A PROBABLE IMPACT STRUCTURE IN BETIC CORDILLERA, ALMERÍA, SE SPAIN

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INTRODUCTION: Tabernas Basin (Betic Cordillera) is filled with Neogene, Pliocene and Pleistocene sediments, discordant on a metamorphic basement (Fig. 1 and 2). During Tortonian sedimentation an up to 70 m thick bed of breccia (the Gordo Megabed) was deposited. It consists of up to several tens of meters large, rotated sedimentary megablocks frequently capped and/or surrounded by a polymict breccia of mainly up to m-sized clasts of the crystalline (schist) basement. Previous workers have suggested the bed to be a seismite. The polymict composition of the studied breccias intercalated within the otherwise shallow-marine sediments, the presence of megablocks, plastically deformed megablocks and shock metamorphic features in quartzs of polymict breccias have led us to the description and reinterpretation of sediments and geomorphological features in the Tabernas Basin that could be related to an impact structure.

METHODOLOGY: Multiple field studies were carried out over the course of several years to study the geology and geomorphology of the Tabernas Basin and its surroundings with special focus on the Gordo Megabed. These studies were carried out in conjunction with geological mapping and the measurement of parameters of the observed geological structures. Thin sections (97 in total) from the different lithologies and locations were prepared and studied for shock metamorphic features under an optical microscope. Quartz grains displaying planar features were studied using the techniques described in Stöffler and Langenhorst (1994) and Ferrière et al. (2009).

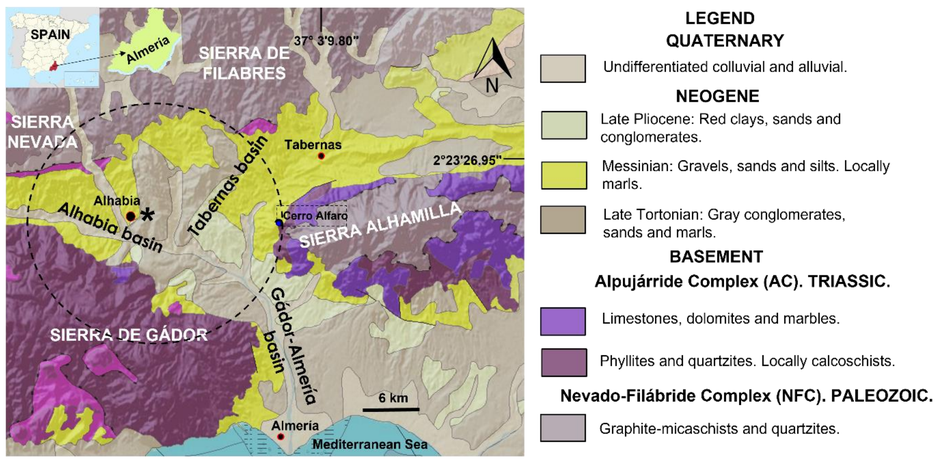

Fig. 1. **General geological setting** of the Neogene basins: Alhabia Basin, Tabernas Basin and Gador-Almeria Basin, situated in southeastern Spain in the province of Almeria. Cartographic viewer, IGME (Instituto Geológico y Minero de España). A magnification of the inset is shown in Fig. 3. The star indicates the inferred center of the impact structure. Stippled circle indicates apparent maximum extent of the disturbed zone.

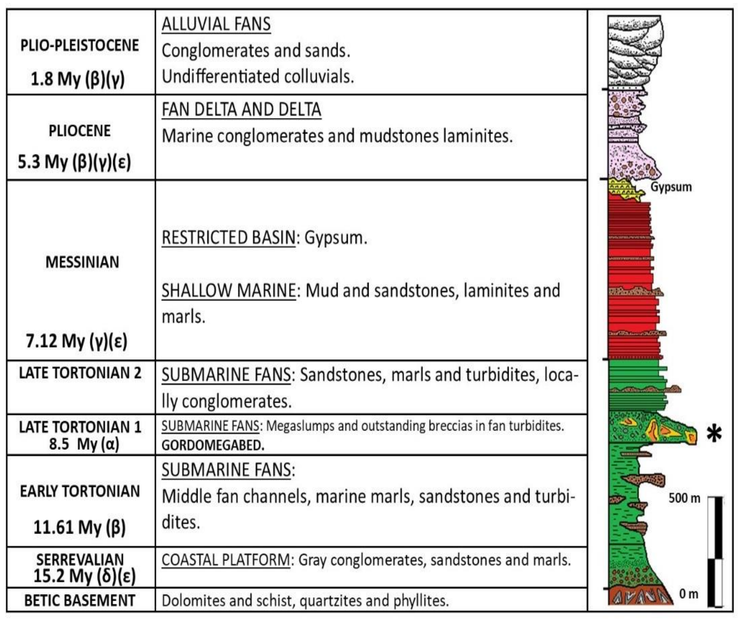

Fig. 2. **Stratigraphic succession** of Neogene and Quaternary sedimentation of the Tabernas Basin [Modified from: (α) Berggren et al. 1995; (β) Crespo-Blanc et al. 2016; (γ) García-García et al. 2016; (δ) Sanz de Galdeano and Vera 1991 and (ε) Weijermars 1991]. Star indicates the stratigraphic position of the proposed impact event and related lithologies.

RESULTS:

Megablocks:

We define megablocks as coherent rock blocks that are tilted or rotated, lithologically homogeneous, and that extend in outcrops over at least 30 meters (i.e. having dimensions of several tens of meters).

The material of the megablocks is often made up of sets of turbidites belonging to the Gordo Megabed and three zones have been identified and mapped:

- Zone 1: Central part of the Neogene basin of Tabernas (Rambla de Tabernas).
- Zone 2: Borders to zone 1 to the east and features such as Cerro Alfaro.
- Zone 3: Neogene basin of Alhabia, on the northern
- flanks of Sierra de Gador.

Plastically Deformed Megablocks:

We have studied three outcrops of these structures SB1, SB2 and SB3 (Fig. 3). They involve recumbent folds with reverse limb whose fold axes follow the direction: N25E, N275E and N210E. They represent plastic internal deformation of the within the slump unit mobilized stacks of Late Tortonian turbiditic marl and sandstones beds, inclined to the NE, W and SW and their directions do not match the main tectonic structures that formed these Neogene basins E-W to NE-SW (Martínez et al., 2017).

Fig. 3. Panoramic photographs of **Plastically Deformed Megablocks** within the slump deposits of the Gordo Megabed. Faults: red lines. Bedding: blue lines. a) Slump block SB1, among rotated blocks and the remains of an eroded breccia made up of black hills of conical morphology. Red green: 130 m. b) Slump block SB2, among tilted blocks. Faults: red lines. Bedding: blue lines. c) Slump block SB3, exceptional (outstanding) megaslump (1), in contact with polymict breccia with clasts graphite-micaschist, quartzites and gneiss (2), and upper erosion surface. Note persons for scale.

Polymict breccias:

Most of the polymict breccias studied are located at the Rambla de Tabernas and present a single lithostratigraphic, mainly graphite-micaschist, quartzite and gneiss, as well as brecciated dolomite, (Fig. 4). These breccias are massives, unstratified, clast supported and lacks visible sedimentary structures. The angular shape of the fragments indicates short transport, but the basement clast lithologies of the breccia originates far from the present locations.

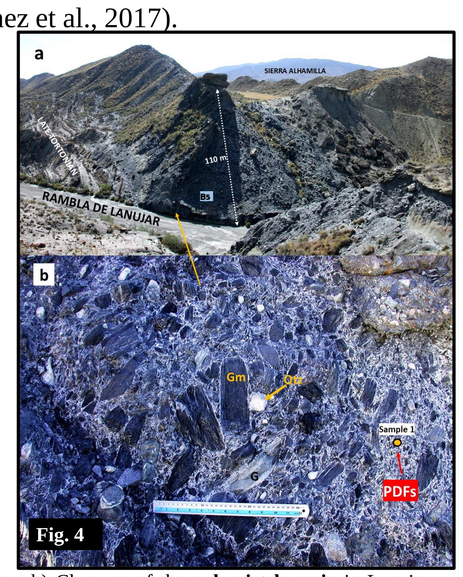

Fig. 4. a) Drone aerial photography of **Lanujar Breccia.** b) Close-up of the **polymict breccia** in Lanujar Rambla, and location of sample 1 analysed for shock evidence, PDFs . The polymict breccia has sharp-edge clasts of graphite-micaschist (GM), quartzite (Qtz) and gneiss (G) belonging to the metamorphic basement of the Tabernas Basin.

Shock-metamorphic features:

The systematic search for quartz grains with shock metamorphic features in breccias, resulted in six quartz grains, five grains displaying one set of planar features and one grain with two sets. The features are straight, parallel, sets of planes with a typical spacing between each plane of 1-5 μm. The planar features penetrate the entire grain in four cases, and in two cases they were only visible near the grain boundary in part of the host grain. The features are generally fresh, but occasionally decorated, i.e., lined by minute fluid inclusions (Fig. 5 and 6). Nevertheless, in light of the indicative, albeit not affirmative, presence of a shocked quartz grains in what we find as analogous lithologies to known impactites based on their composition, appearance, stratigraphic position and geographical distribution, as well as the other sedimentological, stratigraphic, petrographic and geomorphological observations, lead us to propose the existence of a possible impact crater in the Tabernas Basin of Almeria. In our model, the crater is still to large parts preserved, but covered by post-impact materials, which only leaves an already heavily eroded part of the structure visible on the eastern edge.

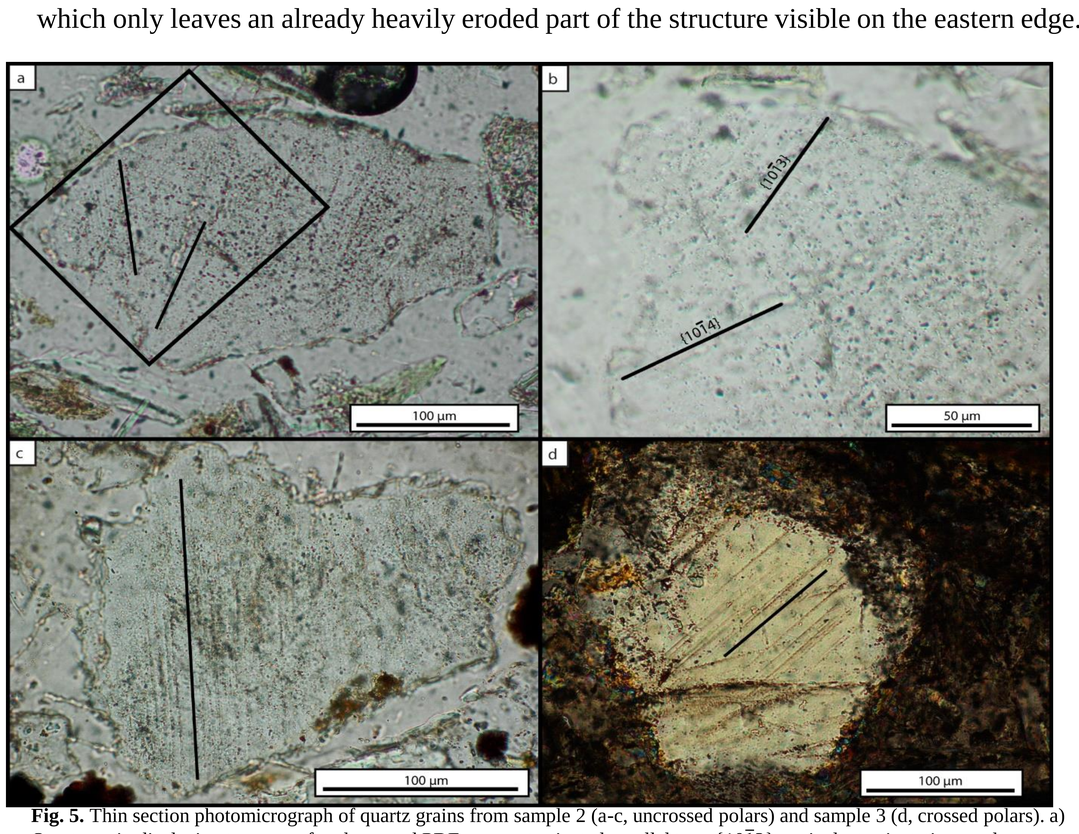

Fig. 5. Thin section photomicrograph of quartz grains from sample 2 (a-c, uncrossed polars) and sample 3 (d, crossed polars). a) Quartz grain displaying two sets of undecorated PDFs, one set oriented parallel to ω {10$\bar{1}$3} equivalent orientations and one set oriented parallel {10$\bar{1}$4} equivalent orientations. b) Close-up of part of the grain in a (black rectangle). Note that the set oriented parallel {10$\bar{1}$4} equivalent orientations, is hardly visible in the image but is clearly observable under the U-stage microscope. c) Quartz grain with one set of decorated planar features. d) Quartz grain with one set of partly decorated planar features.

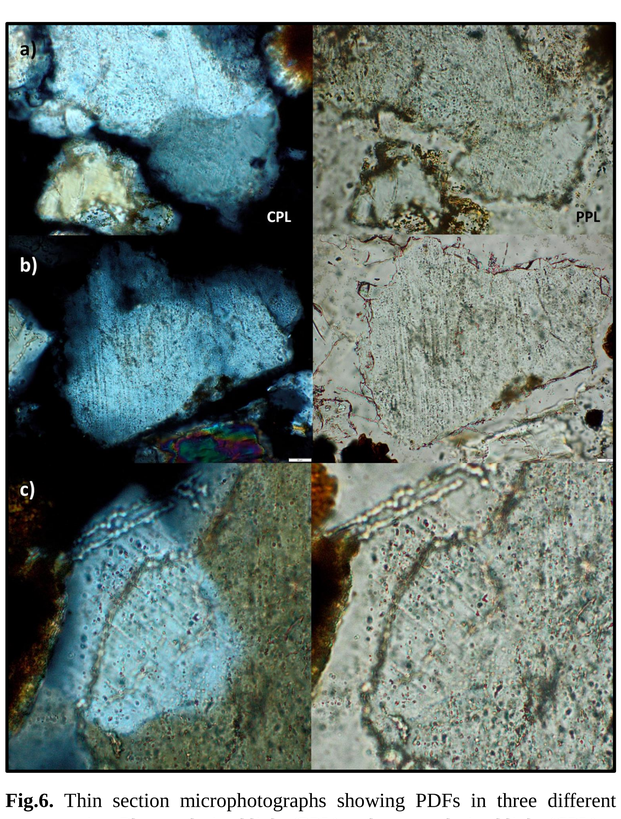

Fig.6. Thin section microphotographs showing PDFs in three different quartz grains. Plane polarized light (PPL) and cross polarized light (CPL).

CONCLUSIONS:

A comparison with established impact craters showing similar geological features suggests that the Tabernas Basin still holds a well-preserved, concentric impact structure with a mainly buried, 4-km wide nested crater in the basement surrounded by a 22-km wide, outer crater formed by extensive gravitative collapse of a tens of meters thick, upper target layer of semi- consolidated sedimentary strata, likely in a shallow aquatic paleoenvironment.

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