

GUELtat ZEMMOUR: AN L4 ORDINARY CHONDRITE FALL IN MOROCCO ON AUGUST 2018.

H. Chennaoui Aoudjehane¹, M. D'Orazio², L. Folco², Å.V. Rosén³, B. A. Hofmann³ and V. Moggi Cecchi⁴, ¹GAIA Laboratory, Hassan II University of Casablanca, Faculty of Science Ain Chock, km 8 Route d'El Jadida 20150 Casablanca Morocco, (chennaoui.hasnaa@gmail.com), ²Scienze della Terra, Università di Pisa, Italy, ³Natural History Museum Bern, Switzerland, ⁴Museo di Storia Naturale – Sistema Museale di Ateneo, Università di Firenze, Italy

Introduction: On 21st of August 2018 around 14:20 (GMT+1), a fireball was seen by many people from the south of Moroccan Sahara. The fall occurred one day before the most important religious celebration for Muslim people “Aid Al Adha”. The detection was immediately reported to Moroccan meteorite hunters. Because of the importance of this religious event, no one went to the fall area to search for a potential pieces of the meteorite on this time. A few days after the fall, the search began and first piece was found on the second week of September a few kilometers on the West of Gueltat Zemmour. It was the area where the report of the deflagration was the most important. We organized a field mission on 22nd September to the fall site to document the fireball information, the fall coordinates and strewnfield and to collect samples. We got the support of the “Moroccan Association of Meteorites” on the field work as well as to get samples for the classification.

Field mission report: Gueltat Zemmour is a military campement, it is located in a desertic and extremely hot area. Close to this campement, many nomads are living. During summer time, mostly all nomads are moving to cooler places north of this area to feed their livestock. Only a few families were there around the time of the fall.

Eyewitnesses from different places, reported a fireball red then yellow-white colored and shining brighter than the sun during about three seconds. In the fall area, this fireball was very large comparable in size to a burning van. It was moving from the northeast to southwest during a few seconds. Nomads in the fall area heard a whistling sound almost identical to the ocean waves, then a strong sound similar to the explosion of a mine followed by a few (5) sonic booms that resonated in the entire Ouled Labiyad valley similar to the thunder and giving the feeling that the mountains will crumble. There was smoke in the sky directly above them.

A group of hunters found many small pieces (up to 15 g) in a valley between Wad Awzireft and Wad Labiyad and the North of Koudiat Rjilya. Larger pieces were found SW of this site. The direction of the fall was NNE-SSW and the strewnfield extends about 12 km in elongation.

Physical description: Very fresh and non weathered pieces where collected. In total, a few small pieces totalling around 500 g and 3 larger ones (5448 g, 1374 g and 426 g) have been reported so far. Large pieces are broken and show a grey coloured interior, they are partially covered by a fresh mat black fusion crust. Small pieces where complete and totally covered by a black matte fusion crust. The stones are very friable. Broken surfaces reveal a fine-grained texture with visible mm-sized chondrules.

Petrography and geochemistry: SEM observation of thick sections shows numerous well-defined chondrules (POP, PO, GPO, PP, RP and glassy chondrules) up to 3mm in diameter. Plagioclases are very small up to 2 µm in size. Mesostasis is microcrystalline. Most metal and sulphides are automorphous grains micron sized to large grains up to 500 microns, they occur inside chondrules as small grains, in the mesostasis as small and large grains and surrounding some chondrules. Magnetic susceptibility measured by SM30 give a $\log \chi$ of 4.95. EMPA analyses performed at the Firenze IGG-CNR laboratories allowed to determine this composition: olivine is $\text{Fa}_{25.95 \pm 0.69}$ with an Fe/Mn ratio of 51.23, orthopyroxene is $\text{Fs}_{20.69 \pm 0.81} \text{Wo}_{1.1 \pm 0.51}$ with an Fe/Mn ratio of 28.51 and plagioclase is $\text{An}_{8.22 \pm 2.37} \text{Or}_{4.78 \pm 0.83}$. Taenite composition is $\text{Ni}_{50.27 \pm 2.73}$. Whole-rock trace-element concentrations by ICP-MS (µg/g): V 59, Cr 2799, Ni 10115, Co 399, La 0.329, Ce 0.879, Pr 0.138, Nd 0.645, Sm 0.211, Eu 0.088, Gd 0.284, Tb 0.054, Dy 0.364, Ho 0.081, Er 0.242, Tm 0.035, Yb 0.236, Lu 0.038.

Terrestrial age confirmation: cosmogenic radionuclides measurement by gamma-spectrometry at the GeMSE facility in October 2018 on a 21.74 g sample showed the presence of several short-lived cosmogenic radionuclides including ⁷Be ($t_{1/2}$ = 53 d) and ⁴⁸V ($t_{1/2}$ = 16 d). Recalculated to August 21, 2018 the ²²Na/²⁶Al activity ratio is 1.7 ± 0.1 , which is consistent with a fresh fall. This measurement confirm the date of the fall reported by eyewitnesses.

Classification and discussion: According to its petrography, geochemistry, chondrules size and number and magnetic susceptibility, “Gueltat Zemmour” is an L4 ordinary chondrite, with a moderate shock intensity S2 and no weathering W0. The total known weight so far is about 8 kg. It is the second L4 fall in Morocco following “Sidi Ali Ou Azza” [1] and one of the 24 small group of L4 falls know in all over the word [2]. For its pristine state and relatively large mass Gueltat Zemmour provides an interesting material to work on this class of meteorites.

References: [1] Chennaoui Aoudjehane H. et al. (2016) *Meteoritics & Planetary Science* 51:S1 abstract 6120, [2] www.lpi.usra.edu/meteor/metbull.php

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