WHAT DO WE KNOW ABOUT THE "CARANCAS-DESAGUADERO" FIREBALL, METEORITE AND IMPACT CRATER? G. Tancredi[1], J. Ishitsuka[2], D. Rosales[2], E. Vidal[2], A. Dalmau[2], D. Pavel[2], S. Benavente[3], P. Miranda[4], G. Pereira[4], V. Vallejos[4], M. E. Varela[5], F. Brandstätter[6], P. Schultz[7], R. S. Harris[7], L. Sánchez[1]. [1]Dpto. Astronomía, Fac. Ciencias, Iguá 4225, 11400 Montevideo, Uruguay, gonzalo@fisica.edu.uy, [2]Instituto Geofísico del Perú, Lima, Perú, [3]Universidad Nacional del Altiplano, Puno, Perú, [4]Planetario Max Schreier, Universidad Mayor de San Andrés, La Paz, Bolivia, [5]Complejo Astronómico El Leoncito – CASLEO, San Juan, Argentina, [6]Naturhistorisches Museum, Vienna, Austria, [7]Dept. Geological Sciences, Brown University, Rhode Island, USA.

Introduction: On September, 15th, 2007, close to noon local time, a bright fireball was observed and heard in the southern shore of the Lake Titicaca, close to the border between Peru and Bolivia (see map in Fig. 1). Many peasants and residents of the town of Desaguadero (Peru) and Guaqui (Bolivia) observed the fireball from East to West. The peasants of the Community of Carancas, 10km south of Desaguadero, that were watching out their llamas and alpacas, heard a big explosion and observed the formation of a mushroom cloud. Minutes after, in the point of explosion, they found a ~15m hole in the terrain, half filled by underground water, and a lot of dispersed blocks of soils of sizes over a meter. Some pieces of a grayish material were found, clearly distinct from the sedimentary rocks of the terrain (molasses or red beds).

We have access to copies of a couple of video recordings of the crater taken less than an hour after the event. The walls of the crater showed a gray powder spread everywhere. Bubbles coming out of the water could be observed to last for several minutes after the event. Several of us from Peruvian and Bolivian institutions visited the site a couple of days after the event. We collected samples of the grayish material as well as samples of the dispersed brown soil. In a preliminary analysis to the collected material, we found the presence of chondrules in the grayish material and we observed that the dispersed blocks showed an ejecta pattern. Taking into account the comments of several witnesses, we tentatively concluded that the phenomenon corresponded to a meteorite strike on the Earth, forming an impact crater.

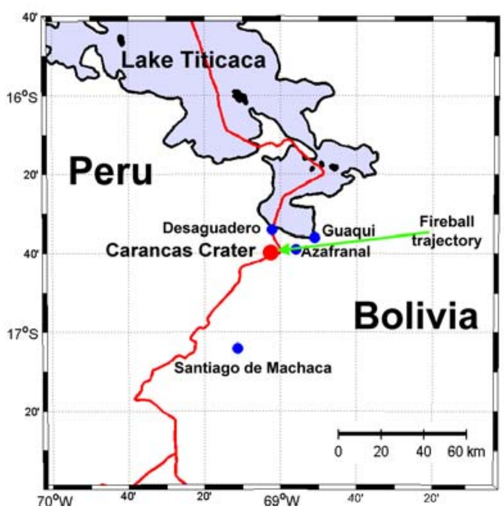

Fig. 1 – Map of the area. The altitude of the impact site is 3824m.

Fig. 2 – Photo of the crater and the close ejecta taken on December, 14, 2007.

It is the first time in the recorded history that several persons witness the formation of an impact crater. An international and multidisciplinary group was created to study this interesting event. In the following sections we analyze the results that we have reached so far about: a) the fireball and its trajectory; b) the meteorites; c) the crater and the ejecta.

The fireball and its trajectory: Unfortunately we have very few objective records of the passage of the fireball. There is just one photo of a wavy smoke trail but without any ground reference; the picture was taken after the trail was deformed due to the winds and it is difficult to estimate the straight trail respect to the ground. Both infrasound as well as seismic stations detects the airblast in the upper atmosphere and, in some cases, the explosion when the meteorite strokes the earth. The infrasound stations of the International Monitoring System located in La Paz, Bolivia (I08BO, 81 km from the impact site) and in Asunción, Paraguay (I41PY, 1620 km) detected the airwaves that can be associated with the fireball. Four seismic stations run by the Observatorio San Calixto (Bolivia) that are located close to La Paz and a station located on a side of Volcano Ubinas (Moquegua, Peru) detected a signal from the event. Brown el al. [1] obtain a trajectory solution using the infrasound and seismic data; they place the fireball radiant at an azimuth of 82° relative to the crater with an entry angle from the horizontal of 63°, and an impact time of 16h40m17s UT.

We have collected a few testimonies of witnesses in an area covering several tens km from the impact site, most of them were east of the crater. Hereby are their testimonies (see map in Fig. 1): 1.- The witnesses located between Desaguadero and Azafranal, facing south, observed the bolide heading from left to right. 2.- There are two sets of reports from the people in Guaqui: ones saw the bolide descending over their head and then, facing south, it headed to the right. The others (closer to the Lake Titicaca) saw the bolide over the hills that are in the southern direction and going from left to right. 3.- In the Communities of Corpa and Yahuri Khorawa (10 km north of Santiago de Machaca), facing north, they saw the bolide from right to left. Taking into account these testimonies and the solution obtained by [1], we compute sets of geocentric radiants centered in the apparent radiant (Az=80°, Alt=60°) and pre-atmospheric velocities from 12 to 18 km/s. We plot the different solutions in an equatorial frame for the impact time with a central meridian passing through the Sun. The solutions are marked with + signs of different colors. The yellow dot corresponds to the Sun and the big black dots to the anti-Sun. We also plot the radiants of NEAs (small black dots) [2]. The solutions of low altitude (i.e. Az=80°, Alt=30°) are less likely compatible with NEAs' orbits.

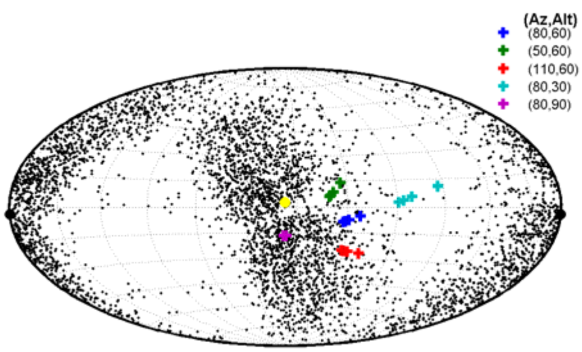

Fig. 3 – Radiants in ecuatorial coordinates of a set of possible solutions (+ signs) and NEAs (black dots)

Note that all the solutions have low inclinations, (i≤5°). The low-velocity alternatives gives aphelion distances inside the Jupiter's orbit. Therefore, we favor the solutions with pre-atmospheric velocities v ≤ 16 km/s, and apparent radiant Az ~ 80° and Alt ≥ 60°.

The meteorites: Several samples of grayish material were collected just a few minutes after the formation of the crater. Petrographic and EMP analysis were performed in two thin sections. The chondrule textures, the minor amount of clinopyroxene as well as the relatively uniform composition of olivine and pyroxene grains (Fs:16.7, Fa:18) allows classification of Carancas as an H 4-5 Ordinary Chondrite. We measure the density of a meteorite sample to be 3630 kg/m^3.

The crater: In Fig. 4 we present a sketch of the crater. Note the difference in height between the NE and SW rim of the crater. This difference is due a natural slope of the terrain. The crater was formed in the bank of an ephemeral river channel. It partly occupies the riverside and the dry bed. The shape of the crater and the distribution of ejecta corresponds to an impact crater rather than a penetration hole.

The meteorite was strongly decelerated in the passage through the atmosphere. Nevertheless, the impact velocity was ~3 km/s. Using Housen and Holsapple [3] cratering laws, we obtain that the impactor should have a diameter of ~1.1m, a mass of ~3 tons and the impacting energy was ~2 ton TNT. No pieces of the meteorite larger than a few kg were found yet.

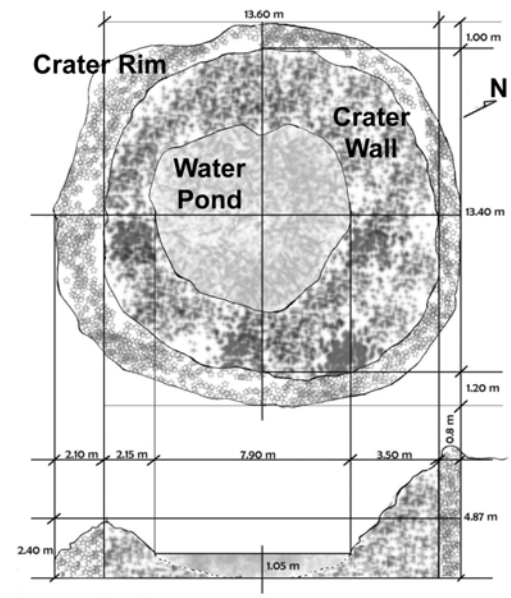

Fig. 4 – Sketch of the crater (drawn by V. Vallejos)

Pieces of brown soil ejected from the crater were found at distance over 350m from the crater in the SW direction, in correspondence with the NE-SW direction of the trajectory. The ejected soil has a density of ~1700 kg/m^3.

References: [1] P. Brown, E.A. Sukara, D.O. ReVelle, W.N. Edwards, S. Arrowsmith, L. Jackson, G. Tancredi , D. Eaton, (2007) subm. to Earth & Planetary Science Letters. [2] G. Tancredi, abstract in IAU Symposium 236 "Near Earth Objects". [3] K. Housen, K. Holsapple (2007) *Icarus*, 187, 345-356.