THE CARANCAS EVENT ON SEPTEMBER 15, 2007: METEORITE FALL, IMPACT CONDITIONS, AND CRATER CHARACTERISTICS. T. Kenkmann[1], N. A. Artemieva[1,2], M. H. Poelchau[1], [1]Museum für Naturkunde, Mineralogie, Humboldt-Universität Berlin, Germany, [2]Russian Academy of Science Moscow, Russia, thomas.kenkmann@museum.hu-berlin.de

Introduction: On September 15, 2007, at 19.45 h world time, a meteorite fall occurred on the Puna plateau south of lake Titicaca near the border of Peru and Bolivia (S 16°39'52''; W69°02'38'', 3.824 m altitude) [1]. The meteorite formed a crater 13-14 m in diameter and ~5 m deep into soil. Ejection occurred to a distance of up to 200 m. The rim height is ~1 m.

Rationale: Uncontrolled and uncoordinated sampling of meteorite fragments by local inhabitants as well as foreigners damaged the crater. The onset of the rain season on the Puna high plateau in mid December furthered the destruction of this unique young crater and could probably destroy it completely in the near future. This prompted us to initiate an adhoc documentation of the crater. We have organized a field trip to Carancas from Jan. 3-13, 2008 (beyond the LPSC abstract deadline). We intend to analyze (i) the crater morphometry, (ii) ejecta distribution, and will (iii) map the crater geology. Morphometrical measurements include the determination of crater diameter, crater depth, rim height, and slope angles in radial sectors. Size, weight, and provenance of ejecta will be measured with radial distance. For geological mapping we will attempt to photograph the crater from an aerial perspective. For the analysis of the crater interior we have to pump out the water and use shallow drilling equipment to analyze the breccia infill and identify possible meteorite residues.

Meteorite Fall according to [1]: The meteorite was observed by many people until it had a distance of about 1000 m from the earth surface. It had a strongly luminous head and a white tail. The apparent trajectory was steeply inclined toward NNE. No atmospheric fragmentation was observed and no other meteorite falls were observed in the vicinity of Carancas. The fall was associated with a strong explosion that was felt in the city of Desaguadero 11 km north of the Carancas crater. Window panes were broken at 1 km distance from the point of impact. Observers reported that the sound lasted for about 15 min.The impact occurred into reddish brown soil of several meters thickness near a creek. The soil covers sediments, mainly siltstones and shales of the Puno Group. The groundwater table at the time of impact was about 1 m beneath the surface. This level of infill was re-reached three days after the fall and caused the formation of a small crater pond. After the impact witnesses reported steam or boiling water in the crater and a plume of smoke with sulfurous smell occurred for several minutes above the crater. Larger fragments of the meteorite were collected by local inhabitants. First investigations showed that the meteorite belongs to the group of H4/5 chondrites.

Estimates of pre-impact conditions. Atmospheric entry and subsequent disruption of a meteoroid was analyzed with a program described by [2-3] and using input parameters for stony meteorites (Tab. 1).

Table 1. Material properties of stony meteorites

Density, kg/m^3	3700
Ablation coefficient, s^2/km^2	0.014
Strength of 1 kg sample σ_0, MPa	4.4
Exponent in Weibull law α	0.1-0.25

The parameter study included a variation of (i) initial velocities ranging from 11 to 25 km/s, (ii) masses ranging from 3 to 30 tons, and (iii) entry angles ranging from 15° to 90°. High impact velocities and steep entry angles lead to substantial fragmentation, low final masses of fragments and, hence, low final velocities. Under such conditions a meteorite strewn field, and not an isolated crater as in the case of the Carancas event is expected. The parameter studies lead to identical size-velocity distributions of final fragments (Fig. 1). That means the velocity is almost entirely controlled the atmospheric mass-dependent deceleration.

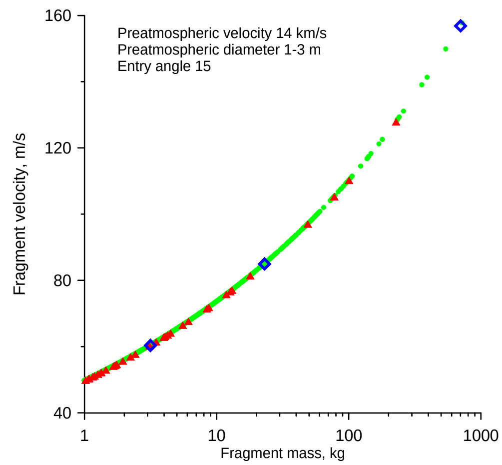

Fig. 1. Final fragment velocities versus fragment mass for various impact scenarios. Green dots represent a 3-m-diameter impactor, red and blue – 3 times smaller impactor (blue is for a stronger stone, i.e. exponent in Weibull distribution is 0.1, not 0.25).

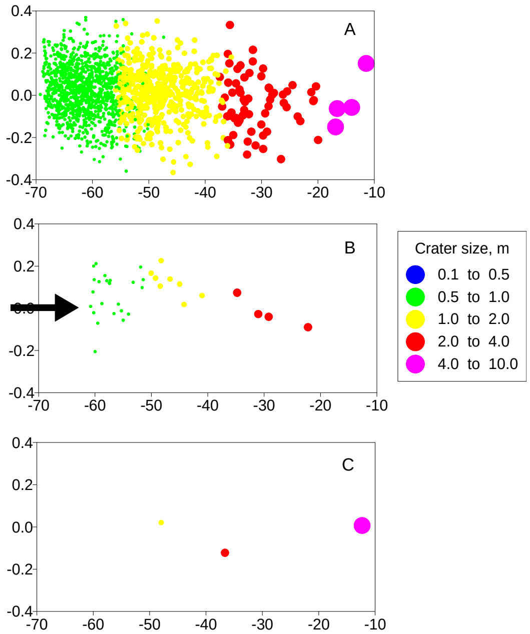

Fig. 2. Strewn fields for 3 scenarios: A – 3-m-diameter stone (52 tons); B and C – the same 1-m-diameter stone (1.9 tons), but C has higher strength. Black arrow shows impact direction. Different colors represent estimated crater sizes.

Best impact scenario. Largest fragments and highest velocities have been obtained at a moderately low initial velocity of 14 km/s and a shallow entry angle of 15°. Large pre-impact mass of 52 tons leads to an intensive strewn field which is strongly elongated along the trajectory (up to 60 km) with largest craters formed at the downrange part of the strewn field (Fig. 2A). Substantially smaller pre-impact masses of 2 tons (Fig. 2B and 2C) create a smaller strewn field (40 km × 0.4 km) with less meteorites and craters. A weak projectile (Fig. 2B) produces several m-sized pits, while a stronger projectile reproduces the Carancas meteorite scenario (Fig. 2C) at best with one major crater pit. This meteorite is also subjected to fragmentation, however, there are less (probably 3-5) fragments which were dispersed over a large area.

Final fragment and its crater. The largest fragment could be the Carancas-meteorite. Its final size in the model is ~ 0.7 m (700 kg), the final velocity is 160 m/s, and the impact angle is almost 90°. Taking into account the altitude of the impact site (3800 m), we can expect an impact velocity of 180 m/s instead of 160 m/s. Craters produced under low-velocity conditions are different from standard hypervelocity impact craters. We denote them "pits". Most probably, the crater had a conical shape and is deeper than "normal" simple craters. Estimates of its diameter strongly depend on the target properties but are close to those of Carancas. *Sound effects.* The fragment struck the surface with a velocity below sound speed in air. However, at altitudes above 10 km its velocity was high enough to produce shock waves in the air, which reached the surface after 30 s (20 s earlier than meteorite itself) (and made the "frightening" noise) (Fig. 4).

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References: [1] Macedo, L., Macharé, J., 2007, The Carancas Meteorite Fall, 15 Setember 2007 Official INGEMMET initial report. [2] Artemieva, N. A., Shuvalov, V.V. 2001 JGR 106, 3297-3310. [3] Bland, P. Artemieva, N. A. 2003, Nature 424(6946), 288-291.

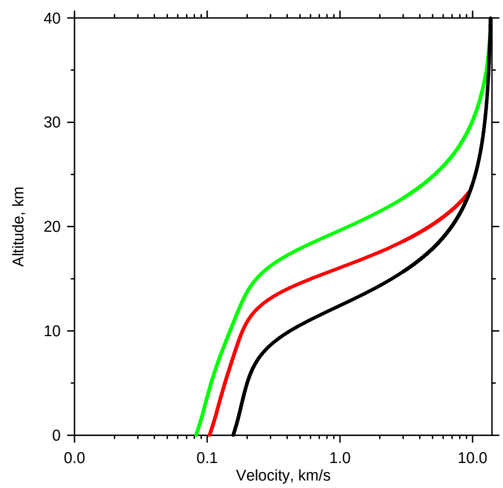

Fig. 3.Fragmentation and deceleration of the Peru-meteorite in atmosphere. First fragmentation occurred at an altitude of 38 km, second – at an altitude of 22 km. In both cases velocity was still higher than 10 km/s. Smaller fragments (green and red curves) decelerated quicker than the Peru-meteorite (black curve). The latter lost 90% of its initial velocity at 12 km altitude; its flight became subsonic at 9-km-altitude.

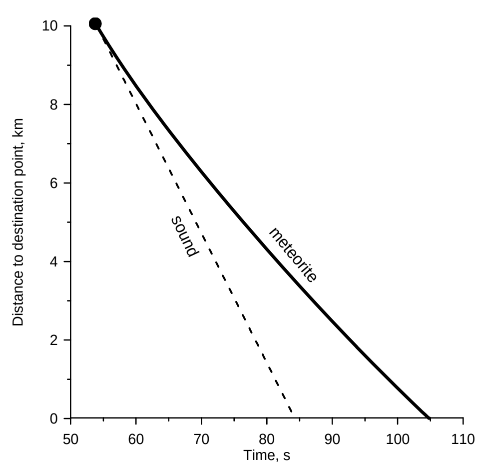

Fig.4. Motion of meteoroid and propagation of shock wave from an altitude of meteoroid deceleration to 330 m/s (sound speed in air)