# Kaş (Turkey/Greece) and Rubielos de la Cérida (Spain) Meteorite Impact Structures: Comparative Insights into Prominent Sedimentary Carbonate Targets

Alison Ure[1], Robert Westaway[2], David R. Bridgland[3], Fernando Claudin[4], Kord Ernstson[5]

[1]School of Environmental, Earth and Ecosystem Science, The Open University, UK [2]School of Engineering, University of Glasgow, UK [3]Department of Geography, Durham University, UK [4]Faculty of Letters, Geography Department, [4]4Llinars del Vallès. Barcelona-08450, Spain; [5]Faculty of Philosophy, University of Würzburg, Germany

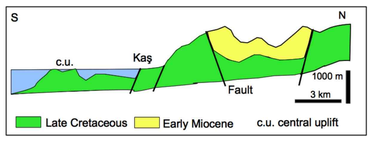
## Introduction

The Kaş structure began to crystallize in many ways as a faithful copy of the large Spanish Rubielos de la Cérida impact structure and the extensive geological impact inventory of Rubielos de la Cérida became a helpful guideline in the terrain exploration of the new Kaş structure. What is special about this is that both structures are laid out in a purely sedimentary target, which is also largely formed in carbonate facies. While the products of meteorite impacts into dense, mostly crystalline and mixed targets are relatively well understood and macroscopic and microscopic deformations of these target rocks are the norm, the response of volatile -rich sedimentary rocks, in particular carbonate rocks, to impact, remains debated. Here we report on a selection of amazingly remarkable similarities in both impact structures as instructive illustrative material for impact terrain studies, especially as they are terrain with predominantly excellent field conditions and mostly easily accessible outcrops in pleasant climates.


## The Kaş Bay impact structure


Location map for the Kaş structure at the Greek/Turkish boundary (green), the suggested extrapolation of the structure to the sea (yellow) and a distinct central uplift in the form of a peak ring (red).

Ure et al. [1, 2] have for the first time suggested a possible Kaş Bay impact structure based on preliminary geologic field evidence. New field studies and laboratory analyses further strengthen the impact hypothesis. With a diameter of about 10 km and a central uplift (Figs. left and below) Kaş Bay is classified as a complex impact structure. The local bedrock is Cretaceous neritic limestone. Based on stratigraphical evidence, uplift and subsidence rates, an age from the Pleistocene epoch is probable.

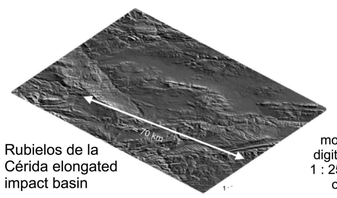




From the geological map of the Teke Peninsula [3]: Strongly simplified and modified cross section.

## The Rubielos de la Cérida impact structure (or impact basin)

– as part of the Azuara/Rubielos de la Cérida impact crater chain

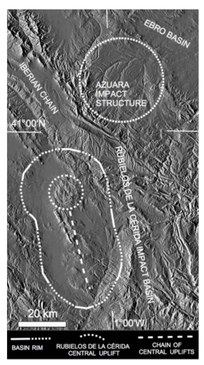
is an elongated impact basin with a central-uplift chain as part of the Mid-Tertiary Azuara multiple impact event (Fig. below) [4 - 8], which is still doubted by some Spanish regional geologists, is given by geological and geophysical evidence like ubiquitous monomictic and polymictic breccias, large systems of monomictic and polymictic breccia dikes, enormous and extended megabreccias, shatter cones, extended impact ejecta, gravity and geomagnetic anomalies, strong shock metamorphism like shock melt, planar deformation features (PDFs) and diaplectic glass in various minerals [4 - 8].

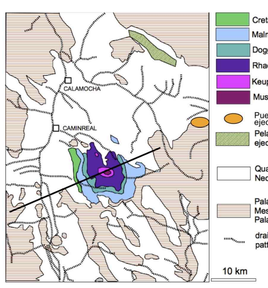



Rubielos de la Cérida elongated impact basin

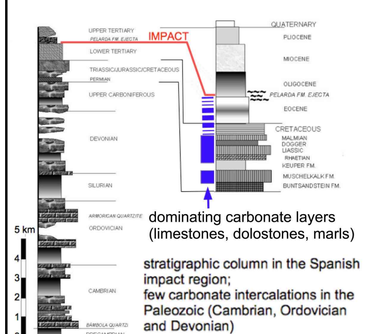
Azuara multiple impact event

modified from the digital map of Spain 1 : 250,000, courtesy of M. Cabedo



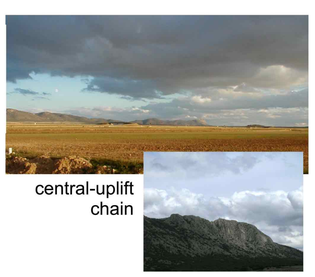




simplified geological map and section of the principal central uplift


dominating carbonate layers (limestones, dolostones, marls)

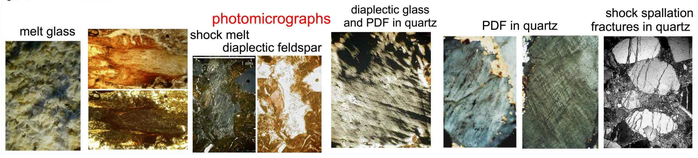
stratigraphic column in the Spanish impact region; few carbonate intercalations in the Paleozoic (Cambrian, Ordovician and Devonian)



central-uplift chain

Abundant and strong shock metamorphism

photomicrographs

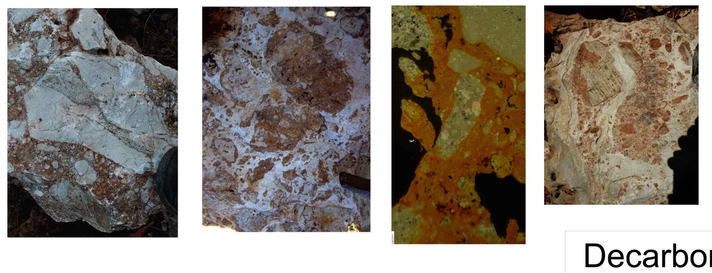



## Kaş

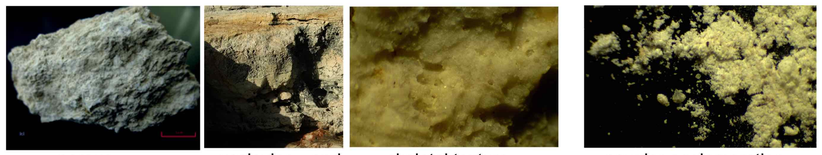
### Megabreccias and scour planes

### Breccia dikes (dike breccias)

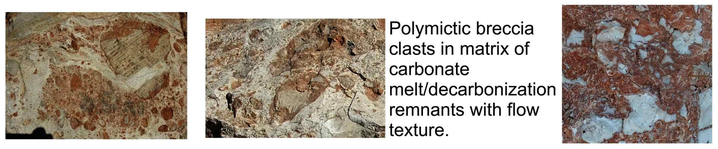
### Polymictic breccias, breccia generations



### Decarbonization, carbonate melt rocks



porous, vesicular and skeletal texture powder agglomeration

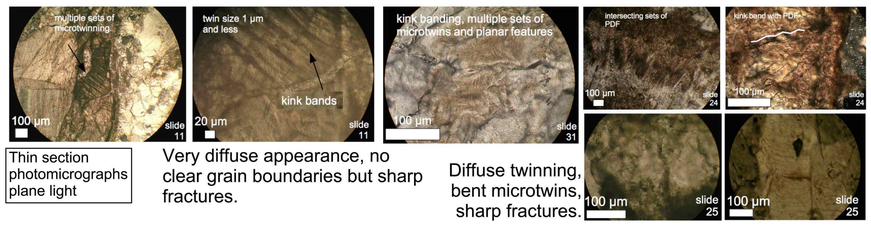


Polymictic breccia clasts in matrix of carbonate melt/decarbonization remnants with flow texture.

Carbonate melt remnants (?) (white filaments) and plastically deformed limestone components.

### Shocked calcite

Multiple sets of microtwins in calcite

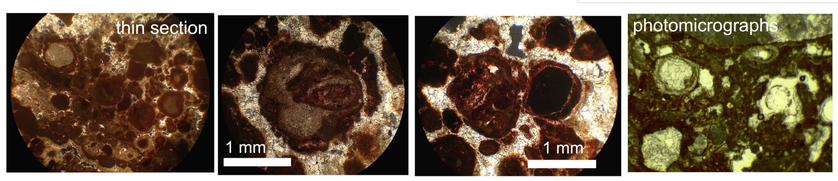



Thin section photomicrographs plane light

Very diffuse appearance, no clear grain boundaries but sharp fractures.

Diffuse twinning, bent microtwins, sharp fractures.

### Accrecionary lapilli, lapillistones




## Rubielos de la Cérida

### Megabreccias and scour planes

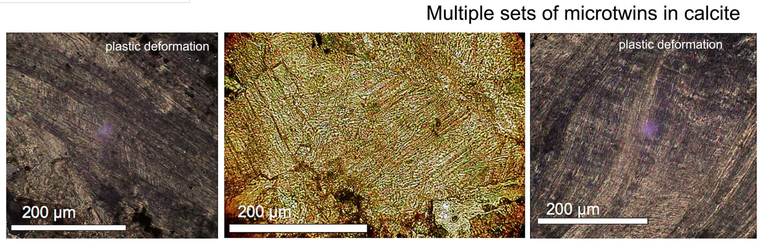
### Breccia dikes (dike breccias)

### Polymictic breccias, breccia generations

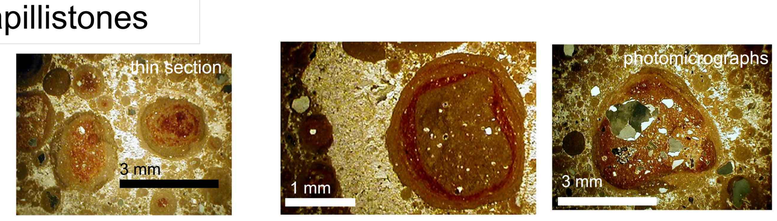
### Decarbonization, carbonate melt rocks


### Shocked calcite

Multiple sets of microtwins in calcite




### Accrecionary lapilli, lapillistones




**References:** [1] Ure, A. et al. (2017) *LPSC XLVIII,* Abstract #1144. [2] Ure, A. et al. (2018) *LPSC XLIX,* Abstract #1455. [3] Bayari, C.S. et al (2011) *Hydrogeol. J.*, 19, 399-414. [4] Ernstson, K., et al. (2002). *Treballs del Museu de Geologia de Barcelona,* 11, 5-65. [5] Ernstson, K. et al. (2001), Geology, 29, 11-14. [6] Hradil, K. et al. (2001) Abstracts, *6th ESF IMPACT workshop, Impact Markers in the Stratigraphic record*, pp. 49-50, [6] Ernstson, K. et al. (2001) Abstracts, *6th ESF IMPACT workshop, Impact Markers in the Stratigraphic record*, pp. 23-24 [7] Claudin, F. et al. (2001) Abstracts, *6th ESF IMPACT workshop, Impact Markers in the Stratigraphic record*, pp. 15-16. [8] Ernstson, K. and Claudin, F. http://www.impact-structures.com/accessed 14/12/18. [9] Pilles, A. et al. (2018) *LPSC XLIX,* Abstract #1994.

**Conclusion:** Very large impact structures in purely sedimentary, in particular predominantly carbonate targets, are rare and have not been much investigated to date. The comparison of two such big structures with an overabundant inventory of impact-typical formations, deformations and petrographic evidence, clearly shows that a considerable neglect of impact research can be observed here.

Even in recent publications, e.g. in a review "of impact melt and breccia dikes in terrestrial impact structures" [9], sedimentary targets are mentioned only casually in a single sentence about lithic breccia dikes, apparently forgetting that such an inventory exists to a much greater extent and variability as exemplified here.