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Use of CT Scanning and Radiography as Legal Expert Evidence in Paleontology (Trilobites of Morocco)

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Abstract: This study presents CT Scanning and radiography techniques applied to invertebrate paleontology, specifically to the detection of trilobites forgeries in Morocco. A well-known technique uses ultraviolet rays to detect falsified resin elements in trilobites. This technique is very effective for the trilobites of the Ordovician of Russia, although it is also used in specimens from other regions as we can see in figure 1: a topotype of the Upper Ordovician of Morocco, *Uralichas hispanicus tardus* Vela & Corbacho, 2009. This technique is not entirely reliable since it only detects the resin but not the density difference of different broken pieces that can be present in an authentic trilobite and its matrix, so these parts could belong to different specimens. This problem is solved with the utilization of a CT Scanning and in some cases with simple radiography. This paper presents mainly holotypes, paratypes and other specimens included in scientific articles, belonging to the Lower Ordovician, Upper Ordovician and Middle Devonian. The authenticity of the figured specimens are further substantiated and demonstrate that they retain the necessary characters to make an accurate description of the designated new species.

Keywords: CT Scanning, Radiography, X-ray, Trilobites, Fakes, Legal Expert in Paleontology

1. Introduction

In this paper the techniques of CT Scanning and radiography applied to the detection of falsifications of trilobites of Morocco are explained and shown especially, holotypes, paratypes and specimens included in scientific documents. Currently the CT Scanning and radiographs have become the most effective tools that can be utilized in Paleontology to demonstrate the authenticity of fossils to a Judicial Expert. All the specimens presented in this paper come from Morocco.

We are currently making a new paper with CT Scannig and radiographs of some specimens of *Platypeltoides* of Morocco, see the paper of the authors of the reference [3].

The main objective of this document is to demonstrate with the techniques of computerized tomography and radiography and ultraviolet light the authenticity of the different holotypes, paratypes and topotype (Figure 1) shown in this paper. This study is aimed at scientists and jurists (judges, prosecutors, lawyers, judicial experts, etc.).

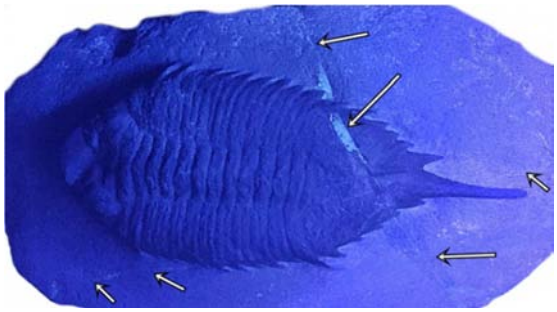

Figure 1. Uralichas hispanicus tardus *used as topotype [2]. It belongs to the Upper Ordovician and comes from El Kaid Errami. Photo made with ultraviolet imaging. The arrows indicate the part of the matrix and the fossil containing resin. It can be affirmed that this fossil is authentic because the resin only affects the area of the union where the matrix has been repaired showing the repaired element of the fossil is only a small part in the pygidium.*

1.1. Historical Background

X-ray computed tomography originated about 100 years ago with the development of mechanical tomography with the earliest attempts of paleontological X-ray imaging; circa 1896 [4].

The application of CT Scanning and radiography to detect paleontological forgeries has been used for many years with vertebrates [5, 6] and with invertebrates [7], not only for the verification of their authenticity but also to see elements of the fossil without the need to remove the matrix, as in some cases it is impossible or would not be advisable as mechanical preparation would cause damage to the specimen, see [8-17].

In recent years it has become standard practice for vendors to send photos of the trilobite recovery work process as it progresses, see (Figure 2). Counterfeits have also been detected in this method, as photos are sometimes sent to the buyer with the unfinished fossil but with repaired or replaced parts. In these cases, CT Scanning and radiography are also effective.

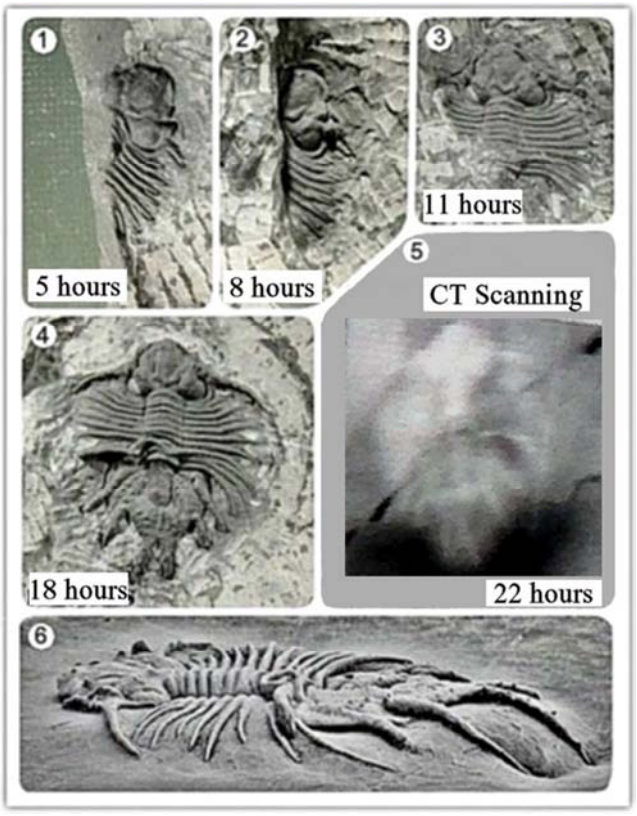

Figure 2. Acanthopyge (Acanthopyge) *sp. It belongs to the Middle Devonian and comes from the Mader Basin. Recovery process of a trilobite made with micro air abrasive media. 5 = CT Scan of the caparace. The trilobite was prepared in Canada by Dave Comfort. It is conserved in Joan Corbacho's collection (JC30).*

1.2. Geographical, Geological Settings and Localities

Platypeltoides cuervoae (Corbacho & López-Soriano, 2012) originating from matrix composed of blue-gray ferruginous sandstones of the Lower Fezouata Formation of the Guelmim area (Morocco). From the Upper Ordovician (Lower Caradoc) sandstones from the Izegguirene Formation of Jbel Bou Nemrou in El Kaid Errami, East of Anti-Atlas (Morocco), *Uralichas hispanicus tardus* Vela & Corbacho, 2009; *Basilicus Calzadai* Corbacho, 2011; *Degamella sendinoae* Corbacho, 2011; *Zeliszkella (Z.) velai* Corbacho, 2011 and *Placoparia* sp.

Two *Acanthopyge* (*A*.) sp. of fine-grained limestone belonging to the Middle Devonian and coming from the El Otfal Formation, located in Jbel bou Lachrchal in the Northeast of the Mader basin and another of the same Formation located in Jbel El Mrakib in the south of the Mader basin (Morocco).

2. Materials and Methods

2.1. Specimens Studied

The holotype and three paratypes of *Platypeltoides cuervoae,* plus another disarticulated caparace that has appeared below them during the scanning process, are presented and an additional specimen of *Platypeltoides cuervoae* from Morocco that was not used for the description of the species nor has it appeared in any scientific article; the holotype of *Basilicus calzadai*; the holotype and a paratype of *Degamella sendinoae*; the holotype of *Zeliszkella* (*Z.*) *velai*; a specimen in [2] of *Placoparia* sp. and three specimens of *Acanthopyge* (*Acanthopyge*) sp. In addition, we present a trilobite that has appeared in a scientific article, [2, 13] a topotype of *Uralichas hispanicus tardus* (Figure 1) that has not been scanned or x-rayed.

2.2. Measurements

Table 1. *Total specimen measurements (in mm).*

Specimen number	Specimen name	Total length
NHMUK-it28944	*P. cuervoae*	125
NHMUK-it28945	*P. cuervoae*	115
MGSB-JC76	*P. cuervoae*	120
MGSB-JC77	*P. cuervoae*	95
JC100	*P. cuervoae*	190
JC29	*Acanthopyge* (Figure 3)	86
MGSB 77680	*Basilicus calzadai*	145
JC20	*Placoparia* sp.	58
MGSB77682	*Zeliszkella* (Z.) *velai*	36
MGSB77681	*D. sendinoae*	28
MGSB77684	*D. sendinoae*	25
JC17	*U. hispanicus tardus*	200
JC30	*Acanthopyge* (Figure 2)	60

2.3. Methods

The methods that have been carried out in this paper are Ultraviolet rays for Figure 1, CT Scanning and radiography for the rest of images.

2.3.1. CT Scanning

Two different CT Scans have been used, one from the Catalan Institute of Paleontology (=ICP) of Sabadell (Spain),

using an industrial CT-scan YXLON Y-TU 450-D09 only for specimen radiographs in June 2013 for specimens of *Acanthopyge* (Figure 3), under the following parameters: 300 kV, 2.3 mA, 1 mm cupper filter, 80 projections, 50 ms.

Another from the Natural History Museum (=NHM) of London (UK) using a micro CT-scan Nikon Metrology HMX ST 225 model in May 2019 for the holotype (NHMUK-it28944) and paratype (NHMUK-it28945) plus another disarticulated caparace that has appeared below them when scanning *Platypeltoides cuervoae* deposited at the NHM in London, (Figure 4), under the following parameters: 225 kV, 500 µA, 1.6 mm silver filter, 3142 projections, 1415 ms exposure time and a voxel size of 0.107728 mm. The image process and 3D final models were carried out by using the software AVIZO 7.1.0.

a) Trilobites of the Middle Devonian of the Mader basin, South of Morocco (Figure 3). Two complete specimens of *Acanthopyge* (*A*.) sp. These CT Scans were used to rule out possible falsifications since they were purchased from a Moroccan fossil specialist and will be used to describe the two new species. The specimen of image 1 was discarded and that of image 2 was reserved as a paratype.

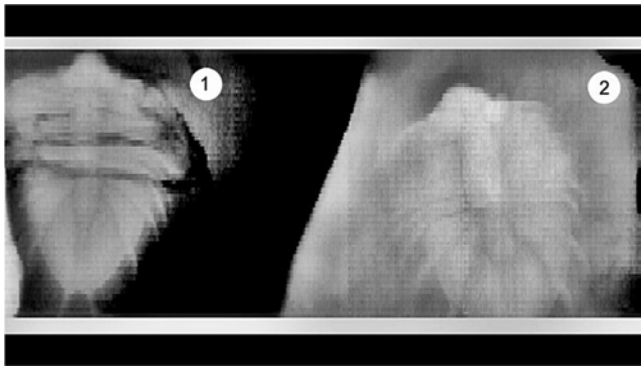

Figure 3. Acanthopyge (A) *sp. CT Scanning. 1= Specimen in which three pieces have been assembled with segments and cannot be guaranteed that the different pieces that are observed are of a single individual. 2 = Presents a totally authentic specimen without any breakage.*

b) Trilobites from the Lower Ordovician of the Guelmim region, Southwest of Morocco (Figures 4, 5 and 8). The holotype and the paratype of *Platypeltoides cuervoae* deposited in the NHM of London (UK) with the numbers NHMUK-it28944 for the holotype and NHMUK- it28945 for the paratype and another disarticulated caparace that has appeared below them during the scanning process are presented (Figure 4, image 2). In Figure 4, it is observed that the repaired elements with resin do not impede the ability to make an accurate description of the species. Typically, the large trilobite fossils of this locality present fractures, it is virtually impossible to extract them completely without breaking. Images 3 and 4 of Figure 4 clearly show that the fossils have not been mounted in the matrix because there is no space or fill between the fossil and the matrix.

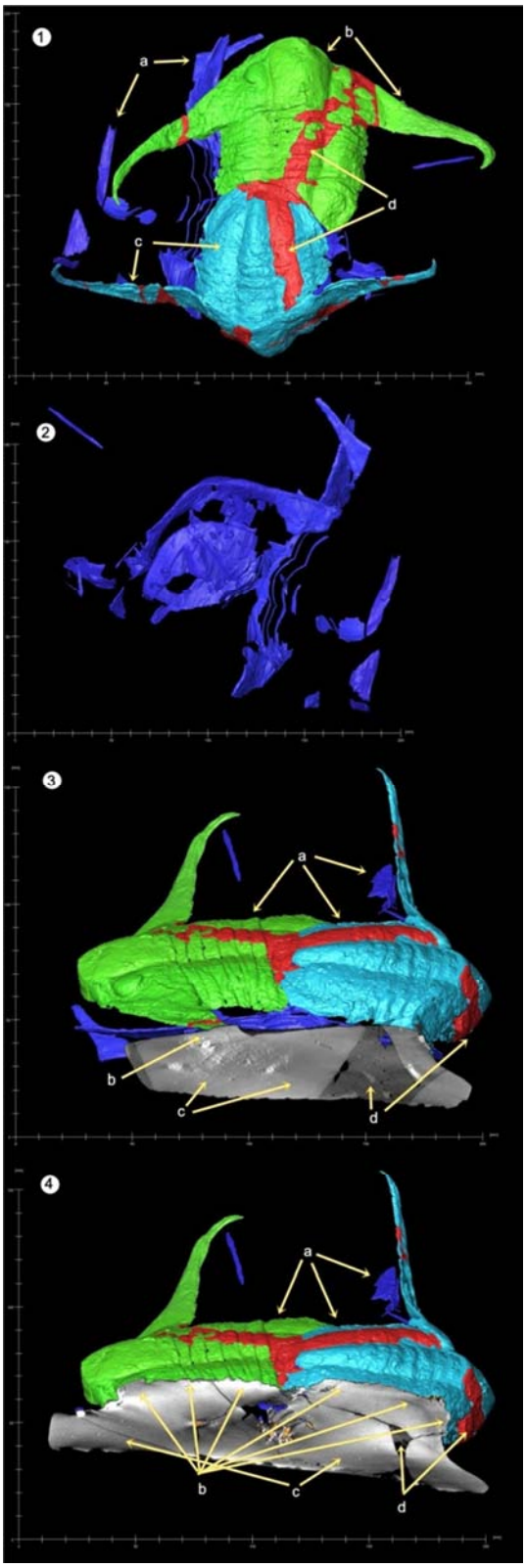

Figure 4. *CT Scanning of* Platypeltoides cuervoae *(Corbacho & López-Soriano, 2012). 1a (dark blue) = disarticulated caparace, 1b (green color) = holotype (NHMUK-it28944), 1c (light blue) = paratype (NHMUK-it28945), 1d (red color) = resin; 2 = disarticulated caparace; 3a = caparaces of the trilobites, 3b = union between the genal spine and the matrix, 3c= matrix, 3d = resin in matrix and fossil; 4a = caparaces of the trilobites, 4b = union between the fossil and the matrix, 4c = matrix, 4d = resin in the matrix and in the fossil.*

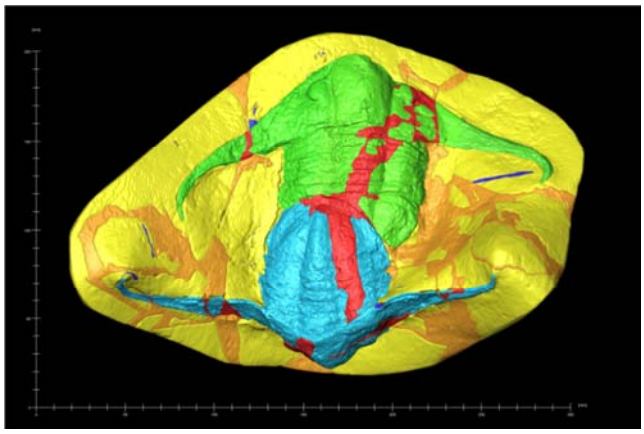

Figure 5. *CT Scanning of the original plate with the specimens of* Platypeltoides cuervoae *that are conserved in the NHM of London (UK). In red, the parts reconstructed with resin are indicated, in orange color = matrix resin.*

2.3.2. Radiographs

The Radiographs were taken at the Veterinary Clinic Morera of Sabadell (Spain) in March 2018 with a Toshiba Model Rotanode - E7239X. The adjustments for the radiographs have been calibrated at 70 and 80 KV and between 24 and 32 mAs.

a) Trilobites from the Lower Ordovician of the Guelmim area, Southwest of Morocco (Figure 6). We present the specimens of two paratypes of *Platypeltoides cuervoae* conserved temporarilly in Joan Corbacho's collection in the Geological Museum of the Seminary (=MGS) of Barcelona (Spain), under the annotations MGSB-JC76 and MGSB-JC77.

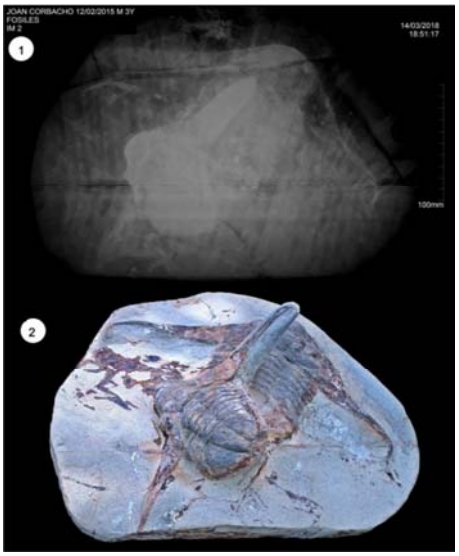

Figure 6. *Radiography of two paratypes of* Platypeltoides cuervoae *(Corbacho & López-Soriano, 2012). 1= In this radiography it is clearly shown that the genal spines are not resin, it is also seen that the left genal spine of the upper individual is complete and the right genal spine, despite being broken, shows all the pieces fit perfectly together. If they were made of resin, they would not be seen on the radiograph. 2= Actual view of the two specimens in image 1.*

b) Trilobite of the Lower Ordovician of the Guelmim region, Southwest of Morocco (Figure 7). A repaired specimen of *Platypeltoides cuervoae* conserved in Joan Corbacho's collection under the annotation JC100. It was purchased at Expominer (fossil fair in Barcelona, Spain) from a Spanish merchant.

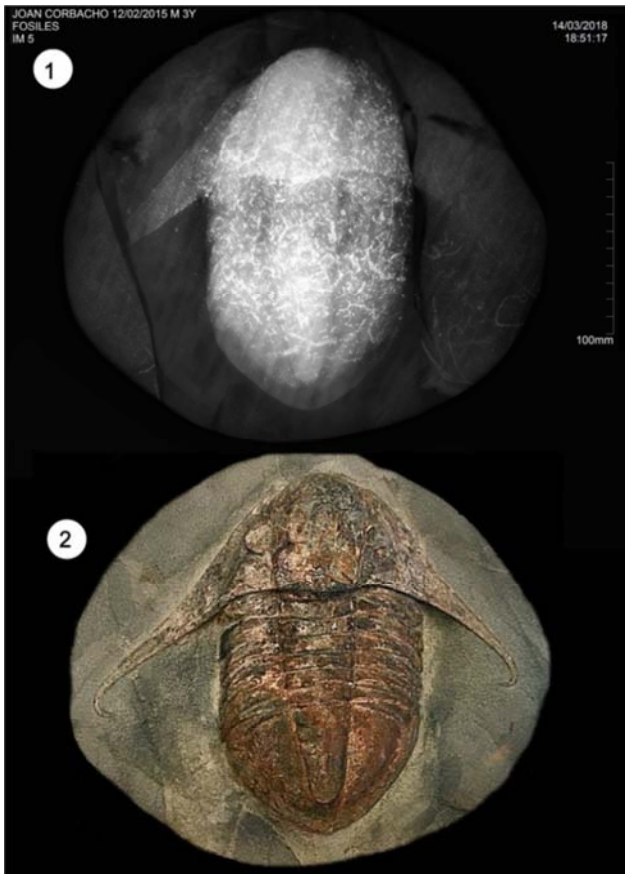

Figure 7. *Radiography of a specimen of* P. cuervoae *from Morocco. 1= It is observed that neither the distal part of the left genal spine nor the entire right genal spine appear precisely where the fractures exist. This is because they have been replaced with matrix material mixed with resin. This is irrefutable proof of the effectiveness of radiographs to verify the authenticity of fossils figured in Figure 5 and this statement is also applicable for the other fossils shown in this document that have been radiographed. 2 = Current view of the specimen of image 1.*

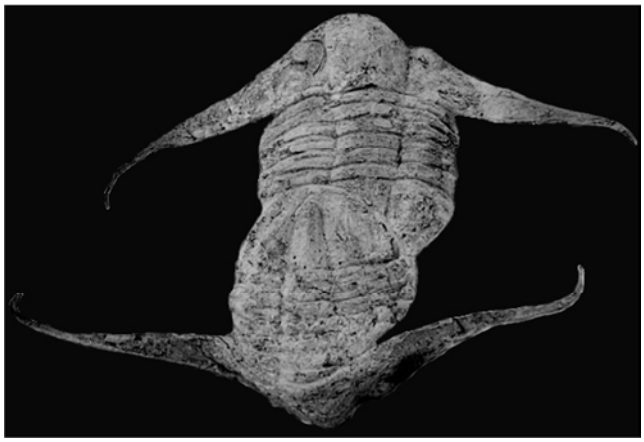

Figure 8. *Original photography of the holotype and paratype of* Platypeltoides cuervoae *preserved at the NHM in London (UK). Images treated with ammonium chloride. After [18].*

c) Trilobite of the Upper Ordovician of Bou Nemrou, El Kaid Errami, East of Anti-Atlas, Morocco (Figure 9). A complete specimen of the holotype of *Basilicus calzadai* deposited in the MGS of Barcelona (Spain) under the annotation MGSB77680. Before performing the radiograph, this specimen was cleaned with acetone to remove a small repair that had been made to the right genal spine.

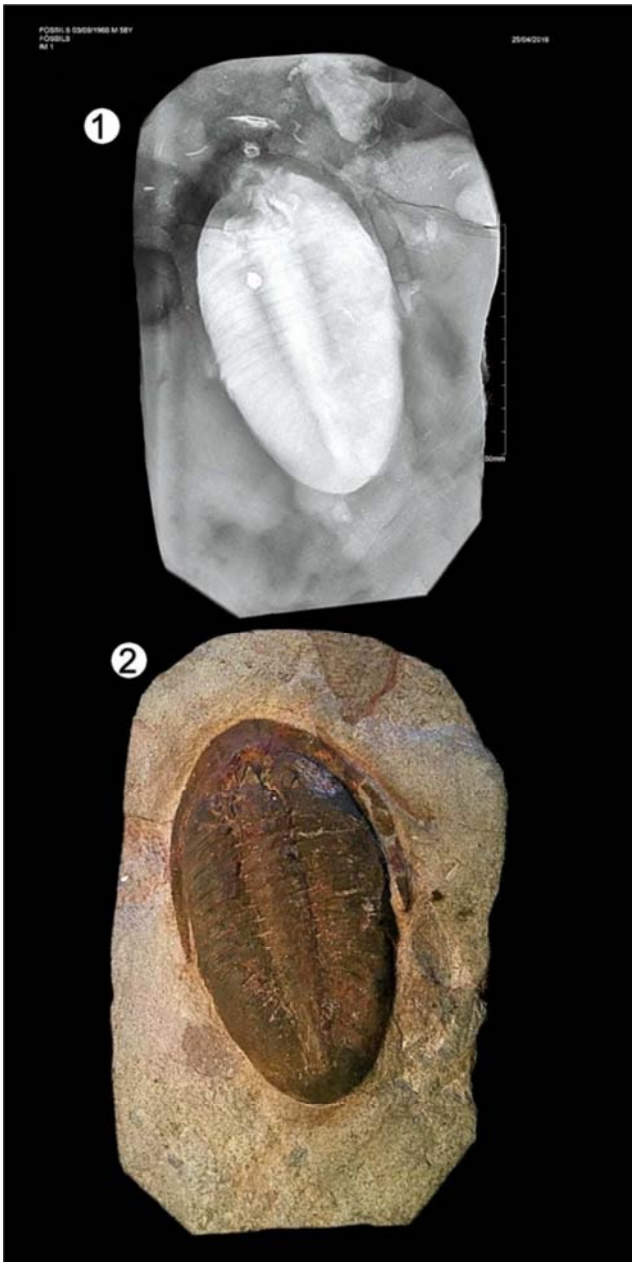

Figure 9. *Radiograph of the holotype of* Basilicus calzadai *Corbacho, 2011. 1 = There is a slight break in the left part of the cephalon and missing pieces in the right genal spine that does not impact the correct description of the species. 2 = Actual view of the specimen showing that all the characteristics of the specimen are exhibited clearly that an accurate description can be determined.*

d) Trilobite of the Upper Ordovician of Bou Nemrou, El Kaid Errami, East of Anti-Atlas, Morocco (Figure 10). A complete example of *Placoparia* sp. figured in the article [2] and conserved in Joan Corbacho's collection (JC20).

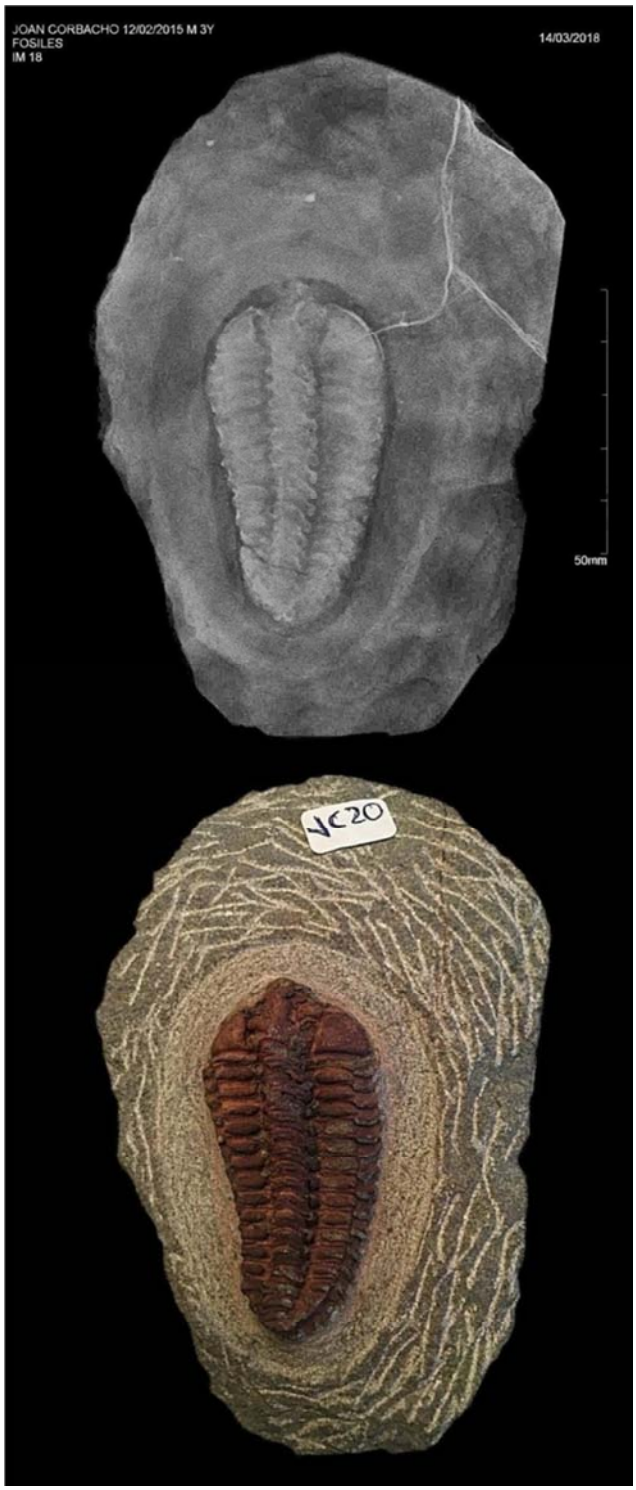

Figure 10. Placoparia *sp. The radiograph confirms that the specimen is complete and only shows a small break at the level of the anterior part of the pygidium.*

e) Trilobites of the Upper Ordovician of Bou Nemrou, El Kaid Errami, East of Anti-Atlas, Morocco (Figure 11). A complete specimen of the holotype of *Zeliszkella* (*Z.*) *velai* and two cranidia of the holotype and the paratype of *Degamella sendinoae* are shown in article [2] and conserved in the MGS of Barcelona (Spain) under the annotations MGSB77682, MGSB77681 and MGSB77684 respectively.

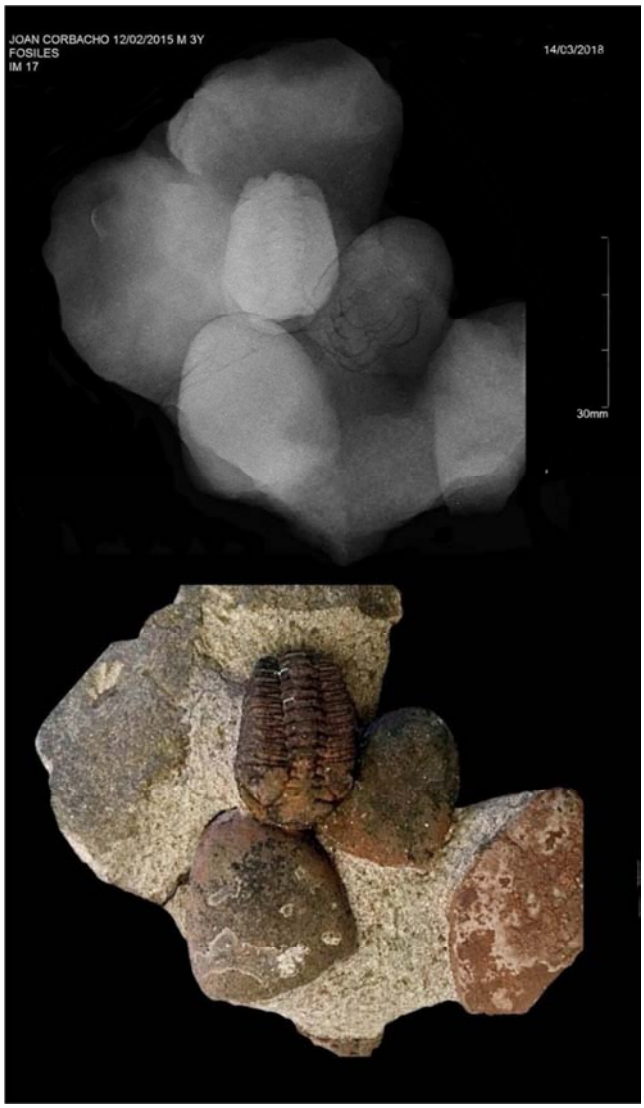

Figure 11. *It is observed in the radiographic image that the holotype of* Zeliszkella (Z.) velai *Corbacho, 2011 and the holotype and paratype of* Degamella sendinoae *Corbacho, 2011 are complete without any fracture. No resin is observed in the fossil or in the matrix.*

2.3.3. Photographs

Photographic imaging was produced utilizing a CANON EOS 1100D digital camera.

2.3.4. Ultraviolet Rays

For the image of Figure 1 an Electronic Inspection Lamp 8W of the brand Sentao Electronics, model YH8-1 has been used. Technical data: Uout=700VAC.

3. Conclusions

This article demonstrates the authenticity of the specimens presented through the use of the CT Scanning and radiography. It also shows an example of the use of ultraviolet rays and another demonstration by high resolution photographs of the fossil recovery process.

With the tests shown here, we can affirm that the presented specimens except those of Figure 3, 1 and that of Figure 7, maintain all the necessary characteristics to make a correct description of a new species. A good illustrative example of this practice comes from Professor Richard Fortey, (NHM) of London (UK) in 2009 who described a new species of Moroccan trilobite, *Asaphellus stubbsi*, in spite of being partly restored, which is explained fully in the text of the description [19].

Computed tomography and radiography are essential tools for judges, prosecutors, lawyers and legal experts in paleontology.

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References

[1] J. Corbacho & C. Sendino 2012. Fossil fakes and their recognition. *Deposits Magazine* 30: 35-40.

[2] J. Corbacho 2011. Trilobites from the Upper Ordovician of Bou Nemrou–El Kaid Errami (Morocco). *Batalleria* 16: 16-36.

[3] J. Corbacho, F. J. López-Soriano, U. Lemke, S. Morrison & K. Hammond 2018. Diversity and Distribution of the Genus *Platypeltoides* (Nileidae) in Morocco. *American Journal of Bioscience and Bioengineering* 6 (2): 13-20.

[4] P. Hohenstein 2004. X-ray imaging for palaeontology. *The British Journal of Radiology* 77: 917, 420-425.

[5] F. Rita, O. Mateus & M. Overbeeke 2008. *Acta Radiológica Portuguesa*, Vol. XX, nº 80, pág. 83-84, Out.-Dez.

[6] J. Corbacho &, J. A. Vela 2009. Falsificación de fósiles del N de Africa (no trilobites). *Batalleria* 14: 53-56.

[7] J. Corbacho, I. Corbacho & S. Morrison 2015. Últimas técnicas detectadas en la falsificación de fósiles. *Batalleria* 22*:* 22-27.

[8] R. Racicot 2017. Fossil secrets revealed: X-Ray CT Scanning and Applications in Paleontology. *The Paleontological Society Papers,* 22: 21–38.

[9] T. Matthews & A. du Plessis 2016. Using X-ray computed tomography analysis tools to compare the skeletal element morphology of fossil and modern frog (Anura) species. *Palaeontologia Electronica* 19.1.1T: 1-46.

[10] D. A. Iurino, M. Danti, S. W. Della Sala & R. Sardella 2013. Modern techniques for ancient bones: Vertebrate Palaeontology and medical CT analysis. *Bollettino della Società Paleontologica Italiana i-xi* doi:10.4435/BSPI.2013.13.

[11] D. Schwarz, P. Vontobel, E. H. Lehmann, C. A. Meyer & G. Bongartz 2005. Neutron Tomography of Internal Structures of Vertebrate Remains: A Comparison with X-ray Computed Tomography. *Palaeontologia Electronica* 8, Issue 2; 30A: 11p, 800KB.

[12] T. Rowe, Z. Luo, R. A. Ketcham, J. A. Maisano & M. W. Colbert 2016. X-ray computed tomography datasets for forensic analysis of vertebrate fossils. *Sci Data* 3 Figshare. http://dx.doi.org/10.6084/m9.figshare.c.1612235.

[13] J. Corbacho 2014. Trabajo de final de Master (TFM); Pericia y Tasación Judicial. *Universidad Europea Miguel de Cervantes*. 36 pp.

[14] J. A. Cunningham, I. A. Rahman, S. J. Lautenschlager, E. J. Rayfield & P. C. J. Donoghue 2014. A virtual world of paleontology. *Trends in Ecology & Evolution* 29 (6): 347-357.

[15] A. Lukeneder 2012. Computed 3D visualisation of an extinct cephalopod using computer tomographs. *Computers & Geosciences* 45: 68-74.

[16] N. Kelley 2017. Paleontology: Scanning for Sea Monsters. *Current Biology* 27: R1305–R1329. https://doi.org/10.1016/j.cub.2017.11.019

[17] J. M. Neenan, T. Reich, S. W. Evers, P. Barrett, S. Pierce & R. Benson 2017. Evolution of the Sauropterygian Labyrinth with Increasingly Pelagic Lifestyles. *Current Biology* 27: 3852–3858.

[18] J. Corbacho & F. J. López-Soriano, 2012. A new asaphid trilobite from the Lower Ordovician (Arenig) of Morocco. *Batalleria* 17: 3-11.

[19] R. A. Fortey 2009. A new giant asaphid trilobite from the Lower Ordovician of Morocco. *Memoirs of the Association of Australasian Palaeontologists* 37: 9-16.