well as published scientific journals and international conference proceedings obtained from the SAO/NASA ADS database were used to compile a set of photographic orbits of bright and slow moving sporadic fireballs. This data set was used to detect groups of meteorite-producing meteoroids of linked orbits among photographic orbits. To detect a group,

functions of distance D_{SH} [7] and D_D [8] were applied. Thresholds values of orbital similarity $D_c \leq 0.2$ [7] and $D_c \leq 0.105$ [8] were adopted to indicate the orbital similarity. Orbital similarity criteria also provided possible identification of parent body of group of meteorite-producing meteoroids. For each group of meteorite-producing meteoroids, the average orbit of the group was calculated. This average orbit was used to detect the link between meteorites and groups of meteorite-producing meteoroids. A group of meteorite-producing meteoroids and meteorites is a group of meteoroids which contributed to the final mean orbit. As a result, several members of each of the four groups were detected and accepted as members of meteorite-producing groups.

3. Summary and Conclusions

Proposed probable links between meteorites and meteorite-producing fireballs were been considered. Group associations between meteorite-producing meteoroids and meteorites were been determined for four carbonaceous chondrites: Murchison, Maribo, Shutters Mill, and Tagish Lake and potentially meteorite-producing bolides on the basis of relationships between their orbits. As a result, several meteorite-producing sporadic slow fireballs were identified as possible members of four studied groups of carbonaceous chondrite meteorites. One can presume that at present time, the identified groups may still contain large meteorite-dropping bodies. In practical terms, this can serve as an incentive for purposeful monitoring of the indicated groups of meteorite-producing fireballs during the identified periods of increased fireball and meteorite activity by the means of both land fireball networks and orbital satellite tools. Future discovery of additional meteorite-dropping carbonaceous chondrites could provide a deeper insight in the possible connection between their groups and meteorites.

Acknowledgements

This work was supported by the International Science and Technology Center, project T-2113.

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