THE CARANCAS METEORITE IMPACT – ENCOUNTER WITH A MONOLITHIC METEOROID. J. Borovička and P. Spurný, Astronomical Institute of the Academy of Sciences, Fričova 298, CZ-25165 Ondřejov Observatory, Czech Republic, borovic@asu.cas.cz.

Introduction: The formation of a 13.5-m wide impact crater by a stony meteorite near Carancas, Peru, on September 15, 2007 was an unexpected event. The last similar crater forming fall was Sterlitamak in 1990 [1], which, however, was an iron meteorite. Stony meteoroids usually disintegrate in the atmosphere and land in many pieces with small velocity. We will present examples of large fireballs observed within the scope of European Fireball Network. All of them experienced atmospheric fragmentation under dynamic pressures lower than typical strength of meteorites measured in the laboratory. Theoretical work also predicts that stony meteoroids will disrupt in the atmosphere [2]. Another surprising aspect was that the Carancas meteoroid entry was not a particularly energetic event, the kinetic energy being of the order of 0.1 kT TNT [3].

Modeling the Carancas fall: We modeled the Carancas fireball using the equations of the flight of ablating meteoroid through the atmosphere for a range of possible trajectory slopes, initial velocities, ablation coefficients, and drag coefficients. In each case, the initial meteoroid mass was adjusted to yield a prescribed impact velocity in the range $2-6$ km/s, assuming that the meteoroid did not fragment. In each run, we computed the initial energy, maximal dynamic pressure, fireball magnitude, and expected diameter of the crater.

We were able to reproduce the observed crater size with initial meteoroid kinetic energy $0.05-0.3$ kT. The maximal dynamic pressure was $20-40$ MPa, i.e. comparable with tensile strength of stony meteorites [4]. The maximal pressure occured between heights 12 and 15 km. The trajectory slope to the vertical was likely lower than 30°, in agreement with the trajectory derived from infrasonic data and orbital considerations [3, 5]. The maximal absolute magnitude of the fireball was in the range -15.5 to -19.5. The maximum brightness always occured at the height 16.5 ± 1 km. The duration of the fireball (the part brighter than -10 mag) was $4-7$ s. Our model predicts impact velocities lower than 4 km/s. If the impact occurred at sea level, the impact velocity would be only 1.5 km/s or lower.

The initial meteoroid mass was probably in the range $1500-10{,}000$ kg (diameter $0.9-1.7$ m), and the mass of the impactor was $900-4000$ kg ($18-80$% of the original mass, depending on the ablation coefficient), corresponding to the diameter $0.8-1.3$ m. All solutions give initial velocity ≤ 20 km/s.

Conclusions: The fact that majority of stony meteoroids fragment in the atmosphere under low dynamic pressures can be ascribed to the presence of internal cracks and inhomogeneities. The fireball observations already suggested that meteoroid strength is a unique property of each body and does not depend on size as it was assumed in many models. The Carancas meteoroid is a nice example of this fact. It was a large but homogeneous and monolithic meteoroid with strength comparable to the strength of small meteorite samples measured in laboratories.

Not only the high strength but also the right size of the meteoroid was important for crater formation. A larger meteoroid would not be slowed down enough in the atmosphere (unless the trajectory were very shallow) and the dynamic pressure would eventually exceed the material strength. The high altitude of the impact site was also important factor in producing the crater.

References

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