A 3D DATABASE: A WAY TO PRESERVE DETAILED IMAGES OF THE TERRESTRIAL LATEST CRETACEOUS GEOLOGICAL HERITAGE IN TRANSYLVANIA (ROMANIA)

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Introduction:

The latest Cretaceous (Maastrichtian) terrestrial formations from Transylvania are famous worldwide for their endemic vertebrate faunal assemblages which include dwarf dinosaurs, fishes, turtles, crocodilians, birds, multituberculate mammals etc. (GRIGORESCU, 2010; WEISHAMPEL et al., 2010). This geological and paleontological heritage within the Hațeg basin comprises the Hațeg Country Dinosaurs Geopark which has been an established organization since 2004. Before the Geopark, several protected geological preserves were already established such as the Sânpetru Valley or the Tuștea Dinosaur Nesting Grounds. However, in spite of their status, during the last decade, the geomorphological evolution of the latest Cretaceous terrestrial exposures has been rather unfortunate, due either to natural factors (e.g. rapid overgrowth by invasive plant species) or the exuberant growth of algae which now permanently cover whole sections of the Râul Mare and Bărbat River exposures. Also, misguided human interventions have taken their tole, as with the bulldozing of the egg bearing horizon of the Tuștea Nesting Grounds (DUMBRAVĂ & SOLOMON, 2012). Other areas exposing latest Cretaceous formations can be found elswhere in Transylvania; in Hunedoara, Alba, Cluj and Sălaj Districts (CODREA et al., 2010, 2012a). Many of these exposures follow the same degradational trend (in Sălaj, the Someș-Odorhei locality, the building of a dam erased the red bed formations containing dinosaur bones; in Alba District, the pollution of the Sebeș River has covered the outcrops with trash. In order to allow paleontologists access to these sites as they were in their nearly original condition, a 3D virtual database is being created at the Babeș-Bolyai University in Cluj-Napoca.

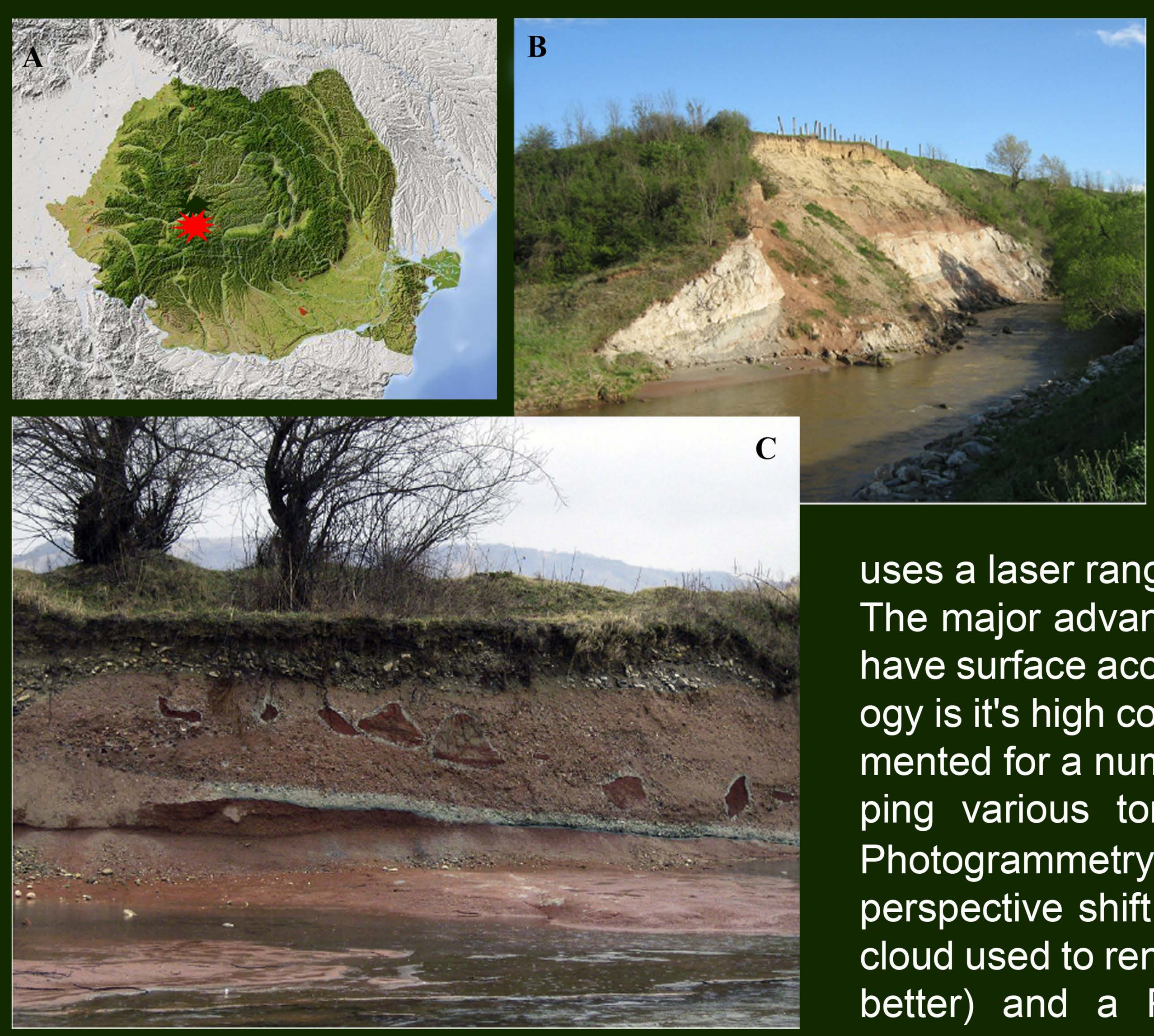

Fig. 1 - The Maastrichtian localities in Alba District chosen as test sites for 3D virtual mapping and continued monitoring. A. general location of the sites. B. Oarda locality in Alba District. C. Sebeș - Glod locality in Alba District (modified from CODREA et al.,

Objectives:

Monitoring will be aimed at all exposures of the latest Cretaceous terrestrial deposits from Transylvania. Apart from the Hațeg Basin (bearing the "classical" – i.e. already documented outcrops such as: Vălioara, Densuș, Ciula Mare, Tuștea, Berthlot, Livezi, Totești, Nălaț-Vad, Sânpetru – Sibișel Valley, Pui; CSIKI et al., 2010), much interest concerns the regions outside the Hațeg basin. We intend to monitor the Rusca Montană Basin (CODREA et al., 2012a), the southwestern part of the Transylvanian Basin, including the localities of Teleac, Ciugud, Oarda de Jos, Lancrăm, Sebeș, Petreștii de Jos, Vurpăr, Șard (CODREA et al., 2010). In these localities, for each of the outcrops of interest, 3D virtual maps will be made yearly over a decade to asess the rate/trend of degradation.

Setting up a 3D database of the sites:

The three dimensional scanning of paleontological sites represents a new approach of tremendous capability which can only be tackled in the virtual realm. For 3D virtual mapping, two different techniques can be used. LIDAR (Light Detection And Ranging) uses a laser rangefinder and simultaneously records the arrival of the reflections, recording data points in a user determined resolution. The major advantage of this method is the small amount of time required for data collection. The point cloud data thus generated can have surface accuracies on the order of a few decimeters and cover hundreds of square meters. The major disadvantage of the technology is it's high cost which can reach into the tens of thousands of dollars for top of the line systems. LIDAR has been successfully implemented for a number of years in North America for paleontological (BATES et al., 2006, 2008) and historical sites and in Egypt for mapping various tombs in the Valley of the Kings (http://www.thebanmappingproject.com/) as well as other archeological sites. Photogrammetry is a 3D scanning technique used for generating 3D surface maps from referenced photographs of a selected area. The perspective shift from one photograph to another is interpreted and interpolated by specialized software in order to generate a point cloud used to render the surface. The great advantage of this technique is that it requires only a digital camera (the higher the quality the better) and a PC, the software used being either freeware (http://ccwu.me/vsfm/) or of very low price (www.agisoft.com). Also, a large user base exists online, making troubleshooting much easier. The major disadvantage of this technique is the time required for data acquisition and its dependence on stable lighting conditions which could otherwise generate texture anomalies. This technique has already been used with much success (BATES et al., 2006; FALKINGHAM et al, 2014). For the Maastrichtian terrestrial formations from Transylvania, we intend in the following decade to use photogrammetry as monitoring tool for the establishment of a 3D virtual topographical database of important, endangered, and less easily accesible paleontological and geological sites.

Requirements and workflow:

An entry level DSLR camera equipped with the best objective lens you can afford and a graphics station or gamer configuration PC. We used a Canon EOS 500D DSLR equipped with a 50mm Canon EFS 1.8 portrait lens on a Manfrotto 190VB tripod. The images were shot in uncompressed RAW format. The dataset was processed on a Lenovo Thinkpad W520 workstation laptop with 16 Gb RAM and an NVidia 2000M professional graphics card with 2Gb of RAM running Photoscan PRO 1.3.3. Unnecesarry parts of the image such as vegetation and sky background were masked out using Photoscan's magic wand tool. Photogrammetry as a technique is very computationally intensive and is CPU based thus requiring large amounts of RAM and a multi core processor. Graphics capability is less important because the final model need not contain a large number of polygons in order to achieve a realistic surface rendering. The results were saved as 3D pdf's with stratigraphical annotations in order to enhance the visual impact.

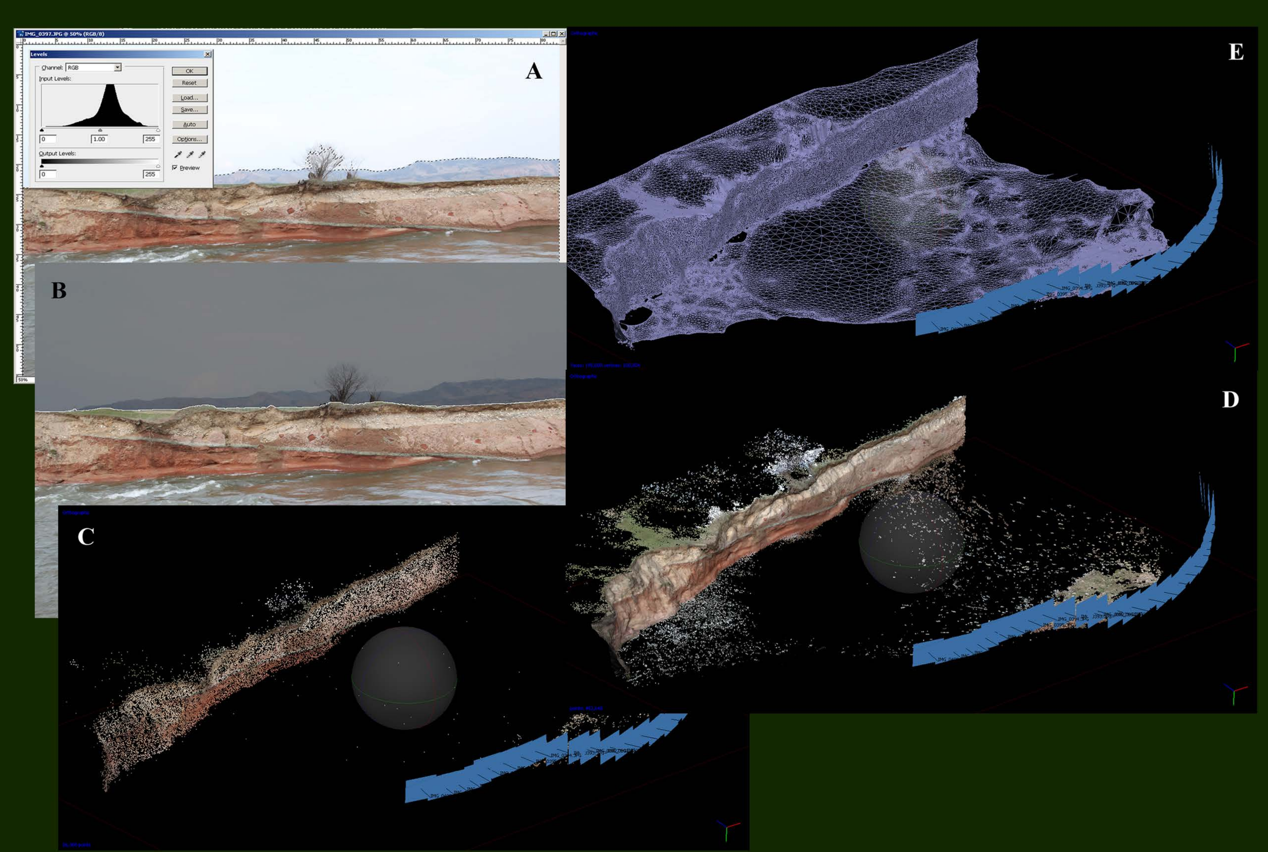

Fig. 2 - 3D photogrammetry workflow. A. raw frame with inverted mask showing the histogram of the area containing the site and riverbed revealing a correct exposure setting. B. same photograph in Photoscan Pro with background hills and sky masked out. C. sparse point cloud generated in Photoscan after image alignement showing the area of interest and estimated camera locations. D. dense point cloud of the site. E. polygon mesh.

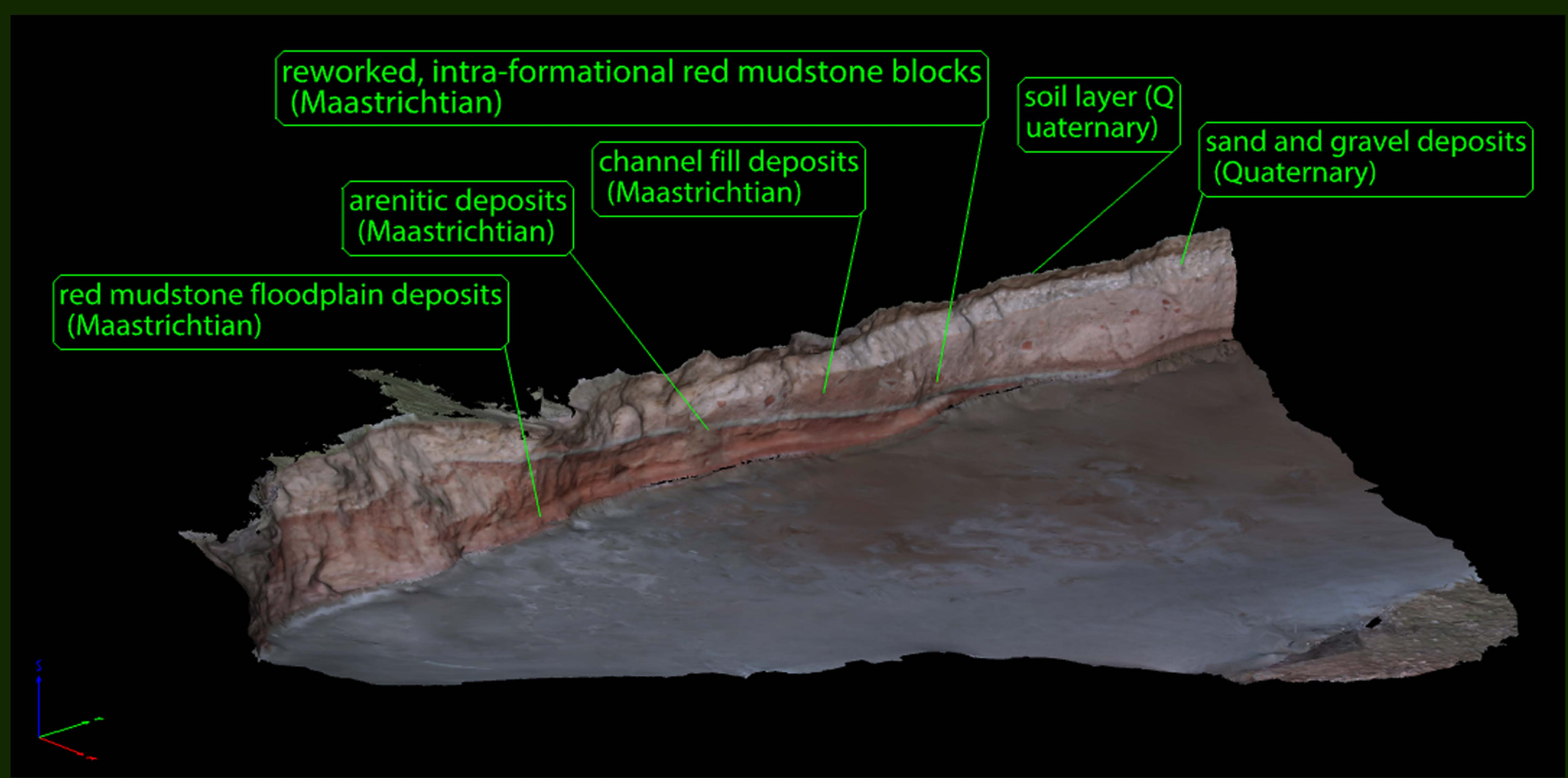

Fig. 3 - 3D annotated pdf of the Sebeș - Glod site in Alba district with 3D comments used to explain the stratigraphy of the site. The final pdf file can be saved in various resolutions allowing display eitherin an internet browser or embedding into a larger pdf. It can be viewed with Adobe acrobar reader 7.0 and above. The 3D model can also be saved in KMZ format for uploading into Google Earth after georeferencing. A GPS module add-on to a DSLR can greatly improve the simplicity and speed of georeferencing a particular site of interest and make it available for worldwide access.

Acknowledgements:

Funding for the research was provided in part by CNCS grant PN-II-ID-PCE-20113-0381, the financial support of the Sectorial Operational Program for Human Resources Development 2007-2013, co-financed by the European Social Fund, under the project number POSDRU/159/1.5/S/132400 with the title „Young successful researchers -professional development in an international and interdisciplinary environment", and the financial support of the Sectorial Operational Programme for Human Resources Development 2007-2013, co-financed by the European Social Fund, under the project POSDRU/159/1.5/S/133391 - "Doctoral and postdoctoral excellence programs for training highly qualified human resources for research in the fields of Life Sciences, Environment and Earth".

References:

BATES K.T., RARITY F., MANNING P.L., HODGETTS D., VILA B., OMS O., GALOBART À. & GAWTHORPE R.L. (2008) - High-resolution LIDAR and photogrammetric survey of the Fumanya dinosaur tracksites (Catalonia): Implications for the conservation and interpretation of geological heritage sites. J. Geol. Soc. London, 165, 115-127; BATES K.T., RARITY F., MANNING P.L., HODGETTS, D., VILLA B., OMS O & GAWTHORPE R.L.(2006) - High-resolution light detection and range (LIDAR) and digital photography of the Fumanya dinosaur track sites (SE Pyrenees): Implications for the conservation and interpretation of palaeontological heritage sites. In Barrett, P.M. & Evans, S.E. (eds), 9th Symposium on Mesozoic Terrestrial Ecosystems and Biotas. Short Papers. Cambridge Publications; CODREA A.V., GODEFROIT P. (2008) - New Late Cretaceous dinosaur findings from northwestern Transylvania (Romania). C. R. Palevol, 7, 289-295; CODREA V., VREMIR M., JIPA C., GODEFROIT P., CSIKI Z., SMITH T. & FĂRCAŞ C. (2010) - More than just Nopcsa's Transylvanian dinosaurs: A look outside the Haţeg Basin. Pal., Pal., Pal., 293, 391–405; CODREA V., VENCZEL M., SĂSĂRAN E., SOLOMON AL., BARBU O. & FĂRCAŞ C.(2012) - The Terrestrial Uppermost Cretaceous Heritage: Proposal for a New Geopark in Alba County, Romania. 7th EUREGEO 2012, 1, 296-297; CODREA V., GODEFROIT P. & SMITH T. (2012a) - First Discovery of Maastrichtian (latest Cretaceous) Terrestrial Vertebrates in Rusca Montană Basin (Romania). In: Bernissart Dinosaurs and Early Cretaceous Terrestrial Ecosystems (Ed.: P. Godefroit), Indiana University Press, 571-581; CSIKI Z., GRIGORESCU D., CODREA V. & THERRIEN F. (2010) - Taphonomic modes in the Maastrichtian continental deposits of the Haţeg Basin, Romania - Palaeoecological and palaeobiological inferences. Pal., Pal., Pal., 293, 375–390; DUMBRAVĂ M. & SOLOMON AL. (2012) –Used and abused: the 'Love Story" between the Tuștea dinosaur nesting site and the Haţeg Country Dinosaurs Geopark.Rev. Roum. Géologie, 56, 1-2, 79-92; FALKINGHAM P.L., BATES K.T. & FARLOW J.O. (2014) - Historical Photogrammetry: Bird's Paluxy River Dinosaur Chase Sequence Digitally Reconstructed as It Was prior to Excavation 70 Years Ago. PloS ONE 9, e93247; GRIGORESCU D. (2010) – The Latest Cretaceous fauna with dinosaurs and mammals from the Haţeg Basin – A historical overview. Pal., Pal., Pal., 293, 271-282; WEISHAMPEL D.B., CSIKI Z., BENTON M.J., GRIGORESCU D. & CODREA V. (2010) - Palaeobiogeographic relationships of the Haţeg biota—Between isolation and innovation. Pal., Pal., Pal., 293, 419-437.