THE TRILOBITE PAPERS 21

An international newsletter for and by trilobite paleontologists
February 2019

Dedicated to Rolf Ludvigsen

The Trilobite Papers Twenty-one
February 2019

Editorial:

One of the difficulties in dealing with trilobites and fossils in general is balancing the needs of a broad range of interested parties and preserving the resource. Fossil sites have been used as: 1) an educational resource for every age; 2) collecting fossils can lead a person into the scientific fields; amateurs (many which donate important specimens) pursuing the fossils just because of the love of fossils; 3) students doing theses (undergraduate, masters, or Ph.D.); and professionals doing research. Some sites are so important (e.g., Burgess Shale), that they need to be preserved and only collected under special circumstances.

All people involved need to be aware of the multiple utility of these fossil sites and respect them accordingly. Unfortunately governmental regulations (at least in the USA) and the actions of a few individuals are making life for the others difficult. Some sites are important and should only be collected with permits, but unfortunately most government agencies use archaeologists and vertebrate paleontologists to set the guidelines as to who, what, and where fossils may be collected. However, most invertebrate fossil sites are a very different resource than archaeological or vertebrate fossil sites. Where as the latter resources are significantly limited (I have worked on both types), most paleontological sites are not limited, the more you dig, the more fossils can be found. Of course this can be abused, I have seen amateur collectors destroy a site in the Highland Range that contained very rare Cambrian soft body remains, but I have seen other collection sites where amateurs have exposed several layers making more material available for children, other amateurs, and professionals.

I don't want to imply that all government actions on fossil sites is wrong. There is another site in Nevada called the Oak Springs Trilobite Site that the Bureau of Land Management (BLM) has made as an educational stop for people to collect lower Cambrian trilobites. Unfortunately, they never bothered to mark where the trilobites are found and most of the paths are through alluvial fan deposits. But at least they set up the site!

Sincerely trilobitic,

Fred Sundberg
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Cover photo: *Arduennops michelsi* "Struve, 1970," Phacopinae, from the Wiltz Beds of Luxembourg, western Europe, middle Late Emsian, late Early Devonian. Internal mold of an incompletely enrolled carapace and detail of the cephalon and one thoracic segment. Mold almost completely covered with manifestations of the hypodermal membrane as thin silicatic layer forming a Voronoi pattern. Specimen whitened with MgO. Sagittal length of cephalon 16 mm. Specimen ESQ 138a is courtesy of the Musée national d`histoire naturelle de Luxembourg, Section Paléontologie. Photographs courtesy of M. Basse.

RESEARCH REPORTS

ARNAUD BIGNON, CICTERRA (Centro de Investigaciones en Ciencias de la Tierra): CONICET- Facultad Cs Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Córdoba (X5016GCA), Córdoba, Argentina
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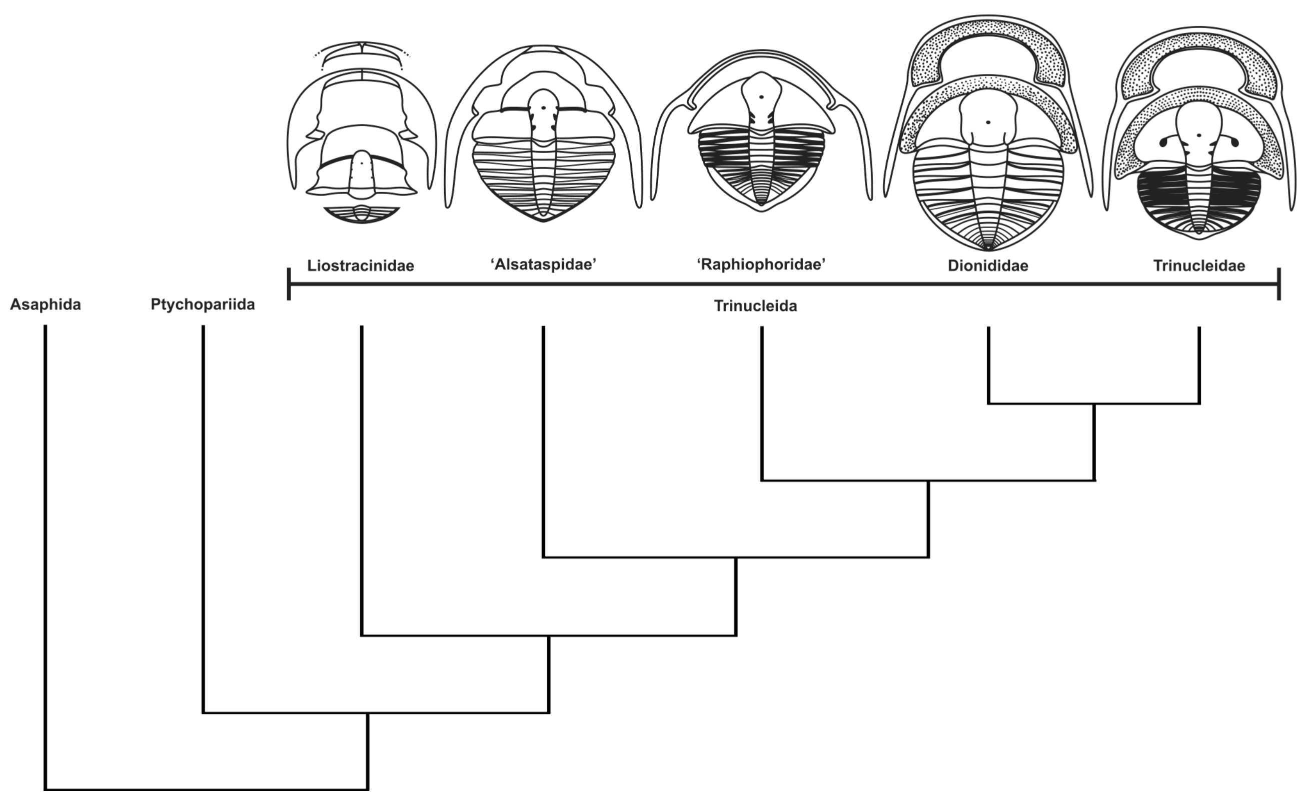
My research is presently focused, with a group of colleagues, on the systematics and phylogeny of the trinucleids. This work began initially with an up-date of the subfamily Trinucleinae, but rapidly, appeared the evidence of such need at the familial and then superfamilial level. We performed a cladistics analysis: 1) to test its monophyly; 2) to check its ordinal affiliation; and 3) to have a preliminary global idea of the group evolution.

The monophyly is confirmed; however, the trinucleids appear more related with Ptychopariida than Asaphida, as presently accepted since the study of Fortey and Chatterton (1988). We had two options, considering trinucleids as a ptychopariid superfamily or erecting it as a distinct order. We chose the second option because the Order Ptychopariida is considered as paraphyletic (Fortey, 1997) and was recently dismantled (Adrain, 2011). It brings more clarity to our understanding of trilobites' evolution to reassess the Order Trinucleida (Bignon et al. submitted). The tree topology (below) obtained suggests the Families Alsataspididae and Raphiophoridae as paraphyletic.

Two others publications are planned, one considering more precisely the evolution and organization of the basal families Liostracinidae, Alsataspididae and Raphiophoridae, another one focused on the families bearing a fringe, the Dionididae and Trinucleidae.

In conclusion, this work highlights the necessity of more investigations on trilobites' evolution at high taxonomical level. Moreover, ontogenetical characters should be submitted to a parsimony analysis as any others ones in order to identify analogies.

Bignon, A., Waisfeld, B. G., Vaccari, N. E. and Chatterton, B. D. E. submitted. Reassessment of the Order Trinucleida (Trilobita).



EUAN CLARKSON
Edinburgh <euan@ed.ac.uk>

I am very happy that Trilobite Papers has been resurrected – thank you to all – and let us keep up the good work.

NIGEL C HUGHES, Department of Earth Sciences, University of California - Riverside. <nigel.hughes@ucr.edu>

My work continues in two main areas. I remain fascinated by the Cambrian history of the equatorial peri-Gondwana region. Our fundable work on the Cambrian in the Himalaya is, I think, drawing to a close, but we have papers in press and in review on the Cambrian history of Pakistan, and particularly the relationships of the Salt Range, from whence *Redlichia noetlingi* and *Treptichnus pedum* were first described (among other interesting taxa). Much of our biostratigraphic work there is aimed at addressing some models for much more recent Himalayan history. I am pleased that our work has played a significant role in debates about switching movement on some of the major Himalayan faults. This year I published a detailed paper on the Parahio Formation, which represent Cambrian Stage 4 and Wuliuan. This paper's principal aim was to clarify some stratigraphic issues, primarily for colleagues based in India. I am a coleader (with Shanchi Peng among others) of IGCP668 on *Equatorial Gondwanan history and Early Palaeozoic evolutionary dynamics* and we just concluded a very successful first conference and field meeting in Thailand. Other work on trilobite development moves in parallel. I am delighted to have Tao Dai in the lab at present working on the development of Cambrian oryctocephalids. Jorge Esteve and I have an interesting collaboration on enrolment in *Aulacopleura koninckii* and I still have a final summary paper to write up on that animal. Jorge and I are working with David Kisailus in our UCR engineering college on enrolment, and our work on early Cambrian microstructure with Helje Parnaste continues. Another project that I am greatly enjoying is working on enrolled proetids from the Carboniferous of Colorado. I have been struck by how different from the Cambrian the late Paleozoic trilobite world seems to have been. Shravya Srivastva visited the lab for 10 weeks on an SN Bose fellowship and moved things forward considerably on *Walcottaspis* and *Osceolia.* I have three excellent students in my lab at the moment: Shelly Wernette, Jin-bo Hou, and Ernesto Vargas-Parra. In addition to Tao, Helje, and Shravya's extended visits, Richard and Jackie Fortey were with us for several weeks in Feb/March, which was also great fun.

2017 and later papers (trilobites figure in most of them in some way or another)

Hou J.-B., Hughes N.C., Yang J., Lan T., Zhang, X.-G and Dominguez C. 2017. Ontogeny of the articulated yiliangelline trilobite *Zhangshania typica* from the lower Cambrian (Series 2, Stage 3) of southern China. *Journal of Paleontology* 91(1):86-99. Doi: 10.1017/jpa.2016.118

Hughes N.C., Hong P.S., Hou J.-B. and Fusco G. 2017. The development of the Silurian trilobite *Aulacopleura koninckii* reconstructed by applying inferred growth and segmentation dynamics: a case study in paleo-evo-devo. *Frontiers in Ecology and Evolution*, 5, article 37, https://doi.org/10.3389/fevo.2017.00037

Hughes N.C. 2017. Biostratigraphical dating conundrums in the Cambrian and earlier stratigraphy of the Indian subcontinent. The Palaeobotanist 66:1-15.

Tang Q., Hughes N.C., McKenzie N.R, Myrow P.M. and Xiao S.-H. 2017. Late Mesoproterozoic–early Neoproterozoic organic-walled microfossils from the Madhubani Group of the Ganga Valley, northern India. *Palaeontology* **60(6)**:869-891.

Bergmann K.D., Finnegan S., Creel R., Eiler J.M., Hughes N.C., Popov L.E. and Fischer W.W. 2018. A paired apatite and calcite clumped isotope thermometry approach to estimating Cambro-Ordovician seawater temperatures and isotopic composition. *Geochemica and Cosmochemica Acta* 224:18-41.

Colleps C.L., McKenzie N.R., Stockli D.F., Hughes N.C., Singh B.P., Webb A.A.G., Myrow P.M., Planavsky N.J. and Horton, B.K. 2018. Zircon (U-Th)/He thermochronometric constraints on Himalayan thrust belt exhumation, bedrock weathering, and Cenozoic seawater chemistry. *Geochemistry, Geophysics, Geosystems.* **19**: 257-271.

Hughes N.C., Myrow P.M., Peng S.-C and Banerjee

D.M. 2018. The Parahio Formation of the Tethyan Himalaya: the type section, thickness, lithostratigraphy and biostratigraphy of the best characterized Cambrian section in the Himalaya. *Journal of the Palaeontological Society of India* **63(1):**1-18.

Hou J.-B., Yang J., Zhang X.-G., Hughes N.C. and Lan T. in press. Trilobite-based biostratigraphy of the Xiaoshiba Lagerstätte. *Fossils and Strata*.

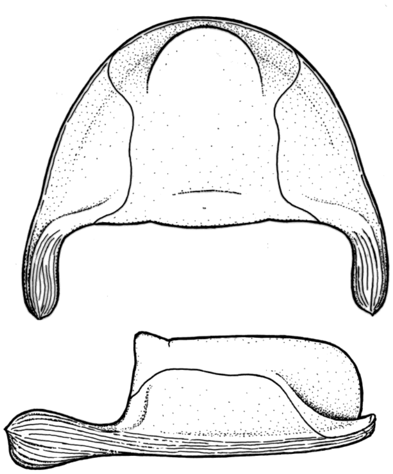
Myrow P.M, Hughes N.C. and McKenzie, N.R. in press. Reconstructing the Himalayan margin prior to collision with Asia: Proterozoic and lower Palaeozoic geology and its implications for Cainozoic tectonics. *In* Treloar P.J. Searle M.P. (eds). Himalayan Tectonics: an update. *Geological Society of London Special Publication*.

Hughes N.C., Myrow P.M, Ghazi S., McKenzie N.R. and DiPietro, J.A. in press. The Cambrian geology of the Salt Range of Pakistan: linking the Himalayan margin to the Indian craton. *Geological Society of America Bulletin*.

Hughes N.C. in press. Evolving understanding of trilobite development: recapitulation to adaptationism. *in* Fusco G. Perspectives on Evolutionary and Developmental Biology: Essays for Alessandro Minelli. Padova University Press, pp. 103-114.

PETER MÜLLER, Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany <mueller-lgh@t-online.de>

Reference to a currently published work on trilobites from the Mississippian of Germany.



Spatulata (*Spatulata*) *tilsleyi* Müller & G. Hahn, 2018, Upper Tournaisian, Germany. A typical representative of the subfamily Cystispininae Hahn & Hahn, 1982. – Müller & G. Hahn 2018: Text-fig. 115.

Müller, P. & Hahn, G. (2018): Die Trilobiten der Erdbach-Kalke von Erdbach (Hessen) und die der „Phillipsien-Bank“ im Raum Warstein (Nordrhein-Westfalen), sowie eine Revision der Cystispininae (mittleres Mississippium). Abhandlungen der Senckenberg Gesellschaft für Naturforschung **574**: 1-237, 145 text-figs, 21 pls; Frankfurt am Main.

JUAN JOSÉ RUSTÁN, CICTERRA (Centro de Investigaciones en Ciencias de la Tierra): CONICET- Facultad Cs Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Córdoba (X5016GCA), Office 11, 1rst. Floor, Córdoba, Argentina
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At present, I have a permanent position as researcher at National Research Council of Argentina (CONICET) and I teach Paleontology for Geology students at University of La Rioja (Argentina). My research concerns specially include systematic, phylogenetic, biostratigraphic and paleobiogeographic aspects of Devonian trilobites and other faunas in the context of Southwestern Gondwanan basins (the Malvinokaffric Realm).

Initially based on some Silurian and Devonian phacopids from this region (like *Paciphacops*, *Viaphacops* and *Echidnops*) we proposed that trilobites could have been burying in soft sediment for moulting, as an extreme defensive strategy (Rustán et al 2011). Later we observed this behavior in the calmoniids *Pennaia* and *Punillaspis* and interpreted it as a clearly polyphyletic character (Rustán et al, 2015). We linked this evolutionary trait with the paleoecological scenario of rising predation pressure during the so-called Mid Paleozoic Marine Revolution (Signor and Brett 1984), which (according Bambach, 1999) triggered when continents started to supply nutrients stored in soils by the vegetation, for the first time to the oceans during the Silurian. We are exploring some additional evidence which suggests that this character is even more frequent than we previously thought. If the infaunal moulting is indeed related to predation pressure, we can expect coeval acquisition of morphological (passive) defenses in prey, remarkably from other trilobites. So, the PhD student Enrique Randolfe is facing the dalmanitids in order to test a phylogenetical pattern of acquisition of defensive spinosity by the middle Paleozoic in these morphologically conservative trilobites. Arnaud Bignon and I are the advisors of Quique and we are carrying out these works in a bigger framework. Together with Catherine Crônier and her French team, we are collaborating with our Argentine colleagues lead by Beatriz Waisfeld, in a major project (supported by our two countries), focused on diversity and disparity of trilobites in order to compare evolutionary dynamics of the group during the Great Ordovician Biodiversification Event and the Mid Paleozoic Marine Revolution.

References

Bambach, R.K. 1999. Energetics in the global marine fauna: a connection between terrestrial diversification and change in the marine biosphere. Geobios 32, 131–144.

Rustán, J. J., Balseiro, D., Waisfeld, B., Foglia, R. D., and Vaccari, N. E. 2011. Infaunal molting in Trilobita and escalatory responses against predation. Geology, 39 (5), 495-498.

Signor, P.W. III and Brett, C.E. 1984. The mid-Paleozoic precursor to the Mesozoic marine revolution. Paleobiology 10, 229–245.

My recent contributions on trilobites include:

Rustán, J. J., Vaccari, N. E., and Balseiro, D. 2015. Infaunal molting in Mid Paleozoic trilobites: new insights based on data from South America. *STRATA*, *1*, 124-5.

Rustán, J.J. 2016 Los trilobites devónicos de Precordillera Argentina: sistemática, filogenia, paleobiogeografía y bioestratigrafía. *Revista de la Facultad de Ciencias Exactas, Físicas y Naturales* 3(2): 133-143.

Rustán, J.J. and Balseiro, D. 2016. The trilobite *Echidnops taphomimus* n. sp. from the Lower Devonian of Argentina: inusual eyes, biogeographic distribution and infaunal molting. *Journal of Paleontology,* 90, 6: 1100-1111.

Rustán J.J., Waisfeld B.G. and Vaccari N. E. The homalonotid trilobite *Burmeisteria* Salter, 1865 in the Lower Devonian of Argentina: new data in the context of Southwestern Gondwana. Journal of Paleontology (under review).

Randolfe E., Rustán J.J. and Bignon, A. The Silurian?-Devonian dalmanitid trilobite *Kasachstania* Maksimova: a taxonomic revision. (in preparation for submitting to Acta Palaeontologica Polonica).

FERNANDA SERRA, (Centro de Investigaciones en Ciencias de la Tierra): CONICET-Facultad Cs Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Córdoba (X5016GCA), Office 11, 1rst. Floor, Córdoba, Argentina
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I recently started working on Upper Cambrian – Lower Ordovician trilobites from the Cordillera Oriental, northwestern Argentina. I am achieving a postdoctoral fellowship (CONICET) aiming to elucidate the relationship between patterns of taxonomic diversity and morphological disparity of trilobites at different spatial scales, to advance in the knowledge of the ecological processes and patterns underlying the significant changes in ecosystems that took place during the early stages of the Ordovician Radiation.

Together with Diego Balseiro and Beatríz Waisfeld we have undertaken a study to better understand the processes that control the diversification of Cambro–Ordovician trilobite communities from the Argentine Cordillera Oriental. We explored patterns of occupancy and diversity trajectories at the local and regional scales through seven intervals (Furongian, lower and upper Tr1, lower and upper Tr2, Tr3 and Fl2-3), and across an onshore-offshore profile. We have now a more detailed picture of the local-regional diversity patterns for the Cordillera Oriental that provide new insights of the ecological changes experienced during the Cambro-Ordovician, and reinforce previously described dynamics for these communities. This recent study was accepted for publication in Palaeontology.

At present, new studies that explore the morphological disparity of trilobites in terms of quantified morphology and morphological space, approached through the use of Geometric Morphometrics, are in progress in our research group (CICTERRA).

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I continue working on latest Furongian-Tremadocian trilobites from the Argentinean Cordillera Oriental, as well as on Cambrian trilobites from the Precordillera, with a focus on systematics, biostratigraphy and paleobiogeography.

Tortello, M.F. 2018. Redescription of a Lotagnostus-Mendoparabolina faunule (Trilobita; late Furongian) from Quebrada San Isidro, Precordillera of Mendoza, Argentina. PalZ (Paläontologische Zeitschrift) 92: 373-386.

Tortello, F., Zeballo, F. and Monti, D. 2018. A late Furongian trilobite assemblage from the eastern Cordillera Oriental (Santa Rosita Formation; Jujuy, Argentina) and its biostratigraphic significance. Revista del Museo Argentino de Ciencias Naturales 20(2):271-282.

Carlorosi, J., Esteban, S.B. and Tortello, M.F. 2019. Early Ordovician conodonts from the Santa Rosita Formation at Pantipampa, Iruya area, northwestern Argentina. Andean Geology 46(1):168-182.

N. EMILIO VACCARI, (Centro de Investigaciones en Ciencias de la Tierra): CONICET- Facultad Cs Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Córdoba (X5016GCA), Office 11, 1rst. Floor, Córdoba, Argentina <evaccari@unc.edu.ar>

I continue working on biostratigraphy and trilobite taxonomy of Furongian-Tremadocian from northwestern Argentina. In particular, I am by the moment devoted to the description of the Furongian trilobites of the Las Vicuñas Formation (Argentine Puna) that includes new and interesting Harpetidae. I am also working in the revision of a peculiar fauna from Sierra de Cajas (west of Cordillera Oriental) described by Benedetto in 1977 based on the type material and new collections from the same locality.

VACCARI, N. E.; B. G. WAISFELD; H.N. CANELO and L. SMITH, 2018. Trilobites from the Iscayachi Formation (Upper Cambrian–Lower Ordovician), Cordillera Oriental, South Bolivia. Biostratigraphic implications. In Suárez Riglos M.; Dalenz Farjat, A. and Pérez Leyton M (Editors) Fósiles y Facies de Bolivia; Capítulo 3: 36-58

MEROI ARCERITO, F.R., WAISFELD, B. G., VACCARI, N. E, MUÑOZ, D.F, 2018. High resolution trilobite biostratigraphy for the Early late Tremadocian (Tr2) interval (Early Ordovician) Santa Rosita formation, Argentine Cordillera Oriental. Ameghiniana 55. 531-553.

Beatriz G. Waisfeld, Centro de (Centro de Investigaciones en Ciencias de la Tierra): CONICET- Facultad Cs Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Córdoba (X5016GCA), Office 11, 1rst. Floor, Córdoba, Argentina
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I am currently working on different aspects of Lower Paleozoic trilobites from west Argentina. Together with the trilobite team at the CICTERRA (Centro de Investigaciones en Ciencias de la Tierra, Córdoba, Argentina) several projects are carried out. One of them focuses on biodiversification of Tremadocian trilobites from the Northwest Argentine. Studies attempt to understand peculiar diversity patterns and ecological structure identified among trilobite-dominated communities in this interval. As well, along with Catherine Cronier we are leading a 3 years collaborative project funded by the Argentine and French governments oriented to explore large scale changes in marine ecosystems during the Lower and Middle Paleozoic (mainly Ordovician and Devonian) from the perspective of evolutionary and biodiversity trilobite dynamics. The CICTERRA team includes Arnaud Bignon, Diego Balseiro, Juan José Rustán, N. Emilio Vaccari, Fernanda Serra, Enrique Randolfe, and Diego Muñoz. The team from the University of Lille includes Claude Monet, Thomas Servais, and Axelle Zacai. Other projects dealing with taxonomy of trilobite faunas from the Argentine Precordillera, and Argentine and Bolivian Cordillera Oriental are slowly moving forward.

VACCARI, N. E.; B. G. WAISFELD; H.N. CANELO and L. SMITH, 2018. Trilobites from the Iscayachi Formation (Upper Cambrian–Lower Ordovician), Cordillera Oriental, South Bolivia. Biostratigraphic implications. In Suárez Riglos M.; Dalenz Farjat, A. and Pérez Leyton M (Editors) Fósiles y Facies de Bolivia; Capítulo 3: 36-58

MEROI ARCERITO, F.R., WAISFELD, B. G., VACCARI, N. E, MUÑOZ, D.F, 2018. High resolution trilobite biostratigraphy for the Early late Tremadocian (Tr2) interval (Early Ordovician) Santa Rosita formation, Argentine Cordillera Oriental. Ameghiniana 55. 531-553.

FREE PUBLICATIONS

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In a clean up at the Geological Museum here in Oslo, a number of copies of the titles listed below have turned up. I do not have the heart to throw all, but interested persons should contact me with a postal address and I will send by return, free of charge.

Bruton, D.L. 1968: A revision of the Odontopleuridae (Trilobita) from the Palaeozoic of Bohemia. Skr. Norske Vitensk. Akad. i Oslo I. Mat. Naturv. Klasse Ny Serie No.25, 1-73, 11 pls.

Owen, A.W. & Bruton, D.L. 1980: Late Caradoc-early Ashgill trilobites of the central Oslo Region, Norway. 62pp, 10 pls. Scandinavian Science Press, Klampenborg, Denmark.

Bruton, D.L. 1981: The arthropod *Sidneyia inexpectans*, Middle Cambrian, Burgess Shale, British Columbia. Phil. Trans. Roy. Soc London B., 295, 619-656, 108 figs.

Bruton, D.L. (ed.) 1984: Aspects of the Ordovician System. Palaeontological Contributions from the University of Oslo, No.295. Universitetsforlaget. ISBN 82-00-06319-4

ANNOUNCEMENTS

Donation of Fossils
Val Gunther

Glade and I just donated 109 cases of fossils to the University of Kansas. It contained thousands of fossils collected from Utah Cambrian over the past 53 years, including **9,120** trilobites. Julien Kimmig, Ph.D. came and picked up the van load.

North American Paleontological Convention
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We have NAPC coming up - there will be plenty of trilobite opportunities. Multiple symposia could be relevant, but I draw particular attention to 5, 7, 13, 28 and 32. The last particularly concerns amateurs.

General info about the conference is available on: http://napc2019.ucr.edu

11TH NORTH AMERICAN PALEONTOLOGICAL CONVENTION
JUNE 23 - 27, 2019 RIVERSIDE, CALIFORNIA

5. Arthropod evolution through deep time: a tribute to Richard Fortey
Organizers: Javier Ortega-Hernández, Jorge Esteve, Joe Moysiuk, Alejandro Izquierdo López
Contact: jortegahernandez@fas.harvard.edu
Arthropods represent the most diverse and abundant animals that inhabit the biosphere, and have maintained this distinction since their origins during the Cambrian Explosion more than 500 million years ago. Arthropods have played a fundamental ecological role throughout the Phanerozoic, and their durable exoskeleton has left behind an impressive fossil record that allows scrutinizing the long evolutionary history of this group. The aim of this symposium is to bring together the international paleontological community and serve as a stage for sharing their latest research on any aspect of the evolution of arthropods that incorporates the fossil record. We encourage presentations that emphasize interdisciplinary approaches to the study of the arthropod fossil record, such as functional morphology, evo-devo and bioinformatics. The symposium will also commemorate the distinguished career of Richard A. Fortey, offer an opportunity to acknowledge his notable contributions in trilobite evolution and his passion for sharing paleobiology beyond strictly academic circles.
Accompanying Poster Session

7. Cambrian Konservat-Lagerstätten and the emergence of modern-style marine ecosystems

Organizers: Rudy Lerosey-Aubril, Robert Gaines, Xingliang Zhang
Contact: leroseyaubril@gmail.com
The diversification of animals in the Cambrian is a critical episode of the history of life, and represents a profound state change in the Earth system. Associated with the colonization of new habitats, this adaptive radiation has led to both a profound restructuring and a major increase in the complexity of marine ecosystems. In particular, the advent of motility and the diversification of feeding habits dramatically increased interactions between their constituents, resulting in a high level of interdependence – a key characteristic of modern marine communities. Konservat-Lagerstätten represent primary sources of palaeontological information for the Cambrian period and as such, are critical for testing hypotheses about the triggers and modalities of this adaptive radiation of early metazoans. This symposium will be dedicated to these exceptional deposits and the remarkable fossil assemblages they yield. It will aim to present and discuss the most recent advances on this topic, but also to identify novel approaches that might permit a more thorough exploitation of this invaluable source of data.
Accompanying Poster Session

8. Symposium in honor of the career of Michael A. Murphy
Organizers: Kathleen Springer, Stanley Finney, Jonathan Matti
Contact: kspringer@usgs.gov
The Symposium to honor Michael A. Murphy brings together a diverse group of paleontologists, biostratigraphers, and geologists who will explore a broad range of topics that center around paleontology and whose careers were influenced at some point by Michael A. Murphy's diverse scientific contributions and especially his mentoring and friendship. The presentations will demonstrate the lasting legacy of Michael A. Murphy—colleague, mentor, and scientist, and friend to us all.

13. The end of Cambrian "boom and bust" and the onset of the Great Ordovician Biodiversity Event (GOBE): diversity patterns, paleoecology, and paleobiogeography - IGCP 653-668 combined symposium
Organizers: Alycia Stigall, Sara Pruss, Rebecca Freeman, Shelly Wernette
Contact: stigall@ohio.edu
The Late Cambrian to Early Ordovician brought a transition between a "boom and bust" pattern of rapid short-term diversifications followed by dramatic collapses of diversity to the 'Great Ordovician Biodiversification Event' (GOBE), which established a more diverse, stable marine ecosystem. This series of diversifications completely modified marine food webs and, for the first time, established modern marine ecosystems. Timing of the Ordovician radiations varied among clades and paleocontinents and may have its roots in the Cambrian. The goal of this session is to bring together paleontologists with diverse background and expertise sets to present new research bearing on the initiating factors and timing of the GOBE, including the Cambrian events that led up to it, on a global and local scale.
Accompanying Poster Session

19. Paleozoic Extinctions: Environmental Call and Biotic Response
Organizers: Diana Boyer, Phoebe Cohen
Contact: boyerd@winthrop.edu
During the Paleozoic, life changed dramatically through ecosystem expansion, increased biodiversity, and evolutionary adaptations. At the same time, the earth system moved towards a more oxygenated state, and experienced significant changes in climate. Overprinted on this time were numerous biocrises, including some of the largest extinction intervals in the Phanerozoic. These events, which range in magnitude and ecological impact, provide the opportunity to examine potential causes and consequences of mass extinctions. This symposium will explore the environmental conditions associated with these extinction events across a range of scales as well as the biotic response to these intervals utilizing a variety of methodologies including

combined fossil and geochemical approaches.

20. Stratigraphic Paleobiology
Organizers: Steve Holland, Emilia Jarochowska, Mark Patzkowsky
Contact: stratum@uga.edu
Stratigraphic paleobiology is the application of a modern view of stratigraphy, specifically event- and sequence-stratigraphy, to an interpretation of the fossil record. Here, we highlight studies that use stratigraphic context to aid in the interpretation of biological history and processes, such as mass extinctions and their recovery, morphological evolution, ecological change, and large-scale evolutionary patterns.

26. Paleontological history of the Indian subcontinent
Organizers: Devapriva Chattopadhyay and Steve Manchester
Contact: steven@flmnh.ufl.edu
The dynamic history of the Indian subcontinent provides one of our best models for examining the effects of insularity, tectonic collision of major land masses and associated climate change on biotic composition and biogeographic affinities. We will review the composition, paleoecology and biogeographic implications of floral and faunal communities from selected Paleozoic, Mesozoic, and Cenozoic strata in the region of present-day India and Pakistan.

28. Growth, development, and evolution in the fossil record
Organizer: Melaine Hopkins
Contact: mhopkins@amnh.org
Growth and development are complex processes that vary dramatically across organisms, in being accretionary, episodic, determinant, and/or indeterminate. Organisms are also capable of plastic responses through development, including remodeling, regeneration, and life history modifications. Because of this and the fact that growth determines body size, developmental processes are important for understanding many ecological interactions. Further, developmental processes are important at both micro- and macroevolutionary evolutionary scales. Genetic variation is subject to selection through phenotypic expression realized through development. Organisms may be constrained by ontogenetic variation in how they respond to selective pressure. Organisms are subject to selection throughout their lifespans, and juvenile traits may confer selective advantage or decrease extinction risk. Developmental processes themselves evolve. Thus knowledge of growth and development is critical to our understanding of evolution. This aim of this symposium is to bring together researchers working on a diverse array of organisms to cover topics ranging from methods for assessing growth and development in fossil organisms, modularity and integration, life history evolution, body size evolution, developmental constraints on evolution, the evolution of allometry, body plan evolution, and other areas of paleo-evodevo.

29. Environmental change and the evolution of form and function
Organizers: Shaun Huang, Stewart Edie, Katie Collins
Contact: shan.huang@senckenberg.de
This symposium focuses on how morphological and functional diversity evolve in relation to environmental changes. We invite presentations demonstrating how environmental factors (e.g., predators, competitors, climate change, tectonic activity, etc.) are related to the evolution of form and function in a wide range of paleobiological systems, and further, what these findings can tell us about spatial and temporal variation in biodiversity (e.g., extinction selectivity, adaptive radiation, etc). We aim to highlight how the development of large fossil databases and rigorous analytical toolkits has improved the power of comparative studies—from addressing local patterns in single lineages to searching for general mechanisms of evolution. Our ultimate goal is to foster discussion on cross-system comparisons and syntheses that can illuminate fundamental principles underlying biodiversity dynamics.
Poster Session

30. New insights into functional morphology: Microstructures, Modeling, and Experimental approaches

Organizers: Carlie Pietsch, Brendan Anderson, Kathleen Ritterbush, Nick Hebdon

Contact: carlie.pietsch@sjsu.edu

Many of the most interesting questions of paleobiology involve features of organisms which either have no modern analog or where potential functions are ambiguous. As function and behavior cannot be observed directly in extinct organisms (and may be difficult to observe in living organisms as well), both vertebrate and invertebrate paleobiologists employ a wide variety of techniques to determine the functional limits imposed on animals by their morphology and physiology. Emerging technologies allow observations of fossils and their reconstructed components in unprecedented detail and flexibility. These insights into the basic biology of organisms inform our understanding of soft-tissue dynamics, paleoecology, behavior, and macroevolutionary trends. This session welcomes presentations ranging from skeletal microstructure to macro-scale analyses of organisms important in the fossil record.

31. Paleontology on Public Lands: Research, Outreach and Resource Management

Organizers: Kathleen Springer, Vincent Santucci

Contact: kspringer@usgs.gov

This symposium, kicked off by keynote speaker Dr. Kirk Johnson, Director of the National Museum of Natural History will be followed by individual thematic sessions focusing on paleontology research on public lands, public outreach and education, as well as management and protection strategies for paleontological resources. At the end of the day, a multi-agency panel (NPS, BLM, USFS, USGS and Smithsonian) will field questions and foster discussion

32. Two to tango: amateur-professional interactions in advancing paleontological knowledge

Organizers: Jack Kallmeyer, David Meyer

Contact: paleojack@fuse.net

The symposium will feature examples of successful collaboration between amateur/avocational and professional paleontologists. The objective is to promote such activity by illustrating proven methodology for those who have not yet realized the benefit of these collaborative efforts. We seek contributions from both amateur/avocational and professional paleontologists who have collaborated successfully on projects with emphasis on how this relationship has benefitted the science of paleontology overall. The thrust of the symposium is to emphasize the methods and ultimate benefits rather than the results or findings of the efforts. Collaborative efforts could include field work, research assistance, or any other effort wherein the amateur contribution was invaluable to the completion of the project.

Poster Session

DID YOU KNOW?

In 1886, Charles Doolittle Walcott considered the *Olenellus* Zone as Middle Cambrian. It was not until 1890 that he considered the zone representing the Lower Cambrian.

Poulsen and the Postage Stamp Pictures

John S. Peel, Dept. of Earth Sciences, Uppsala University, Villavägen 16, 75236, Uppsala, SWEDEN

Christian Poulsen, 1896-1975, Professor in Paleontology, Geological Museum, Copenhagen

In his appraisal of the work of Charles E. Resser, Fred Sundberg (2007) noted Resser's tendency to produce monographs with minute illustrations....postage stamp-sized figures. Resser (1938) on the fauna from Pend Oreille is a striking example. Fred (2007) mentioned that Christian Poulsen (1927) followed the same course in his classic monograph on Greenland Cambro-Ordovician faunas which caused me to remember when I first came across his work.

Christian Poulsen died shortly after I moved to Copenhagen as newly doctored geologist with the Geological Survey of Greenland in June 1973. I met him a couple of times and we discussed his last Greenland paper ....I even reviewed it for him. It was the last in a series of papers which he started to publish on Silurian fossils from North Greenland in 1939 and the early 1940's which was abandoned due to a bitter conflict with the expedition leader and collector Lauge Koch (who collected the material for the 1927 paper). When I appeared at the Greenland Survey (he was retired from a professorship in Copenhagen University) with my still fresh Ph.D on Silurian gastropods, Christian Poulsen dug out his 30 year old manuscript on the gastropods of the Offley Island Formation and published it (1974).....without taking any account of my comments, I might add.

Shortly after his death, by chance I noticed in the trash from the Geological Museum that the original plates from the 1927 paper were thrown out. Unlike the published postage stamps, these were prepared on A3 sheets of card, at 200% linear measurement of the publication size. The prints were excellent, made on matt (not glossy) paper so that he could easily retouch them in ordinary pencil....which he admitted to doing, and did well. With close inspection it is easy to see his efforts. The outlines of his *Kochiella* specimens on pl. XV are clearly "strengthened" with a pencil line. The plates were then obviously reduced during the publication process. I kept them until 1992 when I moved to Uppsala but was then obliged to discard them in the general down-sizing of all my worldly goods! But I made frequent use of them in the years in between while sorting out my own Greenland collections, and I currently deeply regret throwing them out as I try to decipher those Cape Kent and Cape Wood Formation trilobites. His son Valdemar Poulsen (1964) never re-figured any of the material. The types are in good order and safe, in off-site storage at the moment, as National History Museum of Denmark as it is now called undergoes a total re-organisation.

Poulsen's (1927) paper appeared in 2 versions, although the texts are identical.

The official version is the Meddelelser on Grønland vol. 70, part 2, 1927, which appeared in the usual pale blue covers of the series at that time....I am not sure of the exact date of release in terms of days and months.

However, a version in grey covers was printed and in circulation, and available, as his Doctor of Science disputation (not Ph.D, but something significantly higher; Ph.D did not exist in Danish University circles at that time). This carries the line "to be printed as "Meddelser on Grønland" vol. LXX No. 2 (pages 233-343)" on both the title page and the card cover. It was usual for extra copies to be printed to order prior to the official journal publication for use as the thesis.

The thesis was accepted for presentation on 24th Feb. 1927 and the public defence/presentation took place on Thursday 9th of June 1927 at 2 pm in Auditorium A of the University Annex (Studiegaarden) in Copenhagen. It was formally accepted for the degree by the University on 27th September 1927.

Poulsen, C. 1927. The Cambrian, Ozarkian, and Canadian faunas of northwest Greenland: Meddelelser om Grønland, 70: 233–343.

Poulsen, C. 1974. Silurian Pelecypoda, Monoplacophora and Gastropoda from the reefy facies of the Offley Island Formation of Washington Land and Offley Island (Northwest-Green- land). Kongl. Danske Videnskab. Selskab, Biol. Skr. 20, 7, pp. 1-14.

Poulsen, V. 1964. Contribution to the Lower and Middle Cambrian Paleontology and stratigraphy of Northwest Greenland. Meddelelser om Grønland, 164: 1–105.
Resser, C.E. 1938. Middle Cambrian fossils from Pend Oreille Lake, Idaho. Smithsonian Miscellaneous Collections 97(3).
Sundberg, F.A. 2007. Nightmare on Resser Street – dealing with Resser's trilobite taxonomy. *In* Fabulous fossils – 300 years of worldwide research on trilobites. *Edited by* Mikulic, D.G., Landing, E. and Kluessendorf, J. New York State Museum Bulletin, 507: 213–224.

FIELD NOTES

Cambrian trilobites in Sonora, Mexico: 78 years of research

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The discovery of Cambrian rocks in Mexico dates back to 1941 in the area of Caborca, northwestern Sonora. Geologists Isauro Gómez and Lorenzo Torres Izábal conducted an exploration of northern Sonora for Petróleos Mexicanos and noticed the existence of exceptionally well exposed Cambrian rocks in the Cerro Los Arrojos, finding and collecting the first known trilobites in Mexico. By then, the existence of the Cambrian in the country was questioned; however, the collected specimens were identified as characteristic of the middle Cambrian by Alexander Stoyanow in 1942, Professor of Paleontology at the University of Arizona and to whom the first scientific finding of Cambrian strata in Mexico is assigned.

The 1940´s decade became an important epoch for the Cambrian research in Mexico. People from The Smithsonian Institution of Washington D.C. were interested in Cambrian rocks, studying different North America cordilleras. In effect, the collaboration of Smithsonian Institution and the Instituto de Geologia (UNAM) in Mexico, represented by Arthur Cooper (Figure 1) and Alberto Arellano with the purpose to study the the Cambrian and other Paleozoic deposits in Sonora, are a now days a mandatory reference.

Figure 1. Arthur Cooper in the field in some place of USA. Taken from Smithsonian Institution Archives online.

In 1946, Arthur Cooper and Alberto Arellano collected fossils at the top of Cerro Prieto, south of Caborca and carried out the first formal stratigraphic studies within the area, reporting the presence of *Girvanella* and *Olenellus*. The material was obtained mostly from limestone and some shale specimens. In the following years, the material has become an object of study in the region.

In 1948, Christina Lochman (Figure 2) provided an extraordinary contribution to the knowledge of the Cambrian in Mexico. She identified, described and named seven new genera and species of trilobites from the early and middle Cambrian, named *Sombrerella mexicana*, *Mexicaspis stenopyge*, *Mexicella mexicana*, *Proveedoria starquistae*, *Arellanella caborcana*, *Caborcella arrojosensis* and *Kistocare corbini*. This publication emphasizes the importance of the facies that determine the trilobites of the Cambrian in the Caborca area. The described species indicate complete details of the stratigraphic relationships of the different faunas and the generic composition of several faunal assemblages, used

Figure 2. Christina Lochman in 1957. Taken from New Mexico Geology (https://geoinfo.nmt.edu/publications/periodicals/nmg/28/n4/lochman.pdf)

to recognize biozones, used at that time, such as *Obolella*, *Olenellus*, and *Antagmus-Onchocephalus* of the lower Cambrian. As well as the *Albertella* and *Glossopleura-Kootenia* biozones corresponding to the middle Cambrian.

Later in 1952, Arthur Cooper and collaborators made a detailed stratigraphic and paleontological study, establishing the following units of the lower Cambrian, in chronostratigraphic order: Puerto Blanco, Proveedora, Buelna and Cerro Prieto formations, the last one of uncertain age. For the middle Cambrian: Arrojos and Tren formations. Christina Lochman, identified most of the trilobites, citing more than 20 new species. The trilobites of the Puerto Blanco Formation are represented by *Olenellus* sp. and the new species proposed by Lochman: *Wanneria mexicana*, *Wanneria mexicana prima*, *Laudonia mexicana* (syn. *Lochmanolenellus primus* Lieberman 1998, 1999). Arthur Cooper and collaborators identified fragments of olenellids in the Proveedora Formation assigning them to *Wanneria mexicana*. In the Buelna Formation the trilobites *Fritzolenellus truemani* Walcott (syn. *Olenellus fremonti*), *Antagmus buttsi* Resser, and new species by Lochman were recognized, such as *Paedeumias puertoblancoensis* (syn. *Olenellus puertoblancoensis* Lieberman, 1998), *Wanneria walcottana buelnaensis*, *Bonnia sonora*, *Antagmus solitarius*, *Onchocephalus buelnaensis*, *Onchocephalus mexicanus*. The Cerro Prieto Formation did not provided trilobites, whereas the Arrojos Formation contains an abundant trilobite fauna, such as: *Alokistocare althea* Walcott, *Kistocare tontoensis* Resser, *Kootenia exilaxata* Deiss, *Athabaskia bela* Walcott, *Ptychoparia clusia* Walcott, *Zacanthoides holopygus* Resser, *Amecephalus arrojosensis* Lochman, and the new species identified by Lochman: *Alokistocare modestum*, *Alokistocare mexicana*, *Kochaspis cooperi*, *Ptarmigania* (*Ptarmiganoides*) *bispinosa*, *Sonoraspis* sp., *Sonoraspis torresi*, Son*oraspis gomezi* Stoyanow (syn. *Glossopleura* sp., *Glossopleura lioness*), *Albertella supplier*, *Albertella* aff. *A. supplier*, *Mexicapsis difuntoensis*, *Arellanella sonora*, *Inglefieldia imperfecta*, *Pachyaspis deborra*, and *Pachyaspis isabella*, as well as the species already described by Lochman in 1948. The trilobites of the Tren Formation are represented by *Athabaskia minor* Resser, *Inglefieldia* sp. and *Parehmania* sp.

Arthur Cooper, Alberto Arellano, and Christina Lochman participate in the 1st part of publication Paleontology and Stratigraphy of the Cambrian of Caborca, Spanish Edition, published as a complement of the XX International Geological Congress in 1956, celebrated in Mexico. In that publication, they described the Cambrian localities of Caborca, mentioning the exposed formations, and the systematic description of the different paleontological groups of the lower Cambrian and middle Cambrian, such as: cyanobacteria, archaeocyathids, brachiopods, hyolitids, chancelloriids, cephalopods, gastropods and trilobites. This publication presents the original collection of trilobites of the Cambrian of Sonora, initially studied by Alexander Stoyanow, and the fossils identified by Christina Lochman.

In 1975, William Fritz (Figure 3) also evaluated the stratigraphy of Caborca based on trilobites

Figure 3. William Fritz in 1966 in a GSC expedition. Taken from (https://burgess-shale.rom.on.ca/en/history/discoveries/04-gsc.php)

assigned The Buelna and Cerro Prieto formations to the *Bonnia-Olenellus* Zone and determined that the transition to the middle Cambrian occurs near the base of the Arrojos Formation. The correlations of Caborca rocks with similar rocks in the western United States were made by Lochman 1956, Palmer and Halley 1979, and Stewart 1982. The Cambrian strata of Caborca were compared to the Cambrian strata in Argentina by Baldis and Bordonaro (1981).

In 1984, Stewart and collaborators published a report where they provided new information of Caborca. They made an inventory of fossils and studied the paleocurrents, in addition, they made correlations with rocks of the western United States of America. The stratigraphy described in this report is mainly based on rocks from the Cerro Rajón area, which contains the most complete upper Proterozoic and the lower Cambrian strata of the area. As a result, 14 formations were identified and considered as part of what was formerly known as cordilleran miogeoclinal. In the La Ciénega Formation, the aforementioned authors recognized pre-trilobite faunas and the occurrence of trace fossils of trilobites such as *Rusophycus*, inferring the Pre-*Fallotaspis* Zone. The Puerto Blanco Formation contains abundant trilobites that were identified by Christina Lochman and Allison Palmer, being tentatively considered as part of the *Fallotaspis* Zone. In this unit, the authors observed a great variety of facies change.

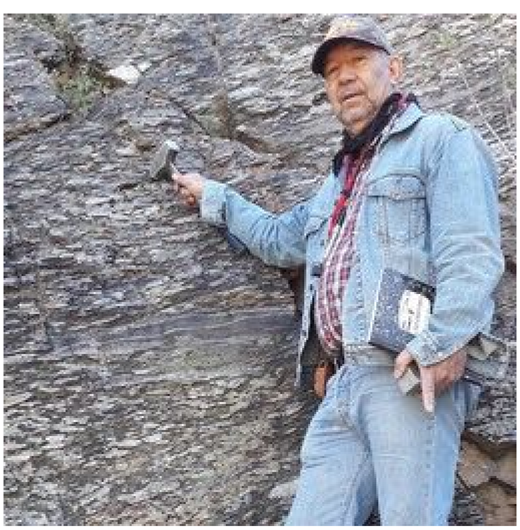


Figure 4. Carlos González León. Taken from (http://www.erno.geologia.unam.mx/comunidad-igl/carlos-manuel-gonzalez-leon).

The Cambrian also crops out in the Sierra del Tule area in Cananea, in northeastern Sonora. It was studied by González León (Figure 4) in 1986, reporting and describing for the first time the Abrigo Formation in the area. The presence of calcareous algae, and trilobites in a sequence of sedimentary rocks of the middle and upper Cambrian (Dresbachian) are lithologically correlated with the Bolsa Quartzite and the Abrigo Formation of Arizona. Allison Palmer collaborated with the identification of the species *Arapahoia* sp., *Cedaria* sp., *Coosella* sp., *Coosia* sp., *Llanoaspis* sp. and *Tricrepicephalus* sp.

In 1987, McMenamin (Figure 5) identified the species *Fallotaspis*? sp. as well as the new species *Nevadia ovalis* and *Avefallotaspis*? *orbis* (syn. *Judomia orbis*) from the lower Cambrian in the region of Caborca. The trilobites that are discussed in that report are important to correlate the Puerto Blanco Formation with other North American units.

The Cambrian rocks of Arivechi, east of Sonora, were studied by Almazán-Vázquez (Figure 6) in 1989. He named La Sata, El Mogallón, La Huerta and Milpillas formations. The biostratigraphic information of these units is not precise and part of the biotic content has been reas-

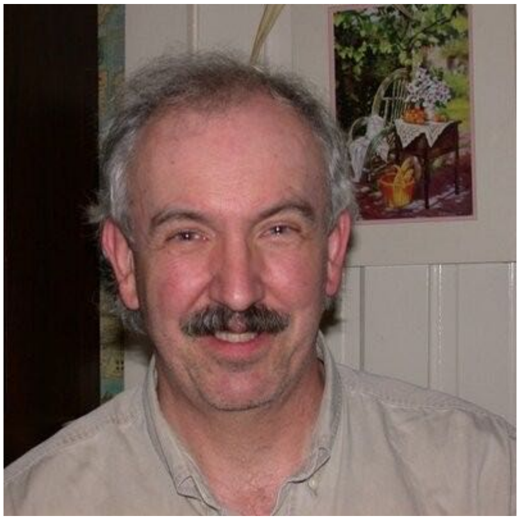


Figure 5. Mark McMenamin. Taken from (https://twitter.com/mcmaverick7).

signed to different taxa. La Sata Formation contains the species *Amecephalus* sp. and *Fieldaspis*? sp., indicating the middle Cambrian and possible an unknown previous Pre-*Glossopleura* Zone. El Mogallón Formation yielded the species *Bathyuriscus* sp., *Ptychagnostus atavus*, *Ptychagnostus michaeli*, *Hypagnostus parvifrons*, *Peronopsis fallax*, *Peronopsis* sp., *Olenoides* sp. cf. *O. marjumensis*, *Modocia typicalis*?, *Modocia* sp., *Utaspis*? sp., suggesting that the rocks belong to the middle part of the middle Cambrian. La Huerta Formation provided indeterminate ptychopariid trilobites, representing the upper part of the middle Cambrian, although the taxa did not show a precise age. The Milpillas Formation is represented by the species *Aphelotoxon* sp., *Elviniella* sp., *Homagnostus* sp., *Pseudoagnostus* sp., *Pterocephalia*? sp. and indeterminate ptychopariids, placing these rocks in the middle part of the upper Cambrian, indicating the *Dunderbergia* or *Elvinia* Zone.

In the same year (1989), Cirett and Aguilar discovered the Cambrian rocks of the San José de Gracia area, central Sonora, describing the stratigraphy of the rocks and identifying the Proveedora, Buelna and Cerro Prieto formations, that were correlated with those of the Caborca area.

In 1996, Vega-Granillo described the geology and made a structural analysis of the Sierra Agua Verde, Mazatán, central Sonora. In this area, a sequence of sedimentary rocks, mainly

Figure 6. Geologic expedition to San José de Gracia in 2006 (left to the right: Rogelio Monreal, Rene Fernandez and Cecilia Santillana behind, Daniel Rivera (at the back), Tobias Schwennicke, Francisco Cuen, Emilio Almazán-Vázquez and Fernanda Enríquez). Photo courtesy of Francisco Cuen.

Figure 7. Frederick Sundberg, Francisco Cuen and Guadalupe Espinoza, Universidad de Sonora, 2013 (Left to the right). Photo courtesy of Francisco Cuen.

limestone interbedded with detrital rocks are exposed. This unit contains *Tonkinella valida*, *Peronopsis fallax depressa* (Syn. *Quadragnostus depressa*), *Tomagnostus* sp. and *Syspacephalus* sp. (syn. *Ptychoparella* sp.), indicating the *Ehmaniella* Zone. Years later, those rocks were assigned to the *Altiocculus* Subzone, due to the presence of *Tonkinella valida*.

After the discovery of the Cambrian rocks of San José de Gracia, several scientists focused their research on the stratigraphy and paleontology of that area. Indeed, these rocks contain a great abundance of fossils, highlighting brachiopods and trilobites.

In 2002, Almazán-Vázquez carried out the first paleontological studies of the Cambrian rocks, as shown by some short summaries published in memoirs. The author mentions the presence of an abundant early and middle Cambrian biota and dividing the sedimentary sequence of El Chihuarruita Hill into seven members (A-G). In that year, Stewart and other authors collected fossils of *Oryctocara* sp., *Peronopsis* sp., *Peronopsis bonnerensis* (syn *Pentagnostus* (*Meragnostus*) *bonnerensis*), *Peronopsis brighamensis*, *Oryctocephalus* sp., *Pagetia* sp. and *Ehmaniella*? sp., among others. Later in 2004, Buitrón and other authors documented the presence of trilobites *Bristolia* sp. cf. *B. bristolensis* from the lower Cambrian and *Peronopsis* sp. cf. *P. bonnerensis* from the middle Cambrian.

Since 2009, Cuen (Figure 7) and other authors have continued geological studies in the San José de Gracia area with an emphasis on stratigraphy and paleontology. They established the rocks of San José de Gracia as reference sections to the Cambrian units of Caborca.

The authors collected specimens of ichnofossils, oncolytic algae, agmats, chancelloriids, poriferans, brachiopods, mollusks, echinoderms, and trilobites, obtaining information to unravel the paleoecology of the deposits, and conducting a re-evaluation of the materials. They identified the trilobites *Bristolia* sp. cf. *B. bristolensis* and *Olenellus* sp. of the lower Cambrian. Based on the above, the lower Cambrian rocks are assigned to the *Bristolia mohavensis-Bristolia insolens* zones. For the middle Cambrian they collected *Peronopsis bonnerensis* (syn *Pentagnostus* (*Meragnostus*) *bonnerensis*), *Peronopsis* sp., *Pagetia resseri*, *Bathyuriscus* sp., *Elrathina antiqua* (syn *Ptychoparella* (*Elrathina*) *antiqua*), *Ogygopsis typicalis*, *Oryctocephalus* sp. and *Oryctocephalites walcotti*, identifying the *Mexicella mexicana* Zone, *Albertella highlandensis* Subzone.

In 2016, Cuen and other authors described the Cambrian stratigraphy of the San José de Gracia area, constituted by four formations: Proveedora, Buelna, Cerro Prieto, and a new formal stratigraphic unit named El Gavilán Formation. In that work, the presence of *Amecephalus arrojosensis* is reported for the first time at the base of the Cerro Prieto Formation, which would be an indicator of the middle Cambrian. El Gavilán Formation contains abundant inarticulate and articulated brachiopods, sponge spicules, chancelloriids, hyolithids, trilobites, among others. Previously, the rocks of this unit had been included as part of the Cambrian rocks of Caborca; however, this new formation reflects lithological differences with the Arrojos Formation of the Caborca area, as well as the presence of agnostid trilobites of middle Cambrian age. It is considered that these rocks were deposited on an outer shelf environment.

In 2018, Cuen and collaborators (Figure 8) performed a biostratigraphic analysis based on the information available from the Cambrian rocks of the Sonora state. Trilobite faunas have been divided into four regions according to their geographical position: northwest region (Caborca), north region (Cananea), central region (San José de Gracia and Mazatán) and east region (Arivechi). The stratigraphy, biota and biostratigraphic considerations for each region are described, being the first time that a detailed biostratigraphic correlation of the rocks of the Cambrian of Sonora is made. Also, in this study, the new Cambrian division proposed by the International Subcommission on Cambrian Stratigraphy is implemented, assigning chronostratigraphic positions to the Cambrian strata of Sonora. The biostratigraphic zones were established according to Webster (2011) and Webster and Bohach (2014).

The Cambrian outcrops of Sonora have a significant value for the stratigraphy of Mexico, since the Cambrian is exposed only in Sonora. Cambrian rocks contain an abundant fossil fauna that

Figure 8. Francisco Cuen, Alfredo Ochoa, Blanca Buitrón and Fredereick Sundberg in a field expedition in San José de Gracia, Sonora, 2018 (lefto to the right). Photo courtesy Francisco Cuen.

probes a close relationship with the North American Craton. The recently published works demonstrate the interest in continuing with the paleontological legacy of these 78 years of research of the Cambrian trilobites in Mexico. The close collaboration between trilobite specialists, such as Frederick Sundberg, has allowed the discovery and study of new locations. To date, an approximate of 90 species of Cambrian trilobites have been documented for the Cambrian of Sonora. In the same way, the establishment of biozones for the different localities leads to biostratigraphic problems due to the inaccuracy of the stratigraphic position of some specimens collected in the last century. The continuous changes in the establishment of the Cambrian ages will allow for more precise studies.

References

Almazán-Vázquez, E. 1989. El Cámbrico-Ordovícico de Arivechi, en la región centrooriental del estado de Sonora. Universidad Nacional Autónoma de México, Instituto de Geología. Revista 08(1):58-66.

Almazán-Vázquez, E., 2002, El Cámbrico Temprano y Medio de San José de Gracia, Sonora Central, México (resumen), in Unión Geofísica Mexicana, 22, núm. 2, 333.

Baldis, B., & Bordonaro, O., 1981. Evolución de facies carbonáticas en la cuenca cámbrica de la Precordillera de San Juan. In VIII Congreso Geológico Argentino. San Luis, Argentina. Actas (Vol. 2, pp. 385-397).

Buitrón. B.E., Almazán, V.E., Mendoza, M.C., 2004, Gogia spiralis el eocrinoide de mayor antigüedad (Cámbrico temprano) de México (resumen), in Unión Geofísica Mexicana, 24, 2, 251.

Cirett, G.J., Aguilar, R.F., 1989, Características geológicas e hidrogeoquímicas del Valle de Ures, Sonora, México: Sonora, México, Universidad de Sonora, Tesis de licenciatura, 137 p.

Cooper, G.A., Arellano, A.R.V., 1946, Stratigraphy near Caborca, northwest Sonora, Mexico: Bulletin American Association Petroleum Geologists, 30, 606-611.

Cooper, G.A., Arellano, A.R.V., Johnson, J.H., Okulitch, V.J., Stoyanow, A., Lochman, C., 1952, Cambrian Stratigraphy and Paleontology near Caborca, northwestern Sonora, México: Smithsonian Miscellaneous Collections, 119, 1-184.

Cooper, G.A., Arellano, A.R.V., Johnson, J.H., Okulitch, V.J., Stoyanow, A., Lochman, C., 1956, Geología y Paleontología de la región de Caborca, norponiente de Sonora: Pt. 1ª, Universidad Nacional Autónoma de México, 259.

Cuen, R.F., 2012, Sobre la Estratigrafía y Paleontología del Cámbrico del área de San José de Gracia, Sonora central: Sonora, México, Universidad de Sonora, Tesis de licenciatura, 73 p.

Cuen, R.F., Almazán-Vázquez, E., Montijo, G.A., Minjárez, S.I., Grijalva, N.F., Monreal, S.R., Schwennicke, T., Ochoa, G., 2009, Faunas marinas de invertebrados del Cámbrico temprano y medio en la parte central del estado de Sonora, México (resumen), in Unión Geofísica Mexicana, 29, 1, 91.

Cuen, R.F., Montijo, G.A., Minjárez, S.I., De la O, V. M., Buitrón, S.B., Sundberg, F., 2012, La biota del Cámbrico de San José de Gracia, Sonora: Consideraciones bioestratigráficas, sistemáticas y paleogeográficas (resumen), in Universidad de Sonora, Departamento de Geología. XXXV Semana Cultural, 33.

Cuen, R.F., Beresi, M.S., Montijo, A., Buitrón, B.E., Minjárez, I., De la O, M., Palafox, J.J., 2013, Chancelloriia Walcott, 1920 y Reticulosa Reid, 1958 del Cámbrico medio de San José de Gracia, Sonora, México: Boletín de la Sociedad Geológica Mexicana, 65, 581-590.

Cuen-Romero, F. J., Valdez Holguín, J. E., Buitrón, B. E., Monreal, R., Sundberg, F., Montijo González, A., & Minjarez Sosa, I., 2016. Cambrian Stratigraphy of San José de Gracia, Sonora, Mexico: El Gavilán Formation, a new lithostratigraphic unit of middle Cambrian open shelf environment. Boletín de la Sociedad Geológica Mexicana, 68(3), 429-441.

Cuen-Romero, F. J., Valdez-Holguín, J. E., Buitrón-Sánchez, B. E., Monreal, R., Enríquez-Ocaña, L. F., Aguirre-Hinojosa, E., & Palafox-Reyes, J. J., 2018. Trilobite-based biostratigraphy (arthropoda-trilobita) and related faunas of the Cambrian from Sonora, Mexico. Journal of South American Earth Sciences, 83, 227-236.

Fritz, W. H., 1975. Broad correlations of some Lower and Middle Cambrian strata in the North American Cordillera. Geological Survey of Canada Paper, 75-1 (Part A):533–540.

Lochman, C., 1948, New Cambrian trilobite genera from northwest Sonora, Mexico: Journal of Paleontology, 22, 451-464.

McMenamin, M. A., 1987. Lower Cambrian trilobites, zonation, and correlation of the Puerto Blanco Formation, Sonora, Mexico. Journal of Paleontology, 61(4), 738-749.

Palmer, A. R. y R. B. Halley. 1979. Physical stratigraphy and trilobite biostratigraphy of the Carrara Formation (Lower and Middle Cambrian) in the southern Great Basin. U.S. Geological Survey. Professional Paper 1047.

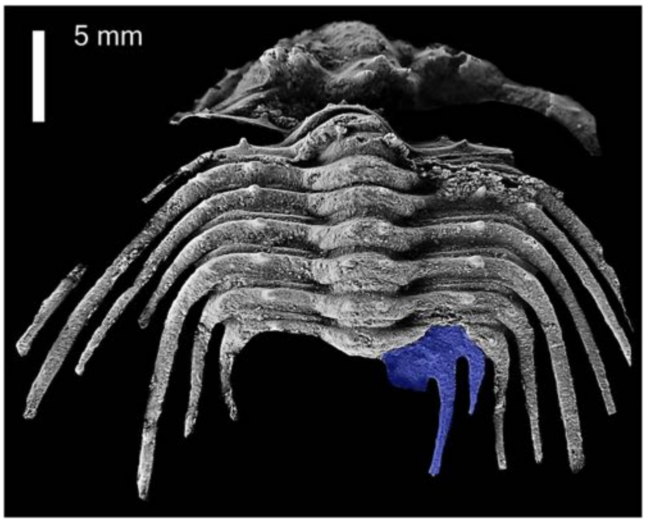
Stewart, J.H., McMenamin, M.A., MoralesRamírez, J.M., 1984, Upper Proterozoic and Cambrian Rocks in the Caborca Region, Sonora, Mexico – Physical Stratigraphy, Biostratigraphy, Paleocurrent Studies, and Regional Relations: U.S. Geological Survey Professional Paper, 1309, 36.

Stewart, J.H., Amaya-Martinez, R., Palmer, A.R., 2002, Neoproterozoic and Cambrian strata of Sonora, México. Rodinian Super continent to Laurentian Cordilleran Margin: Geological Society of America Special Paper, 36, 9-15.

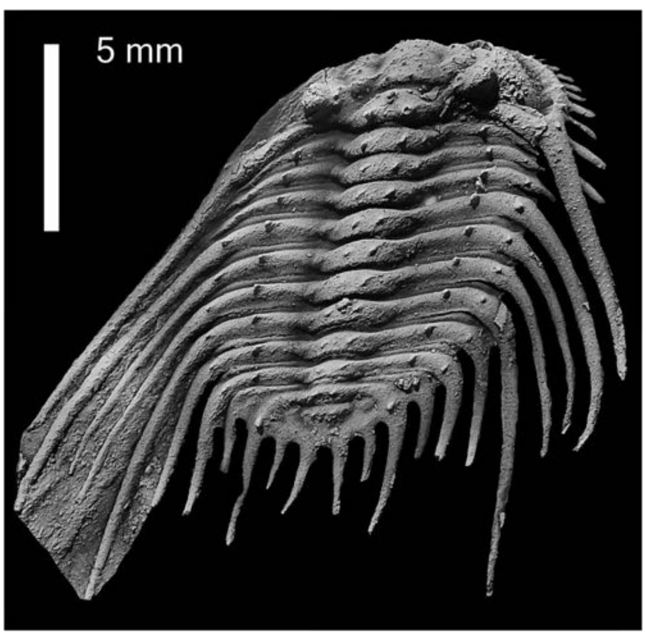
Vega, G.R., 1996. Geología de la sierra de Mazatán. Bol. Depto. Geol. Uni–Son. Vol 13, No. 1, p. 89 – 102.

Reference to: Alberti, M. 2018. *Leonaspis bassei* n. sp. (Trilobita, Odontopleuridae) aus dem basalen Rupbach-Schiefer (Ober-Emsium; Rhenoherzynikum). *Mainzer geowissenschaftliche Mitteilungen*, 46: 7–22.

Martin Basse & Peter Müller
We refigure herein a cast of the holotype (external mold) of this species showing details of the dislocated pygidium, and a cast of the external mold of a recently found articulated specimen of the same species being described as hypotype later.



Cast of holotype of *Leonaspis bassei* Alberti. Blueish area indicating preserved parts of the pygidium. Lahn Syncline, Rhenish Massif, Germany. Rupbach Shale,



Cast of external mold of future hypotype of the same species from the same bed as the holotype. (Photograph by P. Müller.)

THE IMPORTANCE OF THE MARBLE MOUNTAINS

Fred Sundberg
[The following article was written to fulfill a request for me by Nigel Hughes to write about the Marble Mountains for government agencies trying to decide how to regulate the Marble Mountain collecting.]

I cannot think of a single location in the United States that is more important for the training of students and enjoyment of amateurs than the **Marble Mountains**, California. This location is has been the most influential fossil locality in developing my research interest and professional career. I am a paleontologist that began as an amateur. I am internationally known for my work on trilobites. I have several publications on Cambrian trilobite biostratigraphy, taxonomy, and evolution and Cambrian stratigraphy, trace fossils, international correlations, depositional environments and paleoecology. My Cambrian research has involved many areas, including California, Nevada, Utah, Arizona, Washington, Idaho, Tennessee, Virginia, and China. All of this because I was allowed to collect trilobites from the Marble Mountains, **unrestricted**.

Fossil Collecting by Amateurs:
My dad took me out to the Marble Mountains when I was in the 6th grade, and I was hooked on trilobites! Over the years, I made several trips to the Marbles with my family (Dad, Mom, Brothers), with my best friend in high school, the Southern California Paleontological Society, College classes, with my own family, and with friends. This place had a permanent impact on me and the development of my research programs that has generated several professional publications on the Cambrian.

To deprive amateurs access to the Marble Mountains would be depriving future scientists a potential jumping off point to a career in science (not just paleontology or geology). In addition, many people have donated valuable specimens

A young teenager Fred Sundberg (ca 1970s) collecting fossils at the Marble Mountains

from the Marbles to museums and other institutions. I myself donated my entire collections to California State University at Fullerton and several people from the Southern California Paleontological Society have also donated specimens. So when I say amateurs, I am including everybody from young to old.

Collecting and Research Permits:
I am a very strong supporter of **not** requiring collecting or research permits for any location in the Marble Mountains, especially south of US 66. **Exceptions** would include commercial collecting (which I would ban entirely) and the use of heavy equipment (e.g., jackhammers, backhoes) for scientific purposes. This area of the Marble Mountains is really a field classroom for all ages and levels of education. Two examples: 1) in a short notice trip in 1976 for Derek Briggs (a well respected paleontologist, then at the University of Cambridge, now at Yale University), I was asked to take him out to the Marble Mountains where he could collect and see the famous Cambrian locality and 2) during one of my visits to the Marble Mountains in the 1990s, I found an unnamed echinoderm that was donated to Dr. James Sprinkle (the University of Texas at Austin).

If permits are to be required for any research and collecting, then the permit process needs to be significantly modified. If the permitting process is anything that I filled out for the BLM to do collecting in Nevada, then it is not valid. Permit policies have been mostly set by archaeologists and perhaps a few vertebrate paleontologists. Archaeology resources are truly limited, and their approach of collecting, documenting, deposition in a research facility, and at least a partial preservation of the site are fully justified. I worked in the cultural resource business, where I did archaeology, geoarchaeology, history and paleontology. However, invertebrate and some vertebrate sites are not the same as archaeological sites. Most sites, such as the Marble Mountains, have relatively unlimited paleontological resources. The more you dig, the more you find and the more exposure you have for further collecting. I know of only one formation that has been depleted of its paleontological resources, and that is the Miocene Oso Sand of Southern California. The only reason this formation no longer produces abundant fossils is due to construction activities (housing) in Orange County.

In addition, it is ridiculous to collect and number every specimen discovered during a paleontological excavation. First reason, many fossils are fragmented and cannot be identified and thus useless. Second, there is no museum or research center that will take all of the specimens regardless of preservation and completeness (yes the BLM permit required that ALL specimens discovered must be cataloged and deposited in a museum/university). Third, some specimens are covered with calcite and dirt, which prevents their discovery until the material becomes weathered. Fourth, trilobites at the Marble Mountains must be found by splitting hard shale and some layers you cannot split until they weather. Yes, some valuable specimen might be left behind in talus piles—but both professionals and amateurs look through these piles.

Geologic Mapping by Students:
The Marble Mountains (just south of US 66) contains a diverse geology suitable for mapping by beginning to advance undergraduate students. It is so important for students, that as far as I

know, there has been no published detailed map of the area. Having mapped this area, I know the geologic diversity. For the beginning student, they can put their hands directly on rock unit contacts and faults, follow contacts across mountains, trace faults, easily recognize different formations, trace the Jurassic dikes, observe different types of unconformities and contacts, use topographic maps or aerial photographs for mapping, and take abundant strikes and dips of rock layers and faults. For the more advance students, they can document gravity slides, drag folds, anticlines, synclines, determine types of faults. For the more challenging mapping, there are metamorphic rocks exposed in small outcrops on the western side of the range and trace contacts and faults in washes where the area is mostly covered by alluvium on the eastern side of the range. In addition, there is a small adit (about 50 ft long) where a Jurassic dike intruded the Chambless Limestone with a few copper minerals still visible.

During my years at the Marble Mountains, I have seen the area completely empty of classes to having over 50 people from different schools mapping and observing the geology. Schools that I have seen in the area mapping include California State University at Fullerton, San Diego State University, University of Nevada Las Vegas, and California Institute of Technology. I am sure there are several other schools that use this area for teaching as well.

KEEPING FOSSIL SITES OPEN TO COLLECTORS

by Don Bissett; Dry Dredgers Fossil Club (Cincinnati, Ohio, USA), Norton Shores, Michigan, USA; donbissett@gmail.com.

One of the challenges faced by many collectors, both amateur and professional, is access to fossil sites. These localities are rapidly disappearing due to development, legislation, and liability concerns. Yet field trips and collecting are critically important to the study of fossils and stratigraphy, the discovery of new species, extinction, and perhaps even more importantly to generating interest in science in children and young adults (1-3). After all, the next generation of scientists will come from today's youngsters. Thus, it is critically important to keep fossil collecting localities open to the public to provide opportunities for budding scientists to become inspired by science.

For me personally, it was a geology class field trip in the 8th grade that sparked my interest in the sciences. From that point onward, I knew that science was my calling. An undergraduate degree in chemistry was followed by a graduate degree in biochemistry. Now, after a 40-year career in industrial research (and collecting trilobites as an amateur), I still look back to that 1962 field trip as the point in time when I became a scientist. Not surprisingly, I've heard similar stories from several colleagues.

Since field trips are so important to recruiting people to the sciences (1-3), I'll present three examples of how collecting sites were saved from the fate of the trilobites we collect: extinction.

Example 1. The Penn Dixie Fossil Park & Nature Reserve (*aka* Penn Dixie Site) in Hamburg, New York devotes its efforts to science education (penndixie.org). That's quite a leap forward, considering the shady history of the property where the site is located.

For many years, the property had been an abandoned quarry. It was a place where teens went to party, and gun enthusiasts blasted glass bottles with shotguns. Locals used it as a dumping ground for literally tons of garbage. In the eyes of many, it was a public nuisance.

But to amateur collectors, who dug the shale and found Devonian trilobites (see Figure), the site was a gold mine. Because of that, a handful of people wanted to preserve the property as a park. Yet from the start, it was an uphill battle for the Penn Dixie team. In the early 1990s, local leaders and the public were not convinced that buying the site had merit (for educational or scientific value, or for attracting tourism dollars). Competing proposals for use of the land included a waste transfer station and a chemical waste storage area. However, the Penn Dixie team was persistent, spending months campaigning to get citizens and the town council on board. They succeeded, and in 1995 the Hamburg Natural History Society purchased the property. They fenced it, cleaned it up with the help of countless volunteers, and converted it into a fossil and wildlife park. Their mission: to promote hands-on study of natural science.

For its more than two decades of existence, the Penn Dixie site has focused heavily on leading field trips for thousands of children every year. The kids are brought in by the busload from local schools and summer camps to learn about fossils and geology from the Park's staff, to observe nature, and to collect and identify specimens (e.g., corals, brachiopods, trilobites) that erode out of the Devonian shale. Adults, families, geology classes, and professional paleontologists are also welcome at the site. For many years, though, digging for fossils was not permitted.

A creative solution to the problem was proposed by an amateur (from the Dry Dredgers). He proposed that Penn Dixie start a program where volunteer collecting experts (e.g., from the Dry Dredgers) would demonstrate to other amateurs how to dig and split the shale to find the site's trilobites. A fee would be paid to Penn Dixie to participate. The digging would not only bring in more income for the site, it would also expose more shale from which more fossils (such as

Figure caption: Prone *Phacops (Eldredgeops) rana*, Devonian, Windom Shale, Smoke Creek Bed, Penn Dixie Site, Hamburg, New York. The articulated specimen on the slab of shale is 4.3 cm long.

brachiopods, corals, and small trilobites) could be exposed with each rainstorm. That would replenish specimens on the surface for the busloads of children to collect.

After considerable debate, the proposal was eventually accepted by the Hamburg Natural History Society. Thus, approximately 15 years ago, the annual Dig with the Experts was born. The same experts from the Dry Dredgers continue to volunteer for the Dig every year. Since then, it has grown into a huge success story for Penn Dixie: more income for the site to fund their programs, collecting opportunities for individuals and families, and fossil material on the surface for the bus loads of school children, providing them hands-on opportunities to collect and study, and to be stimulated by science.

Example 2. A commercial rock quarry in Paulding, Ohio had for several years allowed amateur fossil clubs and professional paleontologists into the quarry to collect and study the Devonian Silica Shale and its fossils (e.g., brachiopods, corals, echinoderms, trilobites, fish) that are exposed during mining. Eventually, though, concerns about liability resulted in the mine being closed to collectors.

However, an amateur collector was determined that this was not the end of the story. He talked at length with the quarry management about other options. Based on these discussions, he then pressed collectors to write and send letters to the quarry urging them to keep the site open. That resulted in many amateurs, fossil clubs (including the Dry Dredgers), and professionals formally encouraging the quarry to remain accessible.

Because of the many convincing arguments received in the letter-writing campaign, the quarry felt compelled to find a solution. Later they announced that a fossil park would be established in 2016. Thus was born the Paulding County Community Fossil Garden, which is open to everyone for collecting. It is located on a corner of the quarry property that is far from the potential hazards of the mining operations. Periodically, additional freshly mined shale is added to the park to replenish the rock. And with each rainstorm, more fossils are exposed for collecting.

Example 3. The Trammel Fossil Park started as an industrial development site. During excavations to prepare for building lots, fossil-rich Ordovician strata were exposed. The exposure quickly drew the attention of amateurs, professionals, and educators. The owner (Mr. R. L. Trammel) graciously allowed collecting. The site was often visited by geology classes from the University of Cincinnati (UC), and from as far away as New York, to study the stratigraphy and to look for its brachiopods, bivalves, echinoderms, and trilobites.

Seeing the enthusiasm of the collectors and the value of the ten-acre plot to the advancement of science, Mr. Trammel donated the property to the City of Sharonville, Ohio. Subsequently, a cooperative effort involving Mr. Trammel, the City, UC, and the Dry Dredgers led to the founding in 2003 of Trammel Fossil Park (sharonville.org). The site is still a popular collecting locality for individuals, clubs, geology classes, and even by the North American Paleontological Convention attendees as part of the 2009 NAPC meeting in Cincinnati.

While saving fossil collecting sites from extinction is a fairly rare event, it can happen. The cited examples have in common the proactive collaboration among landowners, the public, local leaders, professionals, and/or amateurs. While there is no formula for how to do it, the key is for an individual or group of individuals to lead the way in finding creative solutions that keep localities accessible.

References:

1. P.J. Stokes, Diversity in geoscience: Critical incidents and factors affecting choice of major, Ph.D. Dissertation, Department of Geosciences, University of Ari-

zona, 2016.
2. P.J. Stokes, R. Levine, and K.W. Flessa, Why are there so few Hispanic students in Geoscience?, GSA Today, 24, 52-53 (2014).
3. P.J. Stokes, R. Levine, and K.W. Flessa, Choosing the Geoscience Major: Important Factors, Race/Ethnicity, and Gender, Journal of Geoscience Education, 63, 250–263 (2015).

LEGAL EXPERT IN PALEONTOLOGY: A NEW PROFESSION

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Introduction

According to the Dictionary of the Real Academia Española de la Lengua (Royal Spanish Academy of Language), a "report" is the oral or written description of the characteristics and circumstances of an event or issue. ", But the Academy itself gives another definition much closer to the profession of expert, saying in point 3 of this document; that the report is the total discovery made by a lawyer, the prosecutor or an expert before the Court that has to rule the process.

Therefore, we will define the Expert Report as: The document prepared by one or several persons about facts, circumstances or conditions (personal or not) inherent in a known punishable act in a judicial process (although sometimes they ask for private reports). For this function, and this work, it is necessary to possess certain scientific, artistic or practical knowledge.

The expert is a specialist in a particular subject, which normally coincides with a field of professional activity, whether in strictly scientific, artistic or practical matters. Therefore, a certain degree of capacity is required.

In the Spanish Criminal-Procedural Law, the expert evidence is that means of a personal test that consists of the contribution to the process of a third party of a series of specialized or technical knowledge, that the judge does not possess, in order to facilitate the perception and the appreciation of controversial facts.

Therefore the expert is the person who, without being part of a process, brings to the same his scientific, practical or technical knowledge, in order to provide the judge with the specialized "maxims of experience" to assess or perceive certain facts.
There are many other definitions of an expert. Let's see for example the Dictionary of the Royal Academy of the Spanish Language: From the Latin perī tus: 1. Understood, experienced, skilled, practical in a science or art. 2. Person who, possessing certain scientific, artistic, technical or practical knowledge, informs, under oath, the judge about disputed points as they relate to their special knowledge or experience (Corbacho & Martínez, 2014).


Conference on falsification of fossils in the School of Criminology of Catalonia in Barcelona (Spain).

A judicial expert in paleontology is an expert in falsifications, fossil appraisals, basic knowledge of paleontology and knowledge of the laws as any other judicial expert.

Historical background

The first article about paleontological falsifications that took place in Spain was about Moroccan trilobites (Corbacho *et al*., 2007). Later, other groups of fossils were evaluated, such as (Corbacho & Vela, 2009), (Corbacho *et al*., 2011, 2015), (Corbacho & Sendino, 2012, 2015). (Avilés, 2017) and (Corbacho & Adserà, 2017).

The first articles that dealt with the subject of expertise in paleontology are the following: (Corbacho, 2014), (Corbacho & Martínez, 2014) and (Corbacho & Martínez, 2015).

From the School of Criminology of Catalonia in Barcelona, where I taught seminars of paleontological falsifications, they began to teach the first courses on expert evaluation in paleontological falsifications. After completing my final project of Master in Judicial Evaluation and Appraisal at the European University Miguel de Cervantes in Spain (Corbacho, 2014), from the International School of Criminology in Barcelona (Spain), I was selected to collaborate in a study program to lecture the first courses of judicial expertise in the paleontology of Spain.

Current situation

Currently there are several professional schools such as the International School of Criminology, Euroinova, Cenproex, Codesa, Intesa and universities such as the European University Miguel de Cervantes that teach courses of judicial expertise in paleontology.

There are two professional associations in Spain to which legal experts in paleontology are affiliated. Association of Perits and Taxadors of Catalonia (APTC), an association of which I am a founding member and current president and the National Association of Appraisers, Experts and Mediators (ATPM) every day there are more associations of experts that are interested in developing these new professional affiliations.

Collaboration with universities and museums

When a judge, an auction house, an insurance company or a private individual needs a certificate of authenticity or an appraisal of a collection of fossils, they turn to a court expert in paleontology.

The judicial expert in paleontology must have a collaboration with universities or museums where they can perform the necessary tests such as X-rays, scans, etc.

Conclusion

A judicial expert in paleontology is an expert in falsifications, fossil appraisals, basic knowledge of paleontology and knowledge of the laws as any other judicial expert.

It was in the Catalan community (Spain) that the first seminars on fossil forgeries began to be given and after a few years the new profession of judicial expert in paleontology was created.
It has been an honor for me to be a pioneer along with the members of the School of Criminology of Catalonia in the creation of this new profession in Spain.

References

Corbacho, J., Vela, J.A. & Cuevas, J.A. 2007. Falsificación de trilobites del N. de África. *Batalleria* 13: 29-36

Corbacho, J. & Vela, J.A. 2009. Falsificación de fósiles del N. de África. *Batalleria* 14: 45-56

Corbacho, J., Sendino, C. & Tahiri, M. 2011. Palaeontological fakes, *Batalleria* 16: 37-45

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

Corbacho, J. 2014. TFM. En pericia y tasación judicial. Universidad Europea Miguel de Cervantes. DOI: 10.13140/RG.2.1.1872.8489

Corbacho, J. & Martínez, D. 2014. Perito judicial en paleontología: Una nueva visión. *Comunicats* 38: 71-72

Corbacho, J. & Martínez, D. 2015. Sobre peritajes y tasaciones en paleontología. *Comunicats* 40: 71-76

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

Corbacho, J. & Adserà, P. 2017. Sobre unas falsificaciones de fósiles de Tailandia. *Batalleria* 24: 6-8

Webography

Avilés, J. 2017. To Identify Fossil Fakes: What You Need To Know: https://www.jurassic-dreams.com/pages/free-guide-how-to-identify-fossil-fakes-what-you-need-to-know

Corbacho, J. & Sendino, C. 2015. Fossil fakes and their

recognition. *Deposits Magazine*: http://depositsmag.com/2015/12/19/fossil-fakes-and-their-recognition

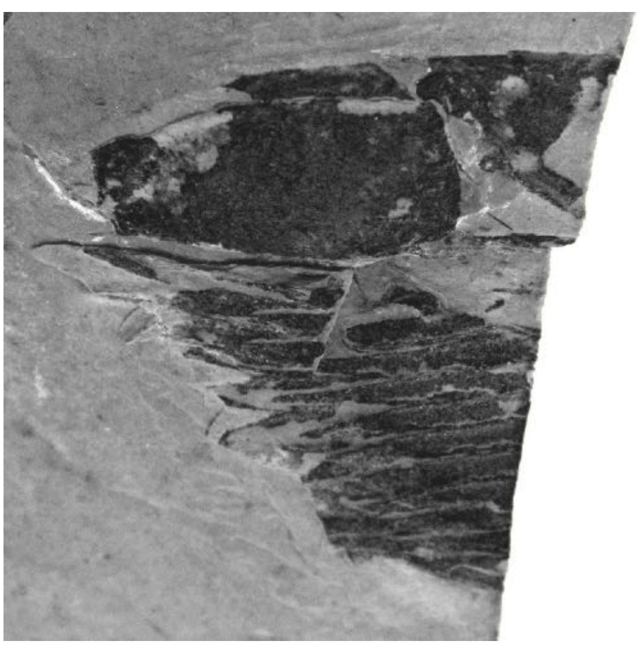
The diversity of Lower Cambrian trilobites from North Wales.

Adrian Ruston and Richard Birch

By assiduous collecting, Dr Richard Birch has increased, perhaps by an order of magnitude, the number and variety of the fossils known from the Llanberis Slates Formation in North Wales. The major part of this collection is housed in the National Museum of Wales under the collection no. 2014:29G.

The small trilobite fauna previously recorded from the Llanberis Slates Formation has made it a key stratum for correlation of the Cambrian System in its historical type-area in North Wales. The original discovery by quarrymen at Penrhyn Quarry, Bethesda, was written up by Woodward (Quarterly Jour. Geol. Soc., London, 1888), who described the new species *Conocoryphe viola* from there; his paper stimulated contemporary collectors to further search, but no additional species were reported or described.

When Lake (1931) came to review C. viola in Part 6 of his Monograph of British Cambrian trilobites (Palaeontographical Society, London), he made the mistake of assuming that all the specimens of trilobites from Penrhyn were referable to *C. viola*. He took a cranidium with a well developed eye-lobe to be that of viola, and he accordingly transferred the species to the Middle Cambrian genus *Solenopleura*; he also assigned a compact pygidium to the same species.

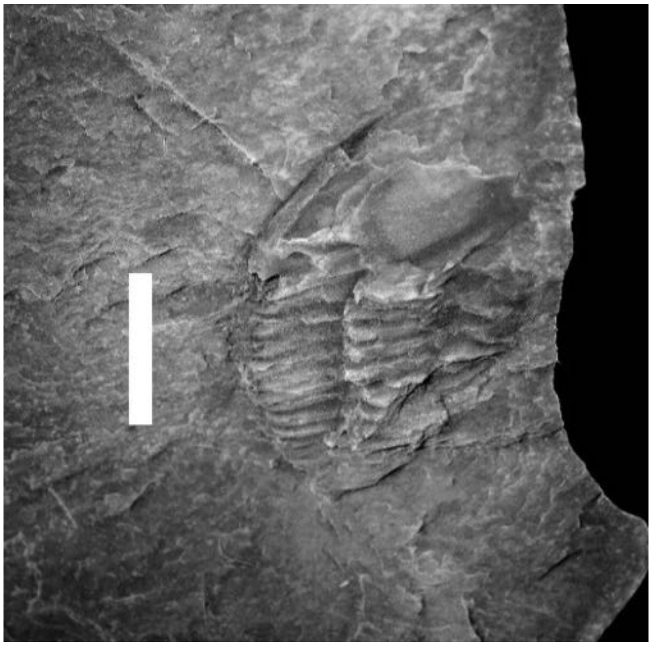


Pseudatops sp.

A few years later, when Lake (1940, ibidem, Part 12) revised the form *Atops reticulatus comleyensis*, which Cobbold (1936) had described from Lower Cambrian strata in Shropshire, he proposed a new genus *Pseudatops* to receive it and *Atops reticulatus* Walcott. At about the same time a new and almost complete specimen of *C. viola* was discovered at Penrhyn Quarry, and was presented to the British Geological Survey. There it was studied by C. J. Stubblefield, who became convinced that the original material of *C. viola* described by Woodward would be better transferred to *Pseudatops*. He co-operated with B. F. Howell, who had access to key specimens from eastern USA, and together they wrote a paper (Howell & Stubblefield 1950, Geological Magazine, vol. 87) discussing *Pseudatops*. They rejected the oculate cranidium figured by Lake as *Pseudatops viola*, and compared it with Protolenus; they also transferred the compact pygidium to the Eodiscidae, as a possible *Serrodiscus* species. They concluded that the Llanberis Slates Formation is most likely of Lower Cambrian age.

Since 1950 there has been no new publication on the palaeontology of the Llanberis Slates, but Birch's collecting has yielded some articulated polymerid trilobites that have not previously been described from the Llanberis Slate, includ-

Serrodiscus sp.



Unknown trilobite

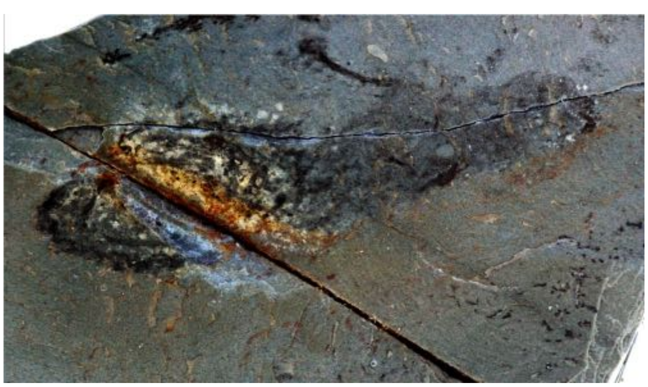
Lower Cambrian of the Avalonian Terrane yet found in Britain, and consequently a significant contribution to the understanding of the pan-global distribution of a 'Burgess-Shale-type' ecosystem in the early Cambrian.

We would also like to credit Lucy McCobb from the National Museum of Wales in Cardiff, who has been such a help with the photography.

Palaeoscolecid with proboscis extended

ing some which may be new. Among the eodiscoid trilobites also collected, there are several specimens of *Serrodiscus* akin to *S. bellimarginatus*, together with a *Mallagnostus* and a form similar to, but not identical with, *Weymouthia*. These confirm the early Cambrian age inferred by Howell & Stubblefield, and associate the Llanberis Slate with the Lower Cambrian horizons of Comley in Shropshire, Nuneaton in the English Midlands, and Newfoundland in Eastern Canada.

Despite trilobites being the major component, and distortion of the slate hampering identification beyond generic level, the collection also contains examples of more enigmatic organisms: hyolithids, bradoriids, bivalved arthropods, vetulicolians, sponges and well-preserved worms. This non-scleritised component mark it out as the most comprehensive fauna from the



Sipunculan

Contributions to Nomenclature of the Class Trilobita, 1

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Discussed and presented here is the correct year of publication of the name *Odontochile* (*Dalmania*) *exilis* EICHWALD, type species of *Estoniops* MÄNNIL, and its updated synonymy.

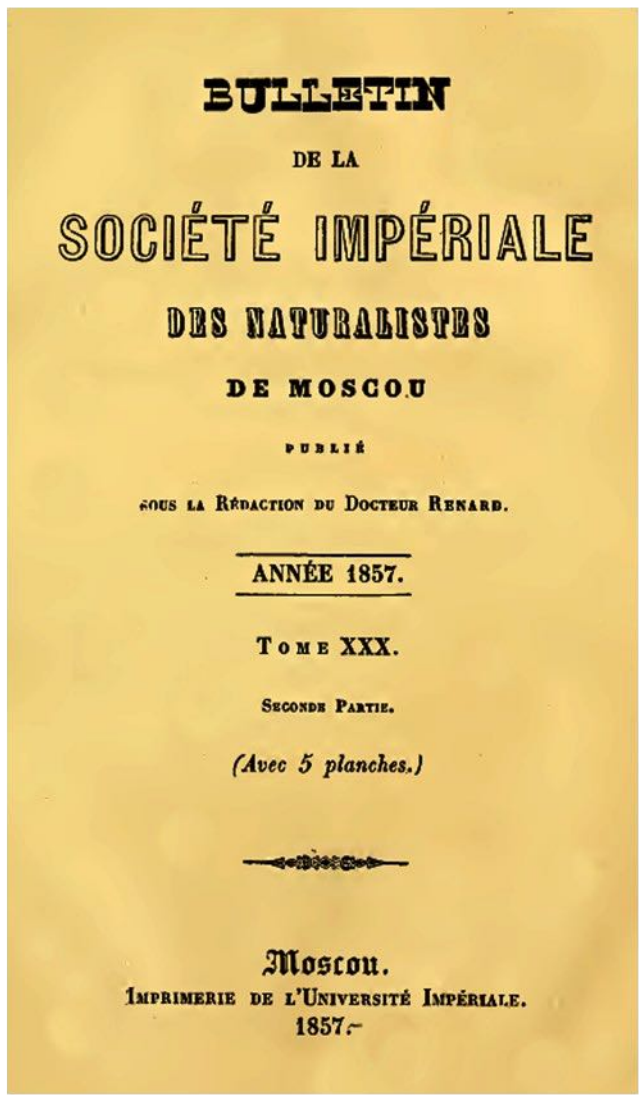
Text-fig. 1: Portrait of the young KARL EDUARD VON EICHWALD (* 04.07.1795, † 10.11.1876), author of the trilobite species *Estoniops exilis*. (Source: Wikipedia.)

The problem

There is helter-skelter in the nomenclature of the species *Estoniops exilis* because the year of its publication varies in literature between 1840, 1855, 1857, and 1858 (see synonymy below). The years 1840 and 1855 are easy to dismiss since related works of EICHWALD bear no trilobite name *exilis*. Among authors, the year 1857 is in use rather than 1858. However, in all these cases the authors do not quote the earliest available publication (text-fig. 2), but the following one with the same content (text-fig. 4). This work of EICHWALD, though dated "1857", has been released for February, 12th, 1858, according to remarks of the censor (text-fig. 3). Therefore, this contribution of EICHWALD dates from 1858, but not from 1857.

The solution

The correct nomenclature of the type species: Of this volume of 1858, a preprint was published in 1857, released by the censor on December, 18th, 1857 (text-figs 4, 5). This publication includes the earliest known mention of the trilobite name *exilis*, in combination with *Odontochile* (*Dalmania*), in a work of EICHWALD. Since the name is accompanied by a short description, it matches the ICZN rules and becomes available as *exilis* EICHWALD, 1857. *Odontochile* (*Dalmania*) *exilis* of the volume of 1858, like-



BULLETIN

DE LA

SOCIÉTÉ IMPÉRIALE

DES NATURALISTES

DE MOSCOU

PUBLIÉ

SOUS LA RÉDACTION DU DOCTEUR RENARD.

ANNÉE 1857.

TOME XXX.

SECONDE PARTIE.

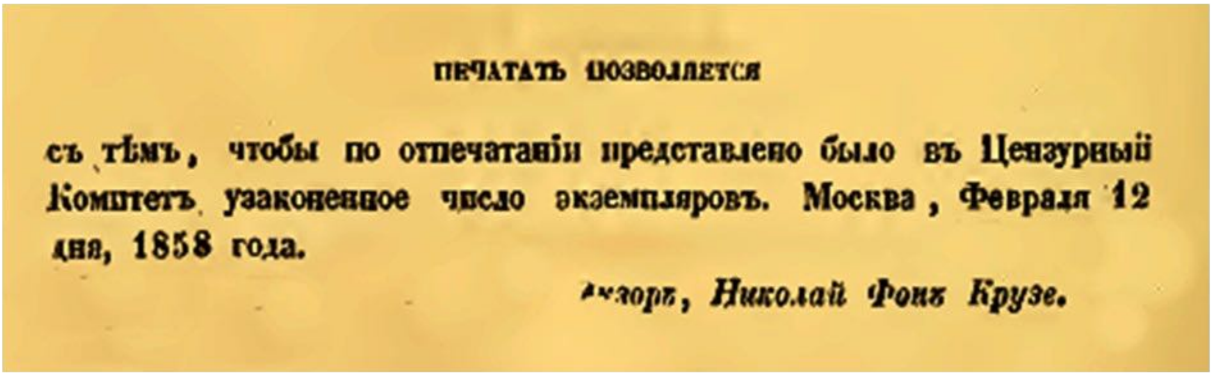
(Avec 5 planches.)

Moscou.

IMPRIMERIE DE L'UNIVERSITÉ IMPÉRIALE.

1857.

Text-fig. 2: Facsimile of the cover (reduced in size) of the volume including the work of EICHWALD (1858) dated "1857".


ПЕЧАТАТЬ ПОЗВОЛЯЕТСЯ

съ тѣмъ, чтобы по отпечатаніи представлено было въ Цензурный Комитетъ узаконенное число экземпляровъ. Москва, Февраля 12 дня, 1858 года.

…зоръ, Николай Фонъ Крузе.

Text-fig. 3: Facsimile of the release by the censor dated February, 12th, 1858, for the volume dated "1857" including the work of EICHWALD (1858).

wise available, thus has to be regarded as a junior objective synonym and primary homonym of the same name of 1857. In contrast, "*Acaste exilis* m[ihi]" of EICHWALD (1860, 1861a) does not denote a new species, though it was common to put „mihi" to denote new species in the early 19th century. In this case, however, it simply replaces the name of EICHWALD. This has to be regarded as very likely because almost all other "mihi" in the same work are combined with names which have already been published in former works of EICHWALD. Further, there is no doubt that *Acaste exilis* was meant to be the same as *Odontochile* (*Dalmania*) *exilis*, as EICHWALD (1860, 1861a) synonymized *Odontochile* (*Dalmania*) EMMRICH, 1844 with *Acaste* GOLDFUSS, 1843.

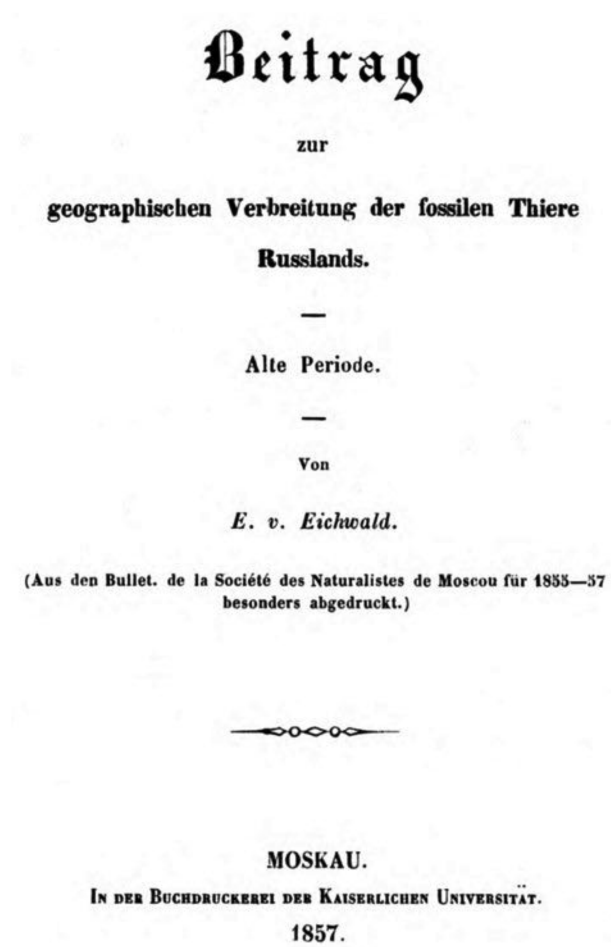
Synonymy
Family Pterygometopidae REED, 1905
Genus ***Estoniops*** MÄNNIL, 1958

Remark: In literature, the year of publication of *Estoniops* varies between 1957 and 1958. This problem can readily be solved by examination of the original publication proving that it was published in the year 1958.

Type species (by original designation): *Odontochile* (*Dalmania*) *exilis* EICHWALD, 1857, from the *Nemagraptus gracilis* graptolite Biozone of the Kukruse Stage, Sandbian, Late Ordovician of the Global Standard (text-fig. 6), of northeastern Estonia, Baltica.

Estoniops exilis **(EICHWALD, 1857)**

Remarks: Hitherto, no valid type has been chosen validizing the species name *Odontochile exilis*. The choice of a lectotoype by ANCYGIN (1970: 17), the cephalon figured by MÄNNIL (1958: Pl. 1, figs 1–3), is invalid since it does not represent a syntype (cf. JAANUSSON & RAMSKÖLD, 1993: 754), though it may serve


Beitrag

zur

geographischen Verbreitung der fossilen Thiere Russlands.

Alte Periode.

Von

E. v. Eichwald.

(Aus den Bullet. de la Société des Naturalistes de Moscou für 1855—57 besonders abgedruckt.)

MOSKAU.

IN DER BUCHDRUCKEREI DER KAISERLICHEN UNIVERSITÄT.

1857.

Text-fig. 4: Facsimile of the cover (reduced in size) of the preprint of the work of EICHWALD (1857).

Изъ Бюллетеня № 4, 1855. № 1, 2 и 4, 1856.
№ 1 и 4, 1857.

ПЕЧАТАТЬ ПОЗВОЛЯЕТСЯ

съ тѣмъ, чтобы по отпечатаніи представлено было въ Цензурный Комитетъ узаконенное число экземпляровъ. Москва, Декабря 18 дня, 1857 года.

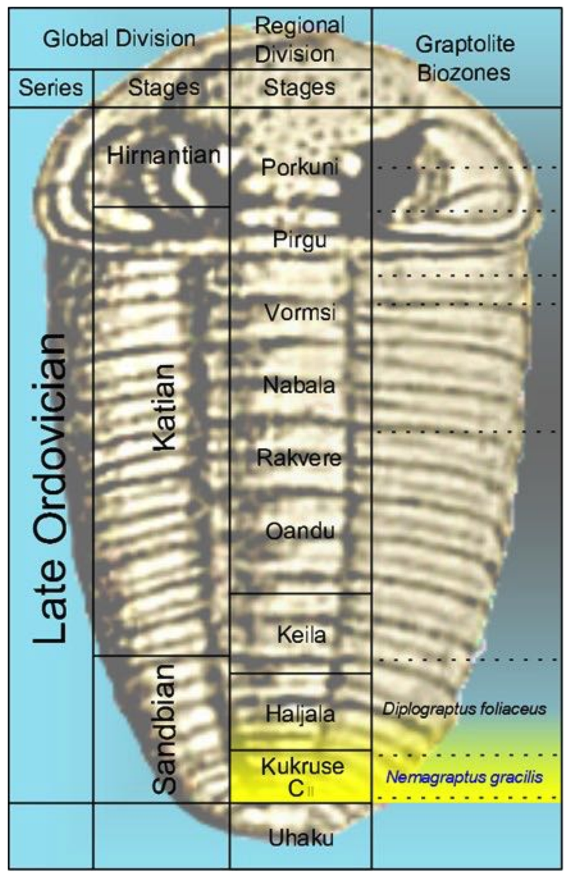
Цензоръ, Николай Фонъ Крузе.

Text-fig. 5: Facsimile of the release by the censor for the preprint of EICHWALD (1857) dated December, 18th, 1857, thus proving 1857 as year of publication.

well as neotype. Therefore, providing any kind of synonymy, as well as any taxonomic assignment, has to appear premature now. Nevertheless, a synonymy is given because on the one hand it impressively demonstrates the helter-skelter explained above. On the other hand, it appears useful for future contributions to share all nomenclatural and bibliographic information gained in the course of this investigation.

SCHMIDT (1881: 86) has regarded *Phacops dubius* NIESZKOWSKI, 1857, as junior subjective synonym of *Phacops exilis*. It is beyond the scope of my contribution to check the validity of SCHMIDT`s proposal and thus I do not consider *P. dubius* in this synonymy, except for its very first occurrence.

* 1857 *Odontochile* (*Dalmania*) *exilis* EICHWALD: 213.
* ?1857 *Phacops dubius* NIESZKOWSKI: 533, pl. 1, figs 1, 2 (cf. SCHMIDT, 1882: 86).
1858 *Odontochile* (*Dalmania*) *exilis* EICHWALD: 325.
1858 *Odontochile exilis* – GIEBEL: 171.
1859 *Odontochile exilis* – EICHWALD: Pl. 52, fig. 28a–c (= type, whereabouts unknown).
1860 *Odontochile* (ou *Dalmania*) *exilis* – EICHWALD: 294.
1860 *Acaste exilis* m. – EICHWALD: 1423.
1861a *Acast. exilis* m. [sic!] – EICHWALD: 418, 519.
1861b [*Acaste exilis*] – EICHWALD: Pl. 31, fig. 28 (cop. EICHWALD, 1859: Pl. 52, fig. 28) (atlas missing explanations, which have been published later, EICHWALD, 1861a: 519).



Text-fig. 6: Stratigraphic occurrences (yellowish area) for finds of *Estoniops exilis* in Estonia. Simplified modern division of the Late Ordovician. Background: Facsimile of one type of *Odontochile exilis* in EICHWALD (1859: Pl. 52, fig. 28b) from "Erras near Reval".

1868.*Dalmania exilis* – BIGSBY: 48.
1881 *Phacops exilis* [*Pterygometopus* as subgenus] [EICHWALD, 1857] – SCHMIDT: 86, 87, pl. 1, figs 19–

21, pl. 12, fig. 13.
? 1881 *Phacops exilis* var. [*Pterygometopus* as subgenus] – SCHMIDT: 87, pl. 1, fig. 18a, b.
1882 *Phacops exilis* [*Pterygometopus* as subgenus] – SCHMIDT: 521, 532 (from listing of trilobite species from the Kuckers Shale; no details).
1885 *Phacops exilis* – GEIKIE: 684 (stratigraphic table).
1885 *Phacops exilis* [*Pterygometopus* as subgenus] – ZITTEL: 615 (no details).
1888 *Phacops exilis* – WIGAND: 44, pl. 6, fig. 5a, b.
1890 *Phacops* (*Pterygometopus*) *exilis* [EICHWALD, 1857] – POMPECKI: 21, 92, Pl. 1, fig. 18.
1893 *Odontochile* (*Dalmania*) *exilis* n. sp. [EICHWALD, 1857] – VOGDES: 55 (cit. EICHWALD, 1857).
1893 *Acaste exilis* EICHW. – VOGDES: 56 (cit. EICHWALD, 1860).
1893 *Phacops exilis* EICHW. [*Pterygometopus* as subgenus] – VOGDES: 207 (cit. SCHMIDT, 1881).
1893 *Phacops exilis* EICHW. – VOGDES: 238 (cit. WIGAND, 1888).
1896 *Pterygometopus exilis* EICHW. [sic!] – KOKEN: 376 (no details).
1897 *Phacops exilis* – KIESOW: 30 (cit. SCHMIDT, 1882: Pl. 1, fig. 19a).
1901 *Phacops exilis* – GEIKIE: 1276 (stratigraphic table, Kukruse stage).
1907 *Phacops exilis* [*Pterygometopus* as subgenus] – SCHMIDT: 3 (cit. different literature).
1908 *Phacops exilis* – WIMAN: 105, pl. 7, figs 1–5.
1911 *Pterygometopus exilis* – BASSLER: 24 (faunal list, no details provided).
1915 *Phacops* (*Pterygometopus*) *exilis* – REED: 54.
1921 *Pterygometopus exilis* – BEKKER: 36 (stratigraphic table).
1922 *Pterygometopus exilis* – WINKLER: 65, 78 (faunal list).
1925 *Pterygometopus exilis* – ÖPIK: 16, tab. 1 (faunal list, no details).
1925 *Pterygometopus exilis* – PATRUNKY: 88 (faunal list).
1927 *Phacops dubius* (= *Pterygometopus exilis* EICHW.) [sic!] – ÖPIK: 31 (no details provided).
1928 *Phacops* (*Pterygometoqus*) *exilis* [sic!] – KUMMEROW: 51 (faunal list).
1928 *Pterygometopus exilis* – PATRUNKY: 32, 33 (faunal list).
1930 *Pterygometopus exilis* – ÖPIK in WINKLER: 31, pl. 11, fig. 8 (cop. SCHMIDT, 1881: Pl. 1, fig. 19a).
1930 *Pterygometopus exilis* – VEBER: 85, 87, 88 (comparison, no details).
1934 *Pterygometopus exilis* (EICHW.) – RÜGER: 34 (faunal list).
1937 *Pterygometopus exilis* – ÖPIK: 73–76, text-fig. 42, pl. 26, fig. 5.
1938 *Pterygometopus exilis* – ASATKIN: 16 (faunal list).
1940 *Pterygometopus exilis* – ALIKHOVA: 4–6 (faunal list).
1940 *Pterygometopus exilis* – THORSLUND: 114 (pygidium, no details), 185 (stratigraphic table).
1945 *Pterygometopus exilis* (EICHW.) – JAANUSSON: 217.
1949 *Pterygometopus exilis* – ALIKHOVA et al.: 10 (faunal list).
1950 "*P*[*terygometopus*]." *exilis* – WHITTINGTON: 540 (no details provided).
cf. 1952 *Pterygometopus* cf. *exilis* (EICHW.) – JAANUSSON: 417 (Kukruse beds, no details).
? 1952 *Pterygometopus exilis* – ÖPIK: 124 (Kukruse Stage of Russia, faunal list, no details).
1953 *Pterygometopus exilis* EICHW. [sic!] – ALICHOVA: 14 (faunal list, no details).
cf. 1953 *Pterygometopus* cf. *exilis* – JAANUSSON: 497 (no details).
1954 *Pterigometopus exilis* EICHW. [sic!] – KELLER: 28 (no details).
1955 *Pterygometopus exilis* – SDZUY: 42 (cit. ÖPIK, 1937).
1956 *Pterygometopus exilis* – KALJO et al.: 45 (faunal list).
1956 *Pterygometopus exilis* (EICHWALD) – TEMPLE: 423 (no details).
1957 *Pterygometopus exilis* (EICHW.) – RÕÕMUSOKS: 112, 118, 125.
1958 *Acaste exilis* EICHWALD, 1858 [as type species of *Estoniops*] – MÄNNIL: 385, 386, 388, pl. 1, figs 1–6.
1959 *Acaste exilis* EICHWALD, 1857 – DEAN: 146 (refering to original assignments).
1959 *Phacops exilis* EICHW. (= *Estoniops exilis* (EICHW.) R. MÄNNIL 1957) – URBANEK: 9 (cit. WIMAN, 1908).
1960 *Pterygometopus exilis* (EICHW.) – ALIKHOVA: 18, 29.
1960 *Pterygometopus exilis* (EICHWALD) – DEAN: 84 (Jemtland, refering to THORSLUND 1940).
1960 *Estoniops exilis* (EICHW.) – RÕÕMUSOKS: 83 (faunal list for Kukruse Stage of Estonia, no details).
1960 *Pterygometopus* (*Pterygometopus*) *exilis* EICHWALD 1855 [sic!] – PILLET in BORDET et al.: 9.
1961 *Pterygometopus exilis* – STANKEVIČ: 35 (faunal list).
1962 *Estoniops exilis* EICHWALD 1855 [sic!] – DEAN: 103 (cit. SCHMIDT, 1881, WIGAND, 1888, ÖPIK, 1937).
1962 *Pterygometopus exilis* – WHITTINGTON: 18.
1970 *Estoniops exilis* (EICHWALD, 1858) – ANCYGIN: 16–19, pl. 4, figs 7–16.
1970 *Pterygometopus exilis* – HUISMAN: 130 (stratigraphic table cop. SCHMIDT, 1907), 131, 132, 134–136, text-fig. 4d, photographs 3–5.
1970 *Estoniops exilis* – RÕÕMUSOKS: 180.
1971 *Pterygometopus exilis* – NEBEN & KRUEGER: Pl. 26, figs 11–13.
1973 *Estoniops exilis* (EICHWALD) – ANCYGIN: Tab. 1 (no details).
1973 *Estoniops* (*Pterygometopus*) *exilis* (EICHWALD 1840) – NEBEN & KRUEGER: Pl. 52, figs 6–8, pl. 83, figs 24–26.
1974 *Acaste exilis* EICHWALD, 1857 [as type species of *Estoniops*] – SHAW: 42.
1977 *Pterygometopus exilis* – ALIKHOVA: 6.
1978 *Estoniops exilis* – LUDVIGSEN: 15 (refering to the type species, no indication).
?1982 *Pterygometopus exilis* EICHWALD 1840 – SCHÄFER: 41 (faunal list, no indication), 52 (drawing lacking relevant details).
1985 *Estoniops* (*Pterygometopus*) *exilis* (EICHWALD 1840) – v. HACHT: 62, pl. 1, figs 24–26 (cop. NEBEN & KRUEGER, 1973: Pl. 83, figs 24–26).

1993 *Estoniops exilis* (EICHWALD, 1858) – JAANUSSON & RAMSKÖLD: 754, 755, pl. 3, figs 5, 8, 9.
1996 *Estoniops exilis* EICHWALD [sic!] – MASLOV et al.: 101 (Uralian finds, no details).
1996 *Pterygometopus exilis* – NÕLVAK & HINTS: 88 (faunal list).
1997 *Phacops* (*Pterygometopus*) *exilis* (EICHWALD, 1858) = *Estoniops exilis* – BRUTON et al.: 64, 74, 78 (cit. SCHMIDT, 1881 and MÄNNIL, 1958).
1997 *Pterygometopus exilis* – HINTS & MEIDLA: 72 (faunal list).
1997 *Estoniops exilis* – RUDOLPH: 38, text-fig. 2.
1999 *Pterygometopus exilis* – TELEŠEV et al.: CD-ROM (not seen).
2000 *Pterygometopus exilis* – TERENTJEV: 83, 85 (faunal list).
2003 *Acaste exilis* EICHWALD, 1858 [as type species of *Estoniops*] – JELL & ADRAIN: 374.
2007 *Estoniops exilis* – DOLGOV: 83 (Diatlicy quarry, St. Petersburg area).
2009 *Phacops* (*Pterygometopus*) *exilis* (EICHWALD, 1858) = *Estoniops exilis* – BRUTON et al.: 1 (files 4248.9a–c, 4248.337a–c) (cit. SCHMIDT, 1881: Pl. 1, figs 19–21, pl. 12, fig. 13, and MÄNNIL, 1958).
pt 2009 *Estoniops exilis* (EICHWALD 1857) – KLIKUSHIN et al.: 378–380, ?: text-figs 599, 601 (St. Petersburg find), recte: 600 (cop. EICHWALD, 1859: Pl. 52, figs 28b, c).
2010 *Estoniops exilis* EICHWALD, 1858 [sic!] – BONINO & KIER: 488, pl. 108, fig. d) (cephalon of a complete carapace, anterior view, "Middle Ordovician of St. Petersburg").
2011 *Estoniops exilis* (EICHWALD) – DOLGOV & MEIDLA: 626, 627, text-figs 4, 5 (stratigraphic tables) (no details provided).
2011 *Estoniops exilis* (EICHWALD, 1858) – TORNEY: 93, 100, fig. 3.1, tabs 5.1, 5.4, 5.5, appendix A (no details provided).
pt 2014 *Estoniops exilis* – KRYLOV & SHIROKOV: 182, 184, 185 (stratigraphic topic, no details provided); cf.: text-fig. 1 (carapace).
2015 *Estoniops exilis* (EICHW.) – VODOLAZSKAJA et al.: 37 (Uralian finds, no details).
pt 2016 *Estoniops exilis*/*Estonops exilis* [sic!] – KRYLOV: 9–11, tabs 2, 3, 5 (stratigraphic tables); cf.: pl. 2, fig. 1 (carapace).
2017 *Estoniops exilis* (EICHWALD, 1858) – KRUEGER: 5, 6, 13–15, 25, tab. 1, text-figs 1, 2, pl. 3, figs 1–9.
cf. 2017 *Estoniops* cf. *exilis* (EICHWALD, 1840) – SCHÖNING: 46, fig. 46 (German erratics, cephalon SgS-1842, Schöning collection).
cf. 2017 *Estoniops* cf. *exilis* (EICHWALD, 1840) – ZAYKA & KRYLOV: 77, tab. 1 (no details).
2018 *Estoniops exilis* (EICHWALD 1857) – BASSE: 198.
2018 *exilis Estoniops* (EICHWALD 1857) – LEMKE: 152.

Bibliography

ALIKHOVA, T. N. (1940): K paleontologičeskoj charakteristike nižneso silura rajona der. Mišinoj gorõ Leningradskoj oblasti. [On the palaeontological characteristic of the Lower Silurian of Mišina Gora in the Leningrad region]. – Sbornik Leningradskogo geologičeskogo upravlenija **6**: 3–7.

Alikhova, T. N. (1953): Rukovodyashchaya fauna brakhiopod ordovikskich otlozhenij severo-sapadnoy chasti russkoj platformy [Key taxa of the brachiopod fauna in the Ordovician deposits of the north-western part of the Russian platform]. – Trudy Vsesoyusnogo Naučno-Issledovatel′skogo Geologicheskogo Instituta (VSEGEI) Ministerstva Geologichestii i Okhrany NEDR. – 1–147. Moskau.

Alikhova, T. N. (1960): Stratigrafiya ordovikskich otloženij russkoj platformy [Stratigraphy of the Ordovician deposits of the Russian Platform]. 1–76. Gosgeoltekhizdat, Moskau.

Alikhova, T. N. (1977): Ob"em srednego ordovika na territorii SSSR [Volume on the Middle Ordovician of the territory of the USSR]. – Trudy vsesojuznogo naučno-issledovatel′skogo geologičeskogo Instituta (novaja serija), 202: 3–15.

Alikhova, T. N., Lesnikova, A. F., L′vov, K. A., Nikiforova, O. I. & Jansevskij, M. Ė (1949): Silurijskie otlozenija SSSR [Silurian deposits of the SSSR]. – V knige: Atlas rukovodjaščich form iskopaemych faun SSSR 2 Silur [In the book: Atlas of the handbook of the forms of the fossil fauna of the SSSR 2, Silurian: 5–62. Moskva.

Ancygin, N. Ya. (1970): Trilobity semejstva Pterygometopidae iz ordovikskikh otlozhenij Urala [Trilobites of the family Pterygometopidae from the Ordovician deposits of the Ural]. – In: Materialy po Paleontologii Urala. – 13–42, 180–182. Ural′skoe Territorial′noe Geologicheskoe Upravlenie, Sverdlovsk.

Ancygin, N. Ya. (1973): [Trilobity]. – In: Varganov, V. G., Ancygin, N. Ya., Nasedkina, V. A., Militsina, V. S. & Shurygina, M. V., Stratigrafija i fauna ordovika srednego Urala [Stratigraphy and faunas of the Ordovician of the Middle Urals]. – Nedra: 61–111. Moskau.

Asatkin, B. P. (1938): Gdovskie dislokacii (Leningradskaja oblast). [The Gdov dislocation (Leningrad region)]. – Trudy Leningradskogo Geologičeskogo tresta, 14: 1–62.

Basse, M. (2018): Die Typen der Trilobiten mit deutscher Typuslokalität. Fortschritte in der Forschung im Jahr 2017 bis Frühjahr 2018. – Dortmunder Beiträge zur Landeskunde, naturwissenschaftliche Mitteilungen, 48: 185–226.

Bassler, R. S. (1911): The early Paleozoic Bryozoa of the Baltic Provinces. – Smithsonian Institution, United States National Museum Bulletin, 77: III–XXI, 1–348.

Bekker, H. (1921): The Kuckers Stage of the Ordovician rocks of NE Estonia. – Eesti Vabariigi Tartu Ülikooli, Acta et Commentationes Universitatis Tatuensis (Dorpatensis), A Mathematica, Physica, Medica, 2 (1): 5–92. [Published version of thesis.]

Bigsby, J. J. (1868): Thesaurus Siluricus. The flora and fauna of the Silurian period with Addenda (from recent acquisitions). – III–LII, 1–214. van Voorst, London.

Bonino, E. & Kier, C. (2010): The Back to the Past Museum Guide to Trilobites. – 1st ed., I–XVI, 1–494.

Back to the Past Museum, Puerto Morelos.
Bordet, P., Cavet, P. & Pillet, J. (1960): La faune silurienne de Phuchaucki près de Kathmandu (Himalaya du Népal). – Bulletin de la Société Géologique de France, (7) 2 (1): 3–14.
Bruton, D. L., Hoel, O. A., Beyene, L. T. & Ivantsov, A. Yu. (1997): Catalogue of the trilobites figured in Friedrich Schmidt`s «Revision der ostbaltischen silurischen Trilobiten» (1881–1907). – Contributions from the Palaeontological Museum University of Oslo, 403: 1–117.
Bruton, D. L., Hoel, O. A., Beyene, L. T. & Ivantsov, A. Yu. (2009): Catalogue of the trilobites figured in Friedrich Schmidt`s «Revision der ostbaltischen silurischen Trilobiten» (1881–1907). Part 3. List of taxa arranged as they occur in sequential monographs except new species appearing in Volume VI (Schmidt 1907), which are included under the appropriate genus and indicated. – 1–17. Palaeontological Museum University of Oslo (only as ISO file, online available).
Dean, W. T. (1959): Duftonia, a new trilobite genus from the Ordovician of England and Wales. – Palaeontology, 2 (1): 143–149.
Dean, W. T. (1960): The use of shelly faunas in a comparison of the Caradoc series in England, Wales and parts of Scandinavia. – In: Sorgenfrei, T. (ed.), International Geological Congress. Report of the Twenty-First Session Norden, part VII: Martinsson, A. & Störmer, L. (eds), Ordovician and Silurian stratigraphy and correlation: 82–87. Berlingske Bogtrykkeri, Copenhagen.
Dean, W. T. (1962): The trilobites of the Caradoc Series in the Cross Fell Inlier of northern England. – Bulletin of the British Museum (Natural History), Geology, 7 (3): 65–134.
Dolgov, O. O. (2007): Middle and Upper Ordovician trilobites from Leningrad district (Russia). In: Ebbestad, J. O., Wickström, L. & Högström, A. (eds): WOGOGOB 2007, 9th Meeting of the Working Group on Ordovician Geology of Baltoscania. Field guide and Abstracts. – Rapporter och medelanden, 128: 82–83.
Dolgov, O. & Meidla, T. (2011): Biostratigrafičeskoe značenie trilobitov srednegoi i verchnego ordovika zapada Leningradskoj oblasti [Trilobite Biostratigraphy in the Middle and Upper Ordovician of Western Leningrad Region]. – Stratigrafiya, Geologicheskaya Korrelyatsiya, 19 (6): 44–56 [618–630].
Eichwald, E. (1857): Beitrag zur geographischen Verbreitung der fossilen Thiere Russlands. Alte Periode. – Preprint/Reprint including the contributions of Eichwald 1855–1858: 1–242. Kaiserliche Universität, Moskau.
Eichwald, E. (1858): Beitrag zur geographischen Verbreitung der fossilen Thiere Russlands. Alte Periode. (Continuation). – Bulletin de la Société Impériale des Naturalistes de Moscou, 30 (4) (for 1857): 305–354.
Eichwald, E. d` (1859): Lethaea Rossica ou Paléontologie de la Russie. Ancienne Période. Atlas. – Pls 1–59. Schweizerbart, Stuttgart.
Eichwald, E. d` (1860): Lethaea Rossica ou Paléontologie de la Russie. Premier Volume. Seconde section de l`ancienne Période, contenant la continuation de la Faune de l'ancienne Période, savoir les Mollusques jusqu'aux Reptiles. – 1–26, I–XIX [269]–1657. Schweizerbart, Stuttgart.
Eichwald, E. (1861a): Paleontologii Rossii. Drevnij period". II. Fauna graubakkovoj gornoizvestkovoj i m"distoslanstsjevastoj formatsij rossii [Palaeontology of Russia. Ancient Period. II. Fauna of the greywacke mountain-limestone, and the Calcareous and Copper Shale Formations of Russia]. – I–XVI, 1–521. Golike, Ionsona, S. Peterburg.
Eichwald, E. (1861b): Paleontologii Rossii. Drevnij period". II. Fauna graubakkovoj gornoizvestkovoj i m"distoslanstsjevastoj formatsij rossii [Palaeontology of Russia. Ancient Period. II. Fauna of the greywacke mountain-limestone, and the Calcareous and Copper Shale Formations of Russia] (Atlas). – Pls 1–38. Golike, S. Peterburg.
Emmrich, H. F. (1844): Zur Naturgeschichte der Trilobiten. – Programm Realschule Meiningen: 1–28. Meiningen.
Geikie, A. (1885): Text-book of geology, Second Edition. – VII–XVI, 1–991. MacMillan and Co., London.
Geikie, A. (1901): Text-Book of Geology (Part Three). In: A Library of Universal Literature. Science. Vol. 31. – I–V, 977–1417. Collier and Son, New York.
Giebel, C. (1858): Referat „Eichwald 1857: Beitrag zur geographischen Verbreitung der fossilen Thiere Russlands; Bullet. nat. Moscou". – In: Giebel, C. & Heinz, W. (Eds): Zeitschrift für die gesammten Naturwissenschaften, 12: 170–171.
Goldfuss, A. (1843): Systematische Übersicht der Trilobiten und Beschreibung einiger neuen Arten derselben. – Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefakten-Kunde, 1843: 537–567.
Hacht, U. v. (1985) (ed.) (contributing authors: P. A. M. Gaemers, U. v. Hacht, G. Hillmer, W. Hinsch, R. Schallreuter, G. Sörensen & C. Spaeth): Fossilien von Sylt. – 1–131. Inge-Maria von Hacht, Hamburg.
Hints, L. & Meidla, T. (1997): Viru Series (Middle Ordovician) and Harju Series (Upper Ordovician). In: Raukas, A. & Teedumäe (eds), Geology and Mineral Resources of Estonia: 66–88. Estonian Academy Publishers, Tallin.
Huisman, H. (1970): Trilobieten van het genus Pterygometopus, F. R. Schmidt 1881, uit Ordovicische kalkzwerfstenen van Groningen en Haren. – Grondboor en Hamer, **14**: 127–144.
Jaanusson, V. (1945): Ueber die Stratigraphie der Viru-resp. Chasmops-Serie in Estland. – Geologiska Foreningens i Stockholm Forhandlingar, **67** (2): 212–224.
Jaanusson, V. (1952): Untersuchungen über baltoskandische Asaphiden I. Revision der mittelordovizischen Asaphiden des Siljan-Gebietes in Dalarna. – Arkiv för Mineralogie och Geologi, **1** (14): 377–464.
Jaanusson, V. (1953): Untersuchungen über baltoskandische Asaphiden II. Revision der *Asaphus*

(*Neoasaphus*)-Arten aus dem Geschiebe des südbottnischen Gebietes. – Arkiv för Mineralogie och Geologi, **1** (15): 465–499.

Jaanusson, V. & Ramsköld, L. (1993): Pterygometopine trilobites from the Ordovician of Baltoscandia. – Palaeontology, **36** (4): 743–769.

Jell, P. A. & Adrain, J. M. (2003): Available generic names for trilobites. – Memoirs of the Queensland Museum, **48** (2): 331–553.

Kaljo, D., Oraspõld, A., Rõõmusoks, A. K., Sarv, L. & Stumbur, H. (1956): Eesti NSV Ordoviitsiumi fauna nimestik 2 Keskordoviitsium: 1–62. Tartu.

Keller, B. M. (1954): Tipovye razrezy Ordovika [Type section of the Ordovician]. – Trudy instituta geologičeskich nauk Akademii Nauk SSSR, **154** (geologičeskaja serija), **65**: 5–47.

Kiesow, J. (1897): Das geologische Alter der im westpreußischen Diluvium gefundenen Coelosphaeridiengesteine und Backsteinkalke. – Schriften der Naturforschenden Gesellschaft in Danzig Neue Serie, **9** (2): 20–40.

Klikushin, V., Evdokimov, A. & Pilipyuk, A. (2009): Ordovician Trilobites of the St. Petersburg Region. – 1–541. Petersburg Paleontological Laboratory, St. Petersburg.

Koken, E. (1896): Die Leifossilien. Ein Handbuch für den Unterricht und für das Bestimmen von Versteinerungen. – 1–848. Tauchnitz, Leipzig.

Krueger, H.-H. (2017): Die Trilobitengattungen *Estoniops* Männil und *Achatella* Delo (Trilobita: Phacopidae, Pterygometopidae) aus ordovizischen baltoskandischen Geschieben. – 1–44. Ampyx, Halle.

Krylov, A. V. (2016): [Stratigraphy and lithology of shale section of Kukruse Formation (Ordovician) – a source of unconventional hydrocarbons in the west of Leningrad area]. – Neftegasovaâ geologiâ. Teoriâ i practika, **11** (1): 1–23. (In Cyrillic with English title and abstract.)

Krylov, A. V. & Shirokov, R. P. (2014): [About the trilobites from blocs and boulders of Ordovician rocks of Northwest-Russia]. – [Geology, Geoecology, Evolutionary Geography. Collective Monograph], **12**: 181–187. (In Russian with English index.)

Kummerow, E. (1928): Beiträge zur Kenntnis der Fauna und der Herkunft der Diluvialgeschiebe. – Jahrbuch der Preußischen Geologischen Landesanstalt zu Berlin für das Jahr 1927, **48**: 1–59.

Lemke, U. (2018): Catalogue of the available names and the non available names of the species and subspecies for the Class Trilobita. 29.548 names, October, 2018: 541 pp. U. Lemke, Wetter/Nordrhein-Westfalen. [Available via ResearchGate.]

Ludvigsen, R. (1978): The Trilobites *Bathyurus* and *Eomonorakos* from the Middle Ordovician of Oklahoma and Their Biofacies Significance. – Life Sciences Contributions Royal Ontario Museum, **114**: 1–18.

Männil, R. (1958): *Estoniops* – nov'ij rod trilobitov iz semejstva Phacopidae ["*Estoniops* – a new genus of Phacopidae (Trilobita)"]. – Eesti NSV Teaduste Akadeemia Toimetised, **6**, Tehniliste ja füüsikalis-matemaatiliste teaduste seeria 1957, **4**: 385–388. (In Russian with English title and summary.)

Maslov, A. V., Ivanov, K. S., Čumakov, N. M., Krupenin, M. T. & Ancygin, N. Ya. (1996): Razrezy verchnego rifeja, venda i nižnego paleozoja srednego i južnogo Urala. Vserossijskogo Soveščanija. Paleogeografija venda rannego paleozoja (PVRP-96) i itogovoj meždunarodnoj konferencii proekta 319 MPGK, 25 Ijulja–2 Avgusta 1996. [Section upper reef, Vendian and Lower Paleozoic in the middle and southern Urals. All-Russian Conference. Palaeogeography of the Vendian and early Palaeozoic (PVRP-96) and joint international conference project 319 MPGK 25th July–2nd August 1996.] – 1–114. Ekaterinburg.

Neben, W. & Krueger, H. H. (1971): Fossilien ordovicischer Geschiebe. – Staringia, Nederlandse Geologische Verenigung, **1**: 58 pp. not numbered, pls 1–50.

Neben, W. & Krueger, H. H. (1973): Fossilien ordovicischer und silurischer Geschiebe. – Staringia, Nederlandse Geologische Verenigung, **2**: 71 pp. not numbered, pls 51–109.

Nieszkowski, J. (1857): Versuch einer Monographie der in den silurischen Schichten der Ostseeprovinzen vorkommenden Trilobiten. – Archiv für die Naturkunde des Liv-, Ehst- und Kurlands, Erste Serie. Mineralogische Wissenschaften, nebst Chemie, Physik und Erdbeschreibung, **1** (1. Lfg.): 517–626. [Preprint present but not available.]

Nõlvak, J. & Hints, L. (1996): Peetri Hillock. In: Third Baltic Stratigraphical Conference Abstracts: 84–88.

Olin, E. (1906): Om de Chasmopskalken och Trinucleusskiffern motsvarande bildningarne i Skåne. – Lunds Universitets Årskrift N. F. 2, **2** (3): 1–79.

Öpik, A. (1925): Beiträge zur Kenntnis der Kukruse- (C2-) Stufe in Eesti. I. – Acta et Commentationes Universitatis Dorpatensis, A **8** (5): 1–18.

Öpik, A. (1927): Die Inseln Rodensholm und Rogö. Ein Beitrag zur Geologie von NW-Estland. – Eesti Vabariigi Tartu Ülikooli, Acta et Commentationes Universitatis Tatuensis (Dorpatensis), A Mathematica, Physica, Medica, **12**: 1–69.

Öpik, A. (1937): Trilobiten aus Estland. Beschreibung altbekannter und neuer Trilobiten aus dem Ordovizium und Silur Estlands, nebst besonderer Berücksichtigung der Extremitätenträger, der Segmentation des Trilobitenkopfes und der Systematik der Lichidae und Cheiruridae. – Eesti Vabariigi Tartu Ülikooli, Acta et Commentationes Universitatis Tatuensis (Dorpatensis), A Mathematica, Physica, Medica, **32**: 1–163.

Öpik, A. (1952): Das Ordovizium. In: Bubnoff, S. v.: Fennosarmatia. Geologische Analyse des europäischen Kerngebiets. IX + 1–454. Akademie-Verlag, Berlin.

Patrunky, H. (1925): Die Geschiebe der silurischen Orthocerenkalke I. Geologischer Teil. Zeitschrift für Geschiebeforschung, **1** (2): 58–95.

Patrunky, H. (1928): Die Trilobiten aus Geschieben der silurischen Orthocerenkalke. Zeitschrift für Geschiebeforschung, **4** (1): 30–44.

Pompecki, J. F. (1890): Die Trilobiten-Fauna der Ost- und Westpreussischen Diluvialgeschiebe. – Beiträge zur

Naturkunde Preussens, **7**: 1–97.
Reed, F. R. C. (1905): Classification of the Phacopidae. – Geological Magazine New Series (5) **2**: 172–178, 224–228.
Reed, F. R. C. (1915): Supplementary Memoir on New Ordovician and Silurian Fossils from the Northern Shan States. – Memoirs of the Geological Survey of India, Palaeontologia Indica New Series **6** (1): I–VI, 1–123.
Rõõmusoks, A. K. (1957): Stratigrafija kukruseskogo gorizonta (C II) Estoniskoj SSR [Stratigraphy of the Kukruse horizon (C II) of the Estonian SSR]. – Učenye zapiski Tartuskogo Gosudarstvennogo Universiteta, **46**: 101–130.
Rõõmusoks, A. K. (1960): Ordovikskaja Systema. [Ordovician System]. In: Orviku, K. K. (ed.), Éstonskaja SSR. Geologičeskoe opisanie i poleznye iskopaemye. [Estonian SSR. Geological description and key fossils]. – Geologija SSSR, **28**: 55–112. Gostoptekhizdat, Moskwa. (In Russian.)
Rõõmusoks, A. K. (1970): Stratigrafiya viruskoy i kharyuskoy seriy (ordovik) severnoy Estonii. I. [Stratigraphy of the Viruan Series (Middle Ordovician) in Northern Estonia]. – Tartu Riiklik Ülikool: 1–345. Valgus, Tallinn. (In Russian with Estonian and English summaries.)
Rudolph, F. (1997): Geschiebefossilien. Teil 1: Paläozoikum. – Fossilien Special edition, **12**: 1–64.
Rüger, L. (1934): Die baltischen Länder (Estland, Lettland und Litauen). In: Handbuch der Regionalen Geologie, **IV**, 4. Abteilung: 1–79, 14 Abb., 1 Taf. Carl Winters Universitätsbuchhandlung, Heidelberg.
Schäfer, R. (1982): Onderzoek naar het voorkomen van Trilobieten in sedimentaire zwerfstenen uit de \`Münsterländer Hauptkiessandzug\` [Investigations on occurrences of trilobites from sedimentary geschiebe of the \`Münsterländer Hauptkiessandzug\`]. – Grondboor en Hamer, **2**: 34–64. (In Dutch.)
Schmidt, F. (1881): Revision der ostbaltischen silurischen Trilobiten nebst geognostischer Übersicht des ostbaltischen Silurgebiets. Abtheilung I. Phacopiden, Cheiruriden und Encrinuriden. – Mémoires de l\`Académie Impériale des Sciences de St.-Pétersbourg, 7. Serie, **30** (1): II–IV, 1–237.
Schmidt, F. (1882): On the Silurian (and Cambrian) Strata of the Baltic Provinces of Russia, as compared with those of Scandinavia and the British Isles. – Quarterly Journal of the Geological Society, **38**: 514–536.
Schmidt, F. (1907): Revision der Ostbaltischen Silurischen Trilobiten. Abtheilung 6: Allgemeine Uebersicht mit Nachträgen und Verbesserungen. – Mémoires de l\`Académie Impériale des Sciences de St.-Pétersbourg, 8. Serie, **20** (8): I–X, 1–104.
Schöning, H. (2017): Trilobiten aus Geschieben des Kies-Sand-Rückens in der Laerheide (Landkreis Osnabrück) – II. Ordovizische Trilobiten. – Osnabrücker Naturwissenschaftliche Mitteilungen, **42/43**: 29–80.
Sdzuy, K. (1955): Die Fauna der Leimitz-Schiefer (Tremadoc). – Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft, **492**: 1–74.
Shaw, F. C. (1974): Simpson Group (Middle Ordovician) Trilobites of Oklahoma. – Journal of Paleontology, Memoir 6, supplement to volume **48** (5): 1–54.
Stankevič, L. I. (1961): Pestovskaja opornaja skvažina (Novgorodskaja oblast) [References for Pestovsk boreholes (Novgorod region)]. – Trudy Vsesojuznogo Neftjanogo Naučno-issledovatel′skogo Geologorazvedočnogo Instituta, **182**: 1–92.
Telešev, S. et al. (1999): The Encyclopedia of Ordovician Trilobites of Russia. CD ROM. Petersburg Paleontological Laboratory, St. Petersburg. [Not seen.]
Temple, J. T. (1956): Notes on the Cheiruracea and Phacopacea. – Geological Magazine, **93** (5): 418–430.
Terentjev, S. S. (2000): Sobytie pozdiego llandejlo – rannego caradoka, Severo-Zapad Rossii (Leningradskaja oblast) [Late Llandeilo event – early Caradoc, north-western Russia (Leningrad region)]. – In knige: Ispol′zovanie sodytijno-stratigrafičeskich urovnej dlja mežregional′noj korreljacii fanerozoja Rossii [In the book: Use of stratigraphic event levels for interregional correlations of the Phanerozoic of Russia]: 81–85. Sankt-Peterburg.
Thorslund, P. (1940): On the Chasmops series of Jemtland and Södermanland (Tvären). – Sveriges Geologiska Undersökning, Ser. C, Avhandlingar och uppsatser, 436, Årsbok **34** (6): 1–191.
Torney, C. (2011): Mineral eyes. Lessons from the natural world. – PhD Thesis. University of Glasgow. (Unpublished.)
Urbanek, A. (1959): Studies on graptolites. II. On the development and structure of graptolite genus *Gymnograptus* Bulman. – Acta Palaeontologica Polonica, **4** (3): 279–338.
Veber, V. N. (1930): Nežne-silurijskie trilobity s južnogo Urala [Lower Silurian trilobites from South Ural]. – Izvestija glavnogo geologo-pazvedočogo upravlenija [U.S.S.R. Bulletin of the Geological and Prospecting Service], **49** (9): 1129–1134.
Vodolazskaja, B. P., Temerin, I. P., Kirillov, V. A., Duk″janova, D. I., etc. (2015): Gosudarstvennaja Geologičeskaja Karta Rossijskoj Federacii. Masštab 1 : 1.000000 (tret′e pokodenie). Serija Ural′skaja. List O-40 – Perm [State Geological Map of the Russian Federation. Scale 1 : 1.000000 (3rd edition). Uralian Series. List O-40 – Perm]. – 1–496. Kartografičeskaja Fabrika VSEGEI, St. Peterburg.
Vogdes, A. W. (1893): A classed and annotated bibliography of the Palaeozoic Crustacea 1698–1892 to which is added a catalogue of North American species. – Occasional Papers of the Californian Academy of Science, **4**: 1–412.
Whittington, H. B. (1950): Sixteen Ordovician genotype trilobites. – Journal of Paleontology, **24** (5): 531–565.
Whittington, H. B. (1962): The Ordovician trilobites of the Bala area, Merioneth. Pt. 1. Monographs of the Palaeontological Society of London, **116** (497): 1–32.
Wigand, G. (1888): Ueber die Trilobiten der silurischen Geschiebe in Mecklenburg. – Zeitschrift der Deutschen geologischen Gesellschaft, **40**: 39–101. [= Wigand, G. (1888): Ueber die Trilobiten der silurischen Geschiebe in Mecklenburg: I. Stück: umfassend die Familien der Phacopidae, Lichidae,

Illaenidae, Cheiruridae, Encrinuridae und Acidaspidae. – Thesis. University of Rostock. – (Unpublished.)]
Wiman, C. (1908): 2. Studien über des Nordbaltische Silurgebiet. II. – Bulletin of the Geological Institution of the University of Upsala, **8** (for 1906–1907): 73–168.
Winkler, H. v. (1922): Eestimaa geoloogia, 1. Ladelugu Urgaegkond-Devoon. [Geologie Estlands]. VIII + 1–182. Pihlakas, Tallinn.
Winkler, H. v. (1930) (Ed.) (with contributions from A. Öpik, J. Reinwaldt, K. v. Middendorff, J. Ottoson & W. v. Rennenkampff): Der Estländische Brennschiefer. Untersuchung, Gewinnung und Verwertung. – I–IV, 1–348. Wassermann, Reval.
Zayka, Ju. U. & Krylov, A. V. (2017): Ordovician erratic trilobites (Arthropoda, Trilobita) from Pleistocene deposits of Belarus (preliminary data). – Vestnik Bargu, Serija biologičeskie nauki, selʹskochozjajstvennye nauki, **2017** (5): 71–82.
Zittel, K. A. (1885): Handbuch der Palaeontologie. I. Abtheilung. Palaeozoologie. II. Band. Mollusca und Arthropoda. – 1–893. Oldenbourg, München and Leipzig.

The Trilobites of Caleb Quarry

Michael Lask

Versions of the following essay were originally featured in: *The MAPS Digest, the Official Publication of the Mid-American Paleontology Society*, Volume 40 No. 2, April 2017, and *Fossil News, The Journal of Avocational Paleontology*, Volume 20.3, Fall 2017. [Presented here with permission from MAPS and Fossil News]

Construction of the Erie Canal in New York State began in 1817. As the project neared Lockport, New York "strange forms" were soon discovered as the rock removed by the project exposed the fossil bearing Rochester Shale of the Silurian. Decades would pass before James Hall would publish (1852) a detailed description of the hundreds of species that were discovered. Discovery, collection, and description would continue thereafter, from various road cuts and creek beds as well as the canal. However, it was not until the Caleb family, near Middleport New York, agreed to have part of their property excavated for a special clay in exchange for building two ponds, that an extensive horizontal exposure of the Rochester Shale would not only be exposed, but specifically quarried for the collection of the Rochester Shale fossils found therein. With the permission of the Caleb family a small association of fossil collecting enthusiasts, headed up by Ray Meyer would start quarrying operations in 1992, and with that, give birth to the Caleb Quarry.

In the decades since, over 120 different species of marine invertebrate fossils of the Rochester Shale have been collected from the Caleb Quarry, including numerous examples that remain formally unnamed. The extensive fauna reveals a diverse tropical sea, dominated by Bryozoan patch reefs populated with numerous echinoderms, mollusks, coral, brachiopods, conullariids, tube worms, graptolites, and of course Arthropods. All have their devotees but the trilobites are a particularly popular favorite of fossil collectors across the globe.

There are ten well documented genera of trilobites found in the Caleb Quarry. Many more have been found in the Rochester Shale, but have not been definitely identified from Caleb Quarry. Countless thousands of specimens have been found since collecting began. The vast majority of complete specimens have been found prone (enrolled examples actually being quite rare) and inverted, consistent with rapid burial, within the numerous storm events documented in the exposure. The best specimens are typically found in the relatively fossil sparse mudstones formed by the storm produced sediment that buried the living communities. This has resulted in several identified "Lagerstatten" beds typically named for a specific fossil dominating the particular layer. This includes several dominated by the trilobites, *Dalmanites*, *Calymene* and *Arctinurus*.

Dalmanites limulurus (Order Phacopida; Figures 1, 2, 17 – 19 and 21 - 24) could be considered the quintessential Caleb Quarry trilobite. The disarticulated parts of this iconic trilobite literally litter the Quarry. It is impossible to walk a few feet without finding *Dalmanites* parts. They range in size from only a few millimeters to over 90 millimeters. The vast majority of specimens are in the range of 50 to 60 millimeters.

These ubiquitous trilobites are found in all different areas of the Quarry, in and about bryozoan reefs and in the open spaces between. Their flat, relatively thin shells would have allowed them to slide just beneath the substrate with their large eyes still protruding above. They are the only trilobites from the Quarry with schizochroal eyes.

As result of their thin exoskeleton compared to other trilobites, most specimens only retain an extremely thin, film-like, fossilized shell except around the outer perimeter. Only the genal and pygidial spines typically retain any significant thickness, and most of these are hollow and display various degrees of corrosion. Interestingly, molted pygidiums and cephalons do not exhibit this deterioration.

During the depositional process the carapaces of *Dalmanites* were oriented parallel to the bedding plane of the sediment. As result of this orientation, when splitting the shale along the bedding plane it reveals a trilobite producing a positive (part) and negative (counter-part), like most trilobite fossils. During separation of the two pieces, much of the thin fossilized shell and its large raised eyes detach into the counter-part. Thus, specimen preparation is a time-consuming effort including removal of the eyes from the counter-part as well as restoration of any corroded exoskeleton.

Since 1992, several thousand specimens of *Dalmanites* have been collected. They typically are found as individuals and can randomly occur in any layer within the quarry. However, after years of excavation several layers were recognized to contain a high concentration of *Dalmanites*.

Finding a pair of *Dalmanites* in close proximity to each other is uncommon. To find multiple specimen plates of three or more *Dalmanites* are exceeding rare. However, three horizons, known as the Multiple *Dalmanites* layers have been recognized to contain a high level of trilobite clustering. The trilobites occur in what appear to be long, relatively narrow, current driven windrows. These layers are the opposite of the norm. Finding a single individual is uncommon, finding a plate of three or more is typical. To date, several plates containing 10 to 20 specimens have been collected. The largest ever found is an exceedingly rare plate of 39 individuals (figure 2).

Figure 1 - *Dalmanites limulurus*

Bumastus ioxus (Order Corynexochida; Figures 3, 4, 20 and 21) is another relatively common trilobite found almost exclusively in the south wall exposure of the Quarry. While disarticulated parts are common and can be found in various layers, complete specimens are most often associated with bryozoan patch reefs. These trilobites range in size from only a few millimeters up to very rare, giant examples in excess of 75 millimeters. Most specimens are in the 20 to 30 mm range. Specimens are often found in various stages of molting as indicated in Figure 4.

Figure 2 - *Dalmanites limulurus*

Calymene niagarensis (Order Phacopida; Figures 5 - 7, 17, 18 and 21) is another relatively common Quarry trilobite although most are actually found in one layer. Specimens of only a few millimeters have been collected and they rarely exceed about 35 millimeters. Unlike all other trilobite species found in the Quarry, *C. niagarensis* specimens are typically found complete. Their shells are much thicker than most of the trilobites of the Quarry and often preserved in a black calcite (not typically seen other than in *Arctinurus*). Some variation in shape, particularly the cephalon, has led to speculation of subspecies or variants. Enrolled specimens (figure

Figure 3 -*Bumastus ioxus*

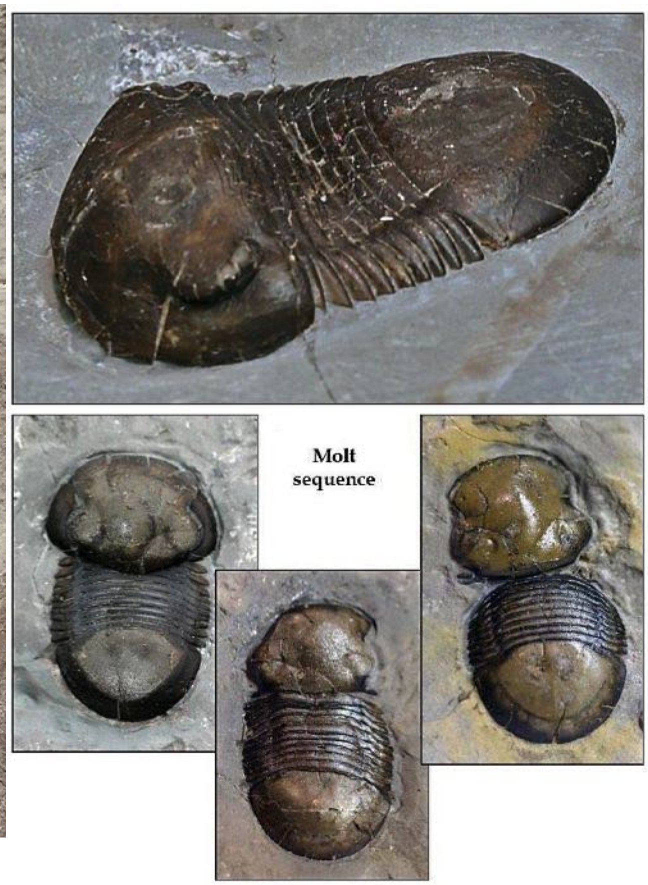
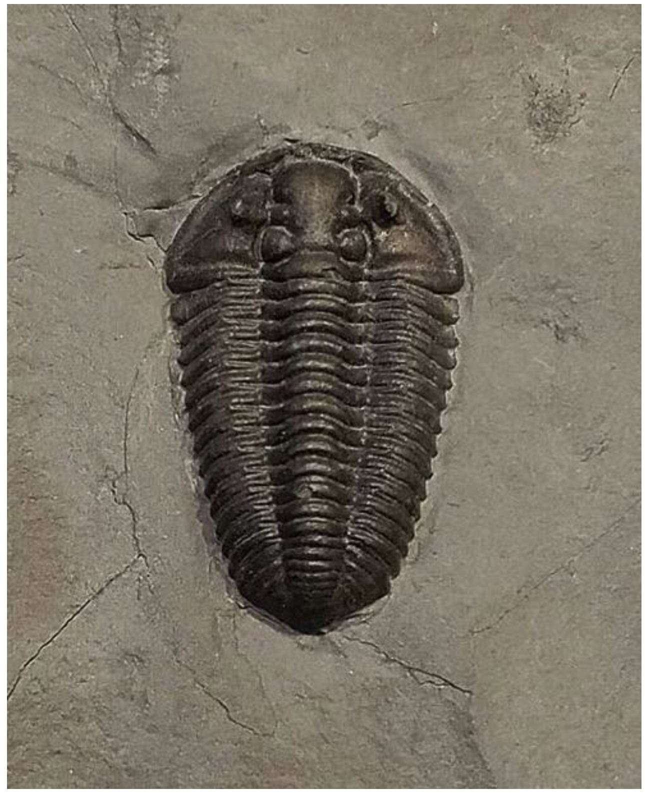


Figure 4 - *Bumastus ioxus*


Starting top left and moving clockwise, Figures 5,6 and 7 - *Calymene niagarensis*

7) are not quite as rare as with the other genera, probably because their thicker, more robust bodies actually allowed them to move when buried by storm sediment.

The rest of the trilobite genera found in the Quarry are much less common. Of those, the most frequently found, and sought after, is *Arctinurus boltoni* (Order Lichida; Figures 8 and 9). These are some of the most desired of trilobite fossils. Prior to the existence of the Caleb Quarry, fossils of *Arctinurus* were indeed extremely rare. Several hundred have been excavated in the years since. They can occasionally be found in any part of the Quarry, with disarticulated parts somewhat common. Most specimens have been found in specific beds, at the deepest levels of the Quarry. Their excavation is extremely difficult, requiring heavy machinery to reveal the layers, and back breaking, physical labor to move and split the razor blade sharp slabs of shale that they are found within. Large areas of vacant rock are often quarried before a single specimen can be found. Moreover, preparation of the collected specimen is extremely tedious, requiring reassembly of the broken pieces and air abrasion back down to the fossil itself. The difficulties of excavation and prepa-

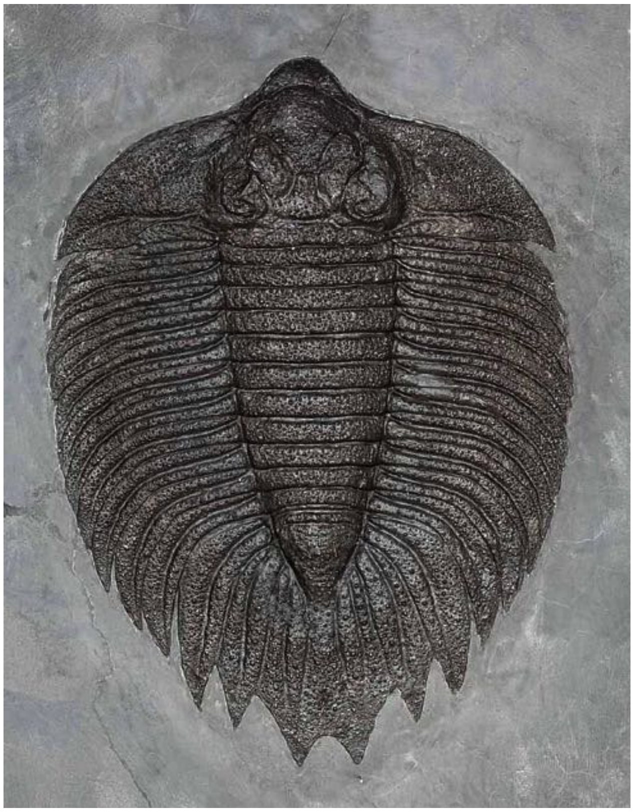


Figure 8 - *Arctinurus boltoni* 6 *Arctinurus* are sometimes found in windrows or “pools” and as such multiple specimen plates have been found.

ration make these fossil treasures rather expensive. Specimens range in size from about 75 millimeters to over 175 millimeters. No specimens smaller than about 75 millimeters have ever been found.

The other Lichid found in the Quarry is *Dicranopeltus nereus* (Order Lichida; Figures 10, note healed wound on the right pleural spines, and 19). This striking trilobite is very uncommon. Years can go by without a complete specimen being found. In fact, they are so rare that even disarticulated parts and incomplete specimens are saved. Most specimens are found in the range of 55 to 60 millimeters in length.

Illaenus insignis (Order Corynexochida; Figures 11 and 24) are similar in appearance to *Bumastus* but far less common. They tend to be larger with less prominent eyes and a flattened border around the pygidium which is not present in *Bumastus*. Most specimens are in the 50 to 75 millimeter range with a few in excess of 80 millimeters. Disarticulated parts are somewhat common.

Radnoria bretti (Order Proetida; Figures 12 and 23) are small trilobites. They rarely exceed 15 millimeters in lenth They are almost always as-

Figure 9 - Arctinurus boltoni

Figure 10 - *Dicranopeltus nereus*

sociated with bryozoan patch reefs, no doubt relying on the shelter for protection. While not common, most specimens are found in the South Wall exposure of the Quarry.

Decoroproetus corycoeus (Order Proetida; Figures 13 and 20) is a far more rare member of the same Order. Probably less than two dozen specimens have ever been found. They are typically about 30 millimeters long. Even disarticulated parts have never been found.

Figure 11 - *Illaenus insignis*

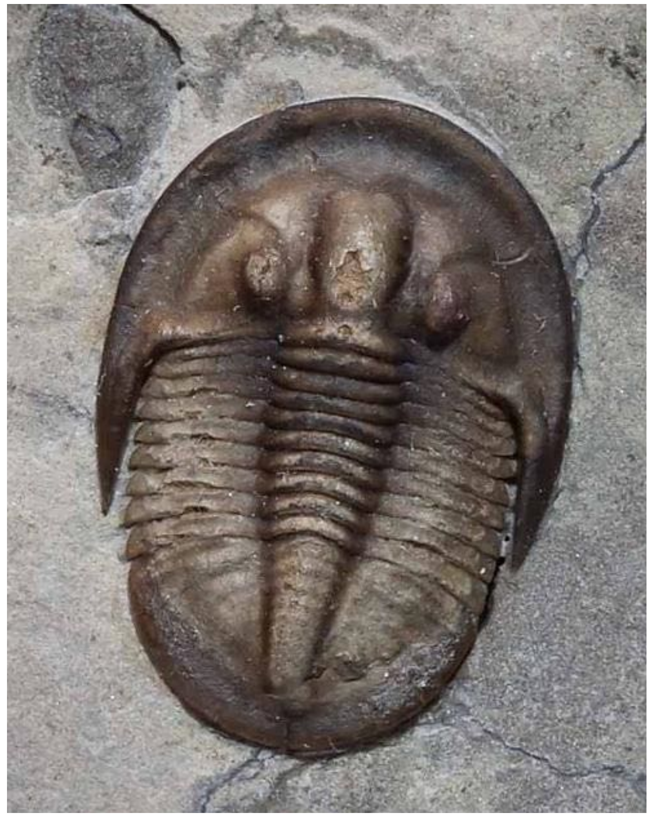


Figure 12 - *Radnoria bretti*

More rare still is *Diacalymene* sp. (Order Phacopida; Figures 14 and 15). Perhaps less than ten specimens have ever been collected (although the species is more common in Roch-

Figure 13 - *Decoroproetus corycoeus*

Figure 14 - *Diacalymene* sp.

ester Shale exposures east of Rochester, New York). They tend to be larger than the *C. niagarensis*, averaging about 45 millimeters long.

The most recently discovered specimen was found by Paul Chinnici on August 23, 2015. The

Figure 15 - *Diacalymene* sp.

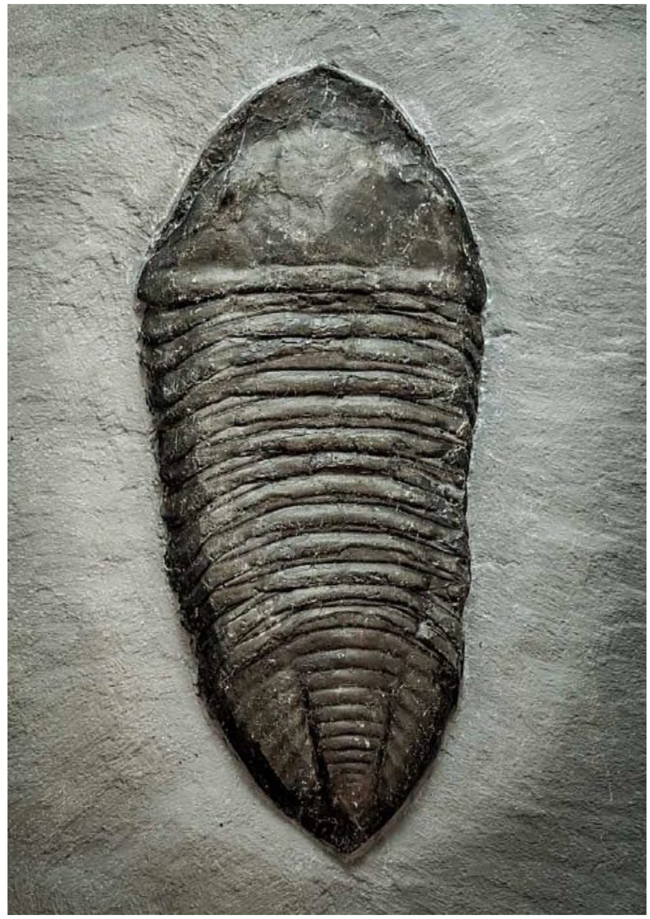


Figure 16 - *Trimerus delphinocephalus*

specimen can be seen in Figure 15 fresh from field and after being prepared by Paul.

Trimerus delphinocephalus (Order Phacopida; Figures 16 and 22) is the largest trilobite collected in the Quarry. While specimens measur-

Figure 17 - *D. limulurus* and *C. niagarensis*

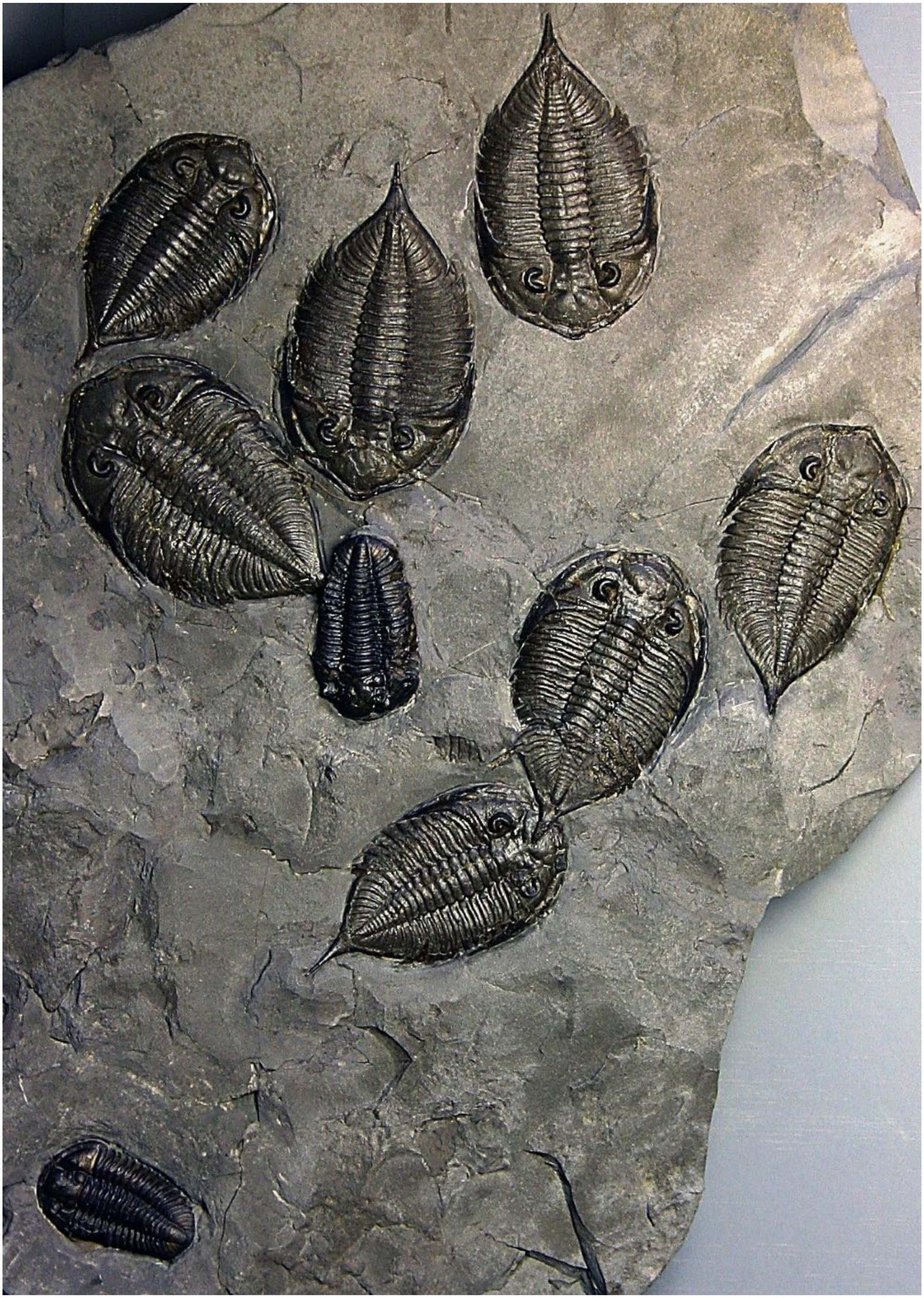


Figure 18 - *D. limulurus* and *C. niagarensis*

Figure 19 - D. nereus and D. limulurus

Figure 20 - *B. ioxus* and *D. corycoeus*

ing only a few millimeters have been found, they tend to be much larger and can range over 200 millimeters in length. Disarticulated parts are rather common throughout all areas of the Quarry, but complete specimens are actually rather rare. Complete specimens tend to be found in the lower levels of the Quarry.

Dr. Denis Tetreault has described *Trimerus* as "mud torpedoes" which would explain why complete specimens are so relatively rare. Unlike most of the other trilobites found in the Quarry which would become impossibly immobilized when buried by storm sediment, *Trimerus* would simply burrow their way out. Since most of the best specimens of all species found in the Quarry were trapped in storm produced mud flows, a creature that could actually crawl out would be far less likely to be fossilized in place. As result, specimens of large and complete *Trimerus* are as prized as an *Arctinurus* and actually much more rare.

Figure 21 - *C. niagarensis, D. limulurus,* and *B. ioxus*

Figure 22 - *T. delphinocephalus* and *D. limulurus*

Trilobites were such a significant feature of the fauna uncovered in the Caleb Quarry that plates with different species have occasionally been found throughout the years. These associations are typically found surrounded by nearly barren shale. A few examples are pictured.

For more information on the trilobites of the Caleb Quarry see *Trilobites of New York*, by Thomas E. Whiteley, Gerald J. Kloc, and Carlton E. Brett, Cornell University Press (2002)

Figure 23 - *D. limulurus* and *R. bretti*

and *The Silurian Experience*, *Second Edition*, by Paul Chinnici and Kent Smith, Primitive Worlds (2015). The later book features the entire fauna of the Quarry and a detailed chapter by Dr. Carlton Brett: *Stratigraphy and Paleoenvironments of the Rochester Shale in Western New York*. Dr. Brett's paper can also be accessed at the Primitive Worlds website: http://www.primitiveworlds.com/stratigraphy--paleoenvironments.html

My thanks to Paul Chinnici, Kent Smith and Fred Barber for their generous and significant assistance in preparing this paper. Featured specimens are from all of our collections (except Figure 2 which resides at the Houston Museum of Natural Science and is currently in their public display).

Figure 24 - *I. insignis* and *D. limulurus*

Short notes on current investigations and publications mainly on Silurian and Devonian trilobites in the Rhenohercynian Zone of the German Variscides

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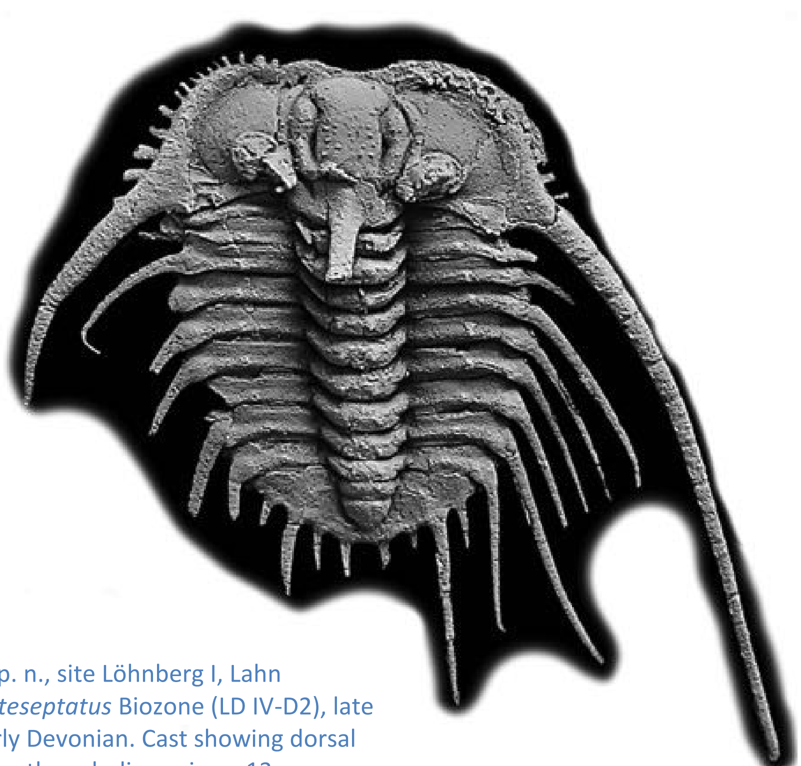
Much work is in progress on different trilobite bearing sites mainly in the Lahn-Dill area (Rhenish Massif east of the river Rhine, Rhenohercynian Zone of the Variscides, Germany).

Basse et al. (2019a) will report on three sites recently discovered in the Lahn Syncline exposing shales as well as shales with limestones of the late Upper Emsian. One of these sites, Löhnberg I, has yielded the ammonoid *Anarcestes* meanwhile, what allows rather precise biostratigraphy. From the same site come new well-preserved complete trilobites, of which we figure one of the most interesting ones herein (text-fig. A).

The two other sites show the same shales but with calcareous intercalations and with an almost completely different trilobite fauna in which proetids dominate. We have identified *Koneprusites* sp. n. including a long range of sizes providing information on the postlarval ontogeny indicating close relations to the Warburgellinae rather than the Cornuproetinae. The Proetinae are represented by early *Helmutia*, or subgenus novum, among others.

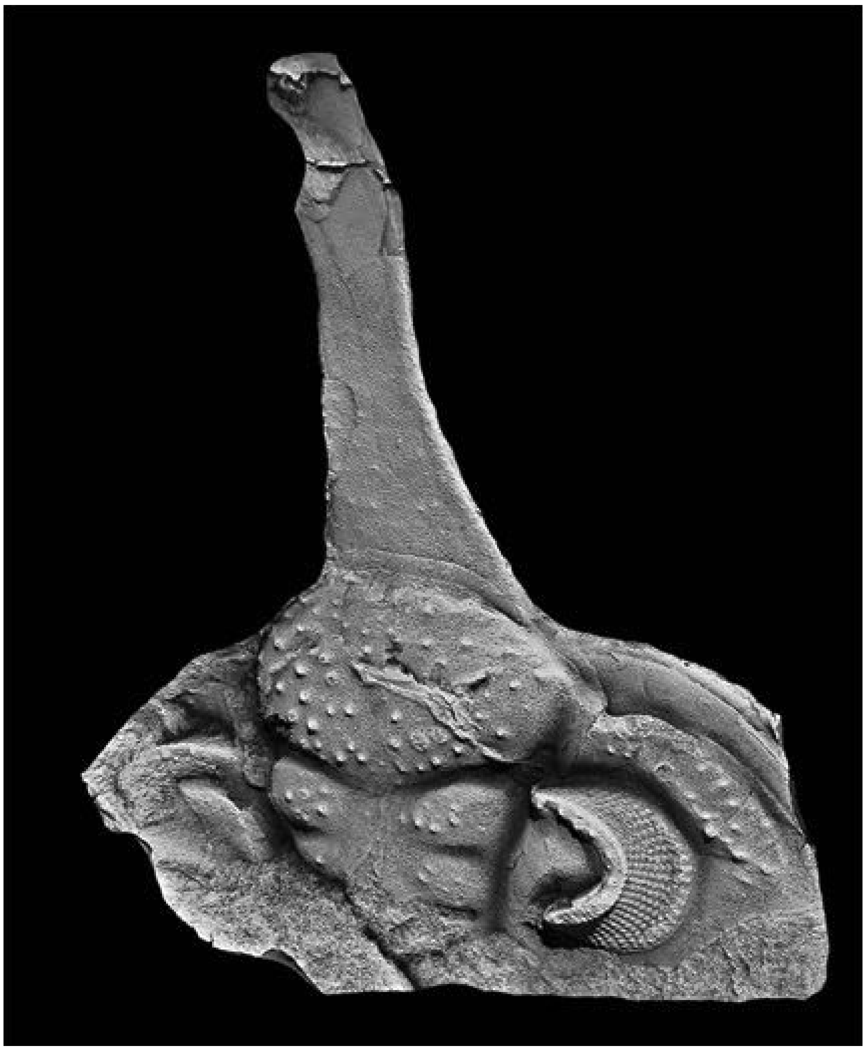
Basse et al. (2019b) tackle German species, and possible species, of the late Upper Emsian kolihapeltine *Sagittapeltis* including new finds from the type locality of its type species in the Dill area, Rhenish Massif. Main topic of this work, however, is the first identification of the kolihapeltine *Heliopeltis* outside of Africa. Great progress has been made in the knowledge of the trilobite faunas of the Late Emsian and the Eifelian of the Rhenohercynian Zone in the past years, due to numerous new finds mainly from the Lahn-Dill area (Rhenish Massif east of the river Rhine). Related work is aiming to establish sound taxonomy to make these trilobites available for modern views on topics like biostratigraphy and palaeobiogeography. Currently, the family Scutelluidae is in the focus of interest, herein some Kolihapeltinae. *Heliopeltis* sp. n. in the Late Emsian of the Rothaargebirge (Sauerland, Northrhine Westphalia), Rhenish Massif north of the Lahn-Dill-area, which is the first proof for this genus outside of Morocco, widens the spectre of Rhenish trilobite genera potentially important for dealing with those questions. Further, this *Heliopeltis* seems to prove the existence outside of Africa of one of hitherto appearingly endemic Moroccan trilobite genera for the very first time.



Text-fig. A. *Leonaspis* sp. n., site Löhnberg I, Lahn Syncline. *Anarcestes lateseptatus* Biozone (LD IV-D2), late Upper Emsian part, Early Devonian. Cast showing dorsal surface of carapace. Length excluding spines: 13 mm. Photograph courtesy of P. Müller.

The closely related *Sagittapeltis* is represented in the Rhenohercynian Zone (Dill area, Harz Mountains) by at least three species, of which only the type species is well known though still problematic in several respect as underlined by new finds. This paper is part of a larger project dealing with a revision of the Siluro-Early Devonian Scutelluidae of the German Variscides (Basse 2019, in prep.).

Basse & Lemke (2019) will report on trilobites from the eastern margin of the Rhenish Massif, the Kellerwald ares, which consists of several different nappe units. Its trilobite-bearing Palaeozoic is represented by Pragian to Visean beds (middle Early Devonian to Middle Mississippian), of which only the faunas of the limestones of the Late Emsian to Early Eifelian, the Early Givetian and the Late Devonian are well-documentated. Since fieldwork is restricted to collecting agricultural ground, except for two quarries in which, however, sampling is forbidden by law, great progress in knowledge should not be expected. Revisions of former finds may serve as additional data sets. The first identification of *Bojoscutellum* for the Kellerwald and a new genus of the Cyrtosymbolinae and the Phacopinae, repectively, fill gaps in the knowledge about the Early and Late Devonian. This contribution includes the first list of all trilobite species and subspecies known from the Kellerwald.



Text-fig. B. Damaged cephalon of *Psychopyge* sp. n. B, Rupbach Valley, Lahn Syncline, Rupbach Shale, middle Upper Emsian, Early Devonian. Cast showing dorsal surface of carapace. Length: 65 mm. Photograph courtesy of P. Müller.

Basse & Müller (2019): New discoveries of the asteropygine *Psychopyge* from the Rupbach Shale, middle Upper Emsian of the Lahn Syncline, confirm the presence of two species of this genus therein as already predicted by Basse & Müller. We figure the most complete cephalon of *Psychopyge* outside of Africa herein (text-fig. B).

In preparation is a work on epidermal structures in trilobites (Basse & Franke 2019). On the base of an internal mold of a carapace of the Upper Emsian phacopine *Arduennops michelsi* (see cover of current volume) from Luxembourg, which is as good as completely and homogeneously covered with a thin silicatic layer expressed as Voronoi pattern, the authors identify its origin as cellular membrane of ventral parts of the carapace. Similar patterns have already been figured from proetines, homalonotines, other phacopines, and asteropygines but have neither been described in detail nor correctly interpreted. Interestingly, this pattern seems to occur only during a geologically short time span, the younger Upper Emsian, and only in the Rheic Ocean, whereas silicatic layers as such are widely distributed geographically and chronologically. That might be due either to the specific chemistry of the sea -water in the Upper Emsian, or to the chemistry of the trilobite carapace.

Papers accepted:

Basse, M., Müller, P., Bohatý, J. & Ahrens, M. (2019a): Paleontological research in the Paleozoic of the Lahn Syncline (Rhenish Massif). Status quo of currently collected Early Devonian fossil sites. – In: Landesamt für Denkmalpflege Hessen (ed.): hessenArchäologie 2018, Jahrbuch für Archäologie und Paläontologie in Hessen; Darmstadt. (In German.)

Basse, M., Müller, P. & Habenicht, J. (2019b): *Heliopeltis* and *Sagittapeltis* in the Emsian of the Rhenohercynian (Trilobita, Early Devonian, German Variscides. – Dortmunder Beiträge zur Landeskunde, naturwissenschaftliche Mitteilungen, **49**; Dortmund. (In German.)

Basse, M. & Lemke, U. (2019): New and little known trilobites from the Early and Late Devonian of the Kellerwald (Rhenohercynian, German Variscides). – Dortmunder Beiträge zur Landeskunde, naturwissenschaftliche Mitteilungen, **49**; Dortmund. (In German.)

Basse, M. & Müller, P. (2019): *Psychopyge* from the Rupbach Shale of the Lahn Syncline – Update for a trilobite – Fossilien, Journal für Erdgeschichte; Wiebelsheim. (In German.)

Papers in preparation:

Basse, M. (2019): The Siluro-Early Devonian Scutelluidae in the German Variscides (Trilobita). (In German.)

Basse, M. (2019): Contributions to Nomenclature of the Class Trilobita, 1. The correct year of publication of Odontochile (Dalmania) exilis Eichwald, type species of Estoniops Männil, with an updated synonymy and bibliographic notes. (In English.)

Basse, M. & Franke, C. (2019): Manifestations of the hypodermal membrane in the phacopine trilobite Arduennops michelsi from Luxembourg (Ardennes, Europe, Early Devonian). (In German.)

Basse, M., Tilsley, J.W. & Müller, P. (2019/2020): A new species of Selenopeltis Hawle & Corda (Trilobita) from the Llanvirn (Ordovician) of Shropshire (Great Britain). (In English.)

2018 TRILOBITE REFERENCES

Scott Morrison

Alberti, M. 2018, *Leonaspis bassei* n. sp. (Trilobita, Odontopleuridae) aus dem basalen Rupbach-Schiefer (Ober-Emsium; Rhenoherzynikum). Mainzer Geowissenschaftliche Mitteilungen, 46:7-22

Álvaro, J.J., Esteve, J., Gracia, F., Zamora, S. 2018, Cambrian trilobites from the Huérmeda Formation (Iberian Chains, north-east Spain) and the inadequacy of the Marianian Stage. Papers in Palaeontology, (ahead-of-print publication)

Álvaro, J.J., Esteve, J., Zamora, S. 2018, Morphological assessment of the earliest paradoxidid trilobites (Cambrian Series 3) from Morocco and Spain. Geological Magazine, 155(7):1566-1595

Armstrong, M.L. 2018. Trilobites from a Cambrian extinction interval at the base of the Steptoean Stage, Riley Formation, central Texas. MSc. Thesis, University of Oklahoma, School of Geology and Geophysics, 255 pp.

Armstrong, M.L., Westrop, S.R., Engel, M. 2018. Integrating Trilobite Biostratigraphy and Carbon Isotope Stratigraphy of the Cambrian (Paibian; Steptoean) Spice Event in Central Texas and Western Utah. GSA 320997 (GSA Annual Meeting in Indianapolis, Indiana, USA - 2018) Paper No. 272-15

Babcock, L.E. 2018 Pathologies in Paleozoic Trilobites. Mainzer Geowissenschaftliche Mitteilungen, 46:129-154

Basse, M. 2018, Die Typen der Trilobita mit deutscher Typuslokalität. Fortschritte in der Forschung im Jahr 2017 bis Frühjahr 2018. [The types of Trilobita with German type locality. Research progress in 2017 until spring 2018.] Dortmunder Beiträge zur Landeskunde, naturwissenschaftliche Mitteilungen, 48:185-226

Basse, M. & Müller, P. 2018, *Phaetonellus* aus dem Devon des Rhenoherzynikums (Trilobita, Emsium und Eifelium, rechtsrheinisches Schiefergebirge). [*Phaetonellus* from the Devonian of the Rhenoherzynikum (Trilobita, Emsium and Eifelium, right bank of the Schiefergebirge).] Dortmunder Beiträge zur Landeskunde, naturwissenschaftliche Mitteilungen, 48:97-183

Basse, M. & Müller, P. 2018, Status quo der Funde von Paralejurus aus den deutschen Varisziden (Trilobita, spätes Silur bis frühes Mitteldevon).[Status quo of the finds of Paralejurus from the German Variscides (Trilobita, late Silurian to early middle Devonian). Mainzer Geowissenschaftliche Mitteilungen, 46:129-154

Beech, J.D., Lamsdell, J.C. 2018, Death Defying Morphologies: Extinction in and Disparity in the Order Harpetida, GSA Annual Meeting in Indianapolis, Indiana, USA - 2018 Paper No. 39-17

Bennett, C.E., Williams, M., Leng, M.J., Lee, M.R., Bonifacie, M., Calmels, D., Fortey, R.A., Laurie, J.R., Owen, A.W., Page, A.A., & Munnecke, A. 2018. Oxygen isotope analysis of the eyes of pelagic trilobites: Testing the application of sea temperature proxies for the Ordovician. Gondwana Research, 57:157-169

Bergström, S.M., Ahlberg, P., Maletz, J., Lundberg, F., Joachimski, M.M. 2018. Darriwilian (Middle Ordovician) chemostratigraphy linked to graptolite, conodont and trilobite biostratigraphy in the Fågelsång-3 drill core, Scania, Sweden. GFF, 140(3):229-240

Betts, M.J., Paterson, J.R., Jacquet, S.M., Andrew, A.S., Hall, P.A., Jago, J.B., Jagodzinski, E.A., Preiss, W.V., Crowley, J.L., Brougham, T., Mathewson, C.P., García-Bellido, D.C., Topper, T.P., Skovsted, C.B., Brock, G.A. 2018. Early Cambrian chronostratigraphy and geochronology of South Australia. Earth-Science Reviews, 185:498-543.

Bicknell, R.D.C. & Paterson, J.R. 2018. South Australian Cambrian trilobite injuries: A new approach to explore the early evolution of predation and lateralisation. pp. 60-61. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi'an. August 2018, Xi'an.

Bicknell, R.D.C., Pates, S., Botton, M.L. 2018. Abnormal xiphosurids, with possible application to Cambrian trilobites. Palaeontologia Electronica, 21(2,19A):1-17

Ballester, A.S., Liñán, E., Gozalo, R. 2018 Los trilobites de Minas Tierga (Marianiense, Cámbrico inferior) de las Cadenas Ibéricas (NE España). [The trilobites of Tierga Mines (Marianiense, Lower Cambrian) of the Iberian Chains (NE Spain).] In: Vaz, N. & Sá, A.A. (eds.) Yacimientos paleontológicos excepcionales en la península Ibérica. XXXIV Jornadas de Paleontología y IV Congreso Ibérico de Paleontología. Cuadernos del Museo Geominero, 27:595-601

Boyce, W.D. & Knight, I. 2018. Trilobite-based recognition of the Early–Middle Cambrian (Dyeran–Delamaran) boundary in the Labrador Group, western Newfoundland, Canada. Geological Association of Canada Newfoundland and Labrador Section - 2018 Spring Technical Meeting Atlantic Geology, 54:134

Budil, P., Fatka, O., Laibl, L., Nohejlová, M., Polechová, M., 2018. Libeň and Letná formations Lagerstätten (Sandbian, Prague Basin, Barrandian area): state of art and perspectives. p. 478. In: 5th International Palaeontological Congress IPC5

Bushuyev, Ye.V. & Komlev, D.A. 2018. New finds of lower Cambrian trilobites in reduction of Konstinskoy Svity River Sukhaya Tunguska (West of the Siberian platform). pp. 31-32. In: Fundamental and applied paleontology. Materials of the LXIV Session Paleontological Society, All-Russian Institute for Geological Research.

Carbonaro, F.A., Langer, M.C., Nihei, S.S., Souza-Ferreira, G., Ghilardi, R.P. 2018. Inferring ancestral range reconstruction based on trilobite records: a study-case on Metacryphaeus (Phacopida, Calmoniidae). Nature Scientific Reports, 8(15179):1-12

Carvalho, M.D.G.P. 2018. Occurrence of *Dipleura dekayi* Green, 1832 (Trilobita; Homalonotidae) in the Devonian of Colombia. American Museum Novitates, 3902:1-8

Chen, Z., Zhao, Y., Yang, X., Wang, M. 2018. *Duyunaspis* Zhang and Qian in Zhou et al., 1977 (Trilobita) from the "Tsinghsutung Formation" (Series 2, Stage

4). of eastern Guizhou, South China. Acta Palaeontologica Sinica, 57(2):181-191
Chirivella, J.B., Liñán, E., Álvarez, M.E.D., Gozalo, R. 2018 Los *Paradoxididos* de la fm. mansilla y base de la fm. Murero (Leoniense superior–Caesaraugustiense medio, serie3 del Cámbrico) en las Cadenas Ibéricas (España). [The *Paradoxides* of the Mansilla Formation and base of the Murero Formation (Upper Leonian-Middle Caesaraugustian, 3 series of the Cambrian) in the Iberian Chains (Spain).] In: Vaz, N. & Sá, A.A. (eds.) Yacimientos paleontológicos excepcionales en la península Ibérica. XXXIV. Jornadas de Paleontología y IV Congreso Ibérico de Paleontología. Cuadernos del Museo Geominero, 27:555-561
Choi, D.K. 2018. Evolution of the Taebaeksan Basin, Korea: I, early Paleozoic sedimentation in an epeiric sea and break-up of the Sino-Korean Craton from Gondwana. Island Arc, (ahead-of-print publication)
Choi, D.K. & Park, T.Y.S. 2018. Erratum to: Recent advances of trilobite research in Korea: Taxonomy, biostratigraphy, paleogeography, and ontogeny and phylogeny. Geosciences Journal, 22(4):681.
Collantes, L., Gozalo, R., Garzón, I., Mayoral, E. 2018. Trilobites del Cámbrico inferior (Marianiense) de la Unidad Fregenal-Cumbres (Sierra norte de Huelva). [Trilobites of the Lower Cambrian (Marianiense) of the Fregenal-Cumbres Unit (Sierra Norte de Huelva).] In: Vaz, N. & Sá, A.A. (eds.) Yacimientos paleontológicos excepcionales en la península Ibérica. XXXIV Jornadas de Paleontología y IV Congreso Ibérico de Paleontología. Cuadernos del Museo Geominero, 27:563-570
Corbacho, J., López-Soriano, F.J., Lemke, U., Morrison, S., Hammond, K. 2018. Diversity and Distribution of the Genus *Platypeltoides* (Nileidae) in Morocco. American Journal of Bioscience and Bioengineering, 6(2):13-20
Crônier, C., Abbache, A., Khaldi, A., Oudot, M., Maillet, Mehadji, S., Ouali, A. 2018. Biodiversity and palaeobiogeographical affinities of Middle Devonian trilobites from Algeria. p. 819 In: 5th International Palaeontological Congress IPC5
Crônier, C., Abbache, A., Khaldi, A., Yacine, M., Oudot, M. 2018. Middle Devonian trilobites of the Saoura Valley, Algeria: insights into their biodiversity and Moroccan affinities. Geological Magazine, 155 (4):811-840
Crônier, C., Oudot, M., Klug, C., De Baets, K. 2018. Trilobites from the Red Fauna (latest Emsian, Devonian) of Hamar Laghdad, Morocco and their biodiversity. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 290(1-3):241-276.
Cuen-Romeroa, F.J., Valdez-Holguín, J.E., Buitrón-Sánchez, B.E., Monreal, R., Enríquez-Ocaña, L.F., Aguirre-Hinojosa, E., Ochoa-Granillo, J.A., Palafox-Reyes, J.J. 2018 Trilobite-based biostratigraphy (arthropoda-trilobita) and related faunas of the Cambrian from Sonora, Mexico. Journal of South American Earth Sciences, 83:227-236
Drage, Harriet, B. 2018, The Evolution of Exoskeleton Moulting in Trilobita. PhD Thesis, University of Oxford, Volumes 1 & 2
Drage, H.B., Holmes, J.D., García-Bellido, D.C., Daley, A.C. 2018. An exceptional record of Cambrian trilobite moulting behaviour preserved in the Emu Bay Shale, South Australia. Lethaia, 51(4):473-492.
Drage, H.B., Laibl, L. & Budil, P. 2018. Postembryonic development of *Dalmanitina*, and the evolution of facial suture fusion in Phacopina. Paleobiology, 44 (4):638-659.
Du, G., Peng, J., Wang, D., Fan, W. 2018. Morphological analysis and ontogeny of the trilobite *Changaspis elongata* from the Cambrian Series 2 of Guizhou, South China. p. 112. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi'an. August 2018, Xi'an
Du, G., Peng, J., Wang, D., Wen, R., Liu, S. 2018. Morphology and trunk development of the trilobite *Arthricocephalus chauveaui* from the Cambrian series 2 of Guizhou, South China. Historical Biology, (ahead-of-print publication)
Ebbestad, J.O.R. & Fortey, R.A. 2018. Stratigraphy and trilobite biofacies of the Late Ordovician (Katian) of the Taimyr Peninsula, Arctic Russia. International Conference on Arctic Margins, Abstract
Esteve, J., Gutiérrez-Marco, J.C., Rubio, P., Rábano, I. 2018. Evolution of trilobite enrolment during the Great Ordovician Biodiversification Event: insights from kinematic modelling. Lethaia, 51(2):207-217
Esteve, J., Zhao Y., Maté-González, M.A., Gómez-Heras, M., Peng, J. 2018. A new high-resolution 3-D quantitative method for analysing small morphological features: an example using a Cambrian trilobite. Nature Scientific Reports, 8(2868):1-10.
Evans, A., Nikolic, M., Hopkins, M., Daly, E.S., Catlett, K., Jernvall, J. 2018. Inhibitory cascade and serial segmentation in teeth, limbs and body segments: from trilobites to hominids. p. 370 In: 5th International Palaeontological Congress IPC5
Fatka, O. & Budil, P. 2018. Digestive structures in the Middle Ordovician trilobite *Prionocheilus* Rouault, 1847 from the Barrandian area of Czech Republic. Geologica Acta, 16(1):65-73
Fatka, O., Budil, P., Laibl, L., 2018. Possible shell disease syndrome in late holaspid Ordovician trilobites. p. 517. In: 5th International Palaeontological Congress IPC5
Feist, R. & Belka, Z. 2018. Late Emsian (Devonian) trilobite communities from the Kess-Kess mounds, Hamar Laghdad (Anti-Atlas, Morocco). Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 290(1-3):277-290
Feist, R. & Weyer, D. 2018. The proetid trilobite *Perliproetus*, a marker of the late Famennian in Central Europe and North Africa. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 287(2):195-206
Flick, U. 2018. Die Trilobiten-Fauna im Greifenstein-Kalk der Typlokalität (Grenzbereich Emsium/Eifelium) – ein Zwischenbericht. [The trilobite fauna from the Greifenstein Limestone at the type locality (boundary Emsian-Eifelian) – an interim report.]

Jahrbücher des Nassauischen Vereins für Naturkunde, 139:133-161
Geyer, G. 2018. *Solenopleura*, *Parasolenopleura* and related conundrums. pp. 116-117. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi'an. August 2018, Xi'an
Geyer, G. & Landing, E. 2018 An exploring expedition to the world's oldest trilobites. pp. 66-70. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi'an. August 2018, Xi'an
Ghobadi Pour, M., Popov, L.E., Omrani, M, Omrani, H. 2018. The latest Devonian (Famennian) phacopid trilobite *Omegops* from eastern Alborz, Iran. Estonian Journal of Earth Sciences, 67(3):192-204.
Gutiérrez-Marco, J.C., Pereira, S., Colmenar, J., Zamora, S., Rábano, I. 2018. Middle Berounian (ca. Sandbian 2-Katian 1) trilobite, brachiopod and echinoderm assemblages from the southern Central Iberian Zone, Spain. p. 844. In: 5th International Palaeontological Congress IPC5
Heath, R.A. 2018. A Palaeoenvironmental Analysis of Ordovician trilobites from the Builth-Llandrindod Wells Inlier, Central Wales. B.Sc. Thesis, University of Manchester, School of Earth and Environmental Sciences, 93 pp.
Heward, A.P., Booth, G.A., Fortey, R.A., Miller, C.G., Sansom, I.J. 2018. Darriwilian shallow-marine deposits from the Sultanate of Oman, a poorly known portion of the Arabian margin of Gondwana. Geological Magazine, 155(1):59-84
Holmes, J.D., Paterson, J.R., García-Bellido, D.C. 2018. Exceptional preservation of *Redlichia* from the Emu Bay Shale, South Australia, including a giant new species. p. 60. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi'an. August 2018, Xi'an
Hong, P.S. 2018. Earliest trilobites of Korea. pp. 118-119. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi'an. August 2018, Xi'an
Hopkins, M.J. 2018, Discovering Parameters That Govern Variation in Trilobite Growth and Body Size Through Modeling. GSA Annual Meeting in Indianapolis, Indiana, USA - 2018 Paper No. 199-10
Jago, J.B., Bentley, C.J., Laurie, J.R., Corbett, K.D. 2018. Some middle and late Cambrian trilobites and brachiopods from the Adamsfield Trough, Tasmania. Alcheringa, (ahead-of-print publication).
Kennedy, R. & Stammers, S. 2018. Trilobites of the British Isles. Siri Scientific Press, 384 pp.
Korovnikov, I.V. 2018. The oldest trilobites from Siberia. p. 325. In: 5th International Palaeontological Congress IPC5
Korovnikov, I.V. 2018. Paleogeographic distribution of the ancient trilobites of the Atdaban period of the early Cambrian in the Altai-Sayan folding area. pp.62-64. In: Fundamental and applied paleontology. Materials of the LXIV Session Paleontological Society, All-Russian Institute for Geological Research
Korovnikov, I.V. 2018. The dynamics of trilobite developments in the Lower and the early Middle Cambrian of the Eastern Siberian platform: The Protolenidae and Oryctocephalidae. Trofimuk Institute of Petroleum Geology and Geophysics, Siberian Branch of the Russian Academy of Sciences. (IPGG SB RAS) - 111 pp.
Korovnikov, I.V. 2018, Middle Cambrian trilobites and biostratigraphy of the section at the Khorbosuonka River (NE Siberian platform). pp.82-85. In: Podobina, V.M. (ed.) 2018 Evolution of Life on the Earth: Materials of the V International Symposium November 12–16, 2018. Tomsk: Publishing House of Tomsk State University
Krueger, H.H. 2018, Die Familie Raphiophoridae (Trilobita) aus ordovizischen baltoskandischen Geschieben. Ampyx-Verlag, 62 pp.
Krylov, A.V. 2018, New Data on the Taxonomy and localities of Ordovician Trilobites (Trilobita: Ptychopariida: Illaenidae, Panderidae) of Leningrad Region. Baranovichi State University Bulletin, 6:57-81
Kundura, J.P. 2018. Trilobite assemblages in Floian of Montagne Noire, France: focus on the upper part of the "Formation de Saint-Chinian". p. 520. In: 5th International Palaeontological Congress IPC5.
Laibl, L. 2018. Evolutionary modifications of early developmental stages in Cambrian trilobites. p. 521. In: 5th International Palaeontological Congress IPC5.
Laibl, L. 2018. Morphological and ecological disparity in early developmental stages of Cambrian trilobites. pp.61-62. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi'an. August 2018, Xi'an
Laibl, L., Cederström, P., Ahlberg, P. 2018. Early postembryonic development in *Ellipsostrenua* (Trilobita, Cambrian, Sweden) and the developmental patterns in Ellipsocephaloidea. Journal of Paleontology, 92 (6):1018-1027.
Lam, A.R., Stigall, A.L., Matzke, N.J. 2018. Dispersal in the Ordovician: Speciation patterns and paleobiogeographic analyses of brachiopods and trilobites. Palaeogeography, Palaeoclimatology, Palaeoecology, 489:147-165
Lavine, R.J. 2018. Patterns of Morphological Diversification within the Suborder Agnostina (Trilobita). GSA 323024 (GSA Annual Meeting in Indianapolis, Indiana, USA - 2018) Paper No. 115-3.
Lebrun, P. 2018. Fossiles du Maroc. [Fossils from Morocco.]. Les Editions du Piat, 298 pages, 950 photos
Lee, S.B. 2018. Refined biostratigraphy of the Cambrian Stage 10 of the Taebaeksan Basin, Korea. p. 122. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi'an. August 2018, Xi'an.
Lefebvre, B., Lerosey-Aubril, R., Martin, E., Gutiérrez-Marco, J.C., García-Bellido, D.C., Rábano, I., Saleh, F., Vidal, M., Van Roy, P. 2018. Fossilized appendages and guts in three phacopid trilobites from the Tremadocian lower Fezouata Konservat-lagerstätte (Lower Ordovician, Morocco). p. 862. In: 5th International Palaeontological Congress IPC5.

Lerosey-Aubril, R., Gaines, R.R., Hegna, T.A., Ortega-Hernández, J., Van Roy, P., Kier, C., Bonino, E. 2018. The Weeks Formation Konservat-Lagerstätte and the evolutionary transition of Cambrian marine life. Journal of the Geological Society London, 175:705-715

Lerosey-Aubril, R. & Peel, J.S. 2018. Gut evolution in early Cambrian trilobites and the origin of predation on infaunal macroinvertebrates: evidence from muscle scars in *Mesolenellus*. Palaeontology, 61(5):747-760

Loch, J.D., Taylor, J.F., Repetski, J.E. 2018. *Lotagnostus*-dominated faunas from the Cambrian Windfall Formation, Nevada, USA: Implications for deliberations over the base of Cambrian Stage 10. pp. 125-126. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi'an. August 2018, Xi'an.

Loch, J.D., Taylor, J.F., Repetski, J.E., Strauss, J.V., Kamerer, W.T. 2018. Paleoenvironmental distribution of the Late Cambrian (Furongian) Agnostoid arthropod *Lotagnostus* in western Laurentia. GSA 324627 (GSA Annual Meeting in Indianapolis, Indiana, USA - 2018) Paper No. 257-3.

Losso, S. 2018. A new genus of dimeropygid trilobites from the Great Basin of the western USA. Masters Thesis, University of Iowa, 121 pp.

Makarova, A.L. 2018. About trilobites of the genus *Nganasanella* Rosova, 1963 (upper Cambrian) and their stratigraphic values. pp. 71-72. In: Fundamental and applied paleontology. Materials of the LXIV Session Paleontological Society, All-Russian Institute for Geological Research.

Meroi Arcerito, F.R., Waisfeld, B.G., Vaccari, N.E., Muñoz, D.F. 2018. High resolution trilobite biostratigraphy for the early late Tremadocian (Tr2) interval (Early Ordovician) Santa Rosita Formation, Argentine Cordillera Oriental. Ameghiniana, (ahead-of-print publication)

Månsson, K. & Clarkson, E.N.K. 2018. A revised ontogeny of the early Ordovician trilobite *Leptoplastides salteri* (Callaway, 1877). Transactions of the Royal Society of Edinburgh: Earth and Environmental Science, (ahead-of-print publication).

Marinšek, M., Križnar, M., Gale, L. 2018. Trilobites from European sites in school and historical geological collections of the Natural History Museum of Slovenia. p.188. In: Slovenian Geological Congress Velenje, 3-5.10.2018 Collection of abstracts.

McAdams, N.E.B.; Adrain, J.M., Karim, T.S. 2018. The pliomerid trilobite *Ibexaspis* and related new genera, with species from the Early Ordovician (Floian; Tulean, Blackhillsian) of the Great Basin, western USA. Zootaxa, 4525(1):1-152

McCobb, L.M.E., McDermott, P.D., Owen, A.W. 2018. The taphonomy of a trilobite fauna from an uppermost Katian echinoderm Lagerstätte in South West Wales. Fossils and Strata, (ahead-of-print publication)

McCobb, L.M.E., McDermott, P.D., Owen, A.W. 2018. The trilobite fauna of an uppermost Katian (Upper Ordovician) echinoderm Lagerstätte from South West Wales. The Palaeontological Association 62nd Annual Meeting - Programme Abstracts.

McClure Jr., T.C. 2018. Change in Edenian *Triarthrus* species along a depth gradient in the Taconic Foreland Basin, Pennsylvania. GSA 311140 (GSA Northeastern Section - 53rd Annual Meeting - 2018) Paper No. 10-21.

Meroi Arcerito, F.R., Waisfeld, B.G., Vaccari, N.E., Muñoz, D.F. 2018, High resolution trilobite biostratigraphy for the early late Tremadocian (Tr2) interval (Early Ordovician) Santa Rosita Formation, Argentine Cordillera Oriental. Ameghiniana, 55(5):531-554

Monti, D.S. & Confalonieri, V.A. 2018. First cladistic analysis of the trilobite family Olenidae from the Furongian and Ordovician. Lethaia, , (ahead-of-print publication).

Moysiuk, J. & Caron, J.B. 2018. Burgess Shale fossils shed light on the agnostid problem. p. 300. In: 5th International Palaeontological Congress IPC5.

Müller, P. & Hahn, G. 2018. Die Trilobiten der Erdbach-Kalke von Erdbach (Hessen) und die der "Phillipsien-Bank" im Raum Warstein (NordrheinWestfalen), sowie eine Revision der Cystispininae (mittleres Mississippium). [The trilobites of the Erdbach limestone of Erdbach (Hesse) and those of the "Phillipsien-Bank" in the Warstein area (North Rhine-Westphalia), as well as a revision of cystispininae (middle Mississippian).] Abhandlungen der Senckenberg Gesellschaft für Naturforschung, 574:1-237

Mychko, E.V. & Alekseev, A.S. 2018. Trilobites from the Gzhelian (Pennsylvanian) of the Moscow Region. Paleontological Journal, 52(5):506-519.

Ng, R.Y. & Adrain, J.M. 2018. Phylogeny and Morphology of the Cambrian-ordovician Trilobite genus *Clelandia* with new and revised Species. GSA 324590 (GSA Annual Meeting in Indianapolis, Indiana, USA - 2018) Paper No. 115-5.

Nowicki, J. & Żylińska, A. 2018. The first occurrence of the earliest species of *Acadoparadoxides* outside West Gondwana (Cambrian; Holy Cross Mountains, Poland). Geological Magazine, (ahead-of-print publication)

Oudot, M., Crônier, C., Neige, P., Holloway, D. 2018. Phylogeny of some Devonian trilobites and consequences for the systematics of *Austerops* (Phacopidae). Journal of Systematic Palaeontology, (ahead-of-print publication).

Pankowski, M.K., Pankowski, M.J., Hegna, T. 2018. Legacy data in phylogenetics and a Re-analysis of mid-paleozoic phacopid phylogeny. GSA 322878 (GSA Annual Meeting in Indianapolis, Indiana, USA - 2018) Paper No. 115-4

Park, T.Y. 2018. Ontogeny of the two co-occurring middle Furongian (late Cambrian) shumardiid trilobites and the protaspid morphology of shumardiids. Geological Magazine, 155(6):1247-1262.

Paterson, J.R., Gaines, R.R., García-Bellido, D.C., Jago, J.B. 2018. The Emu Bay Shale fan delta complex: palaeoenvironmental conditions affecting the community structure of a unique Cambrian Lagerstätte. p. 59. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sci-

ences. 12th-16th August 2018, Xi'an.
Pates, S. & Bicknell, R.D.C. 2018. Elongated thoracic spines as potential predatory deterrents in olenelline trilobites from the lower Cambrian of Nevada. Palaeogeography, Palaeoclimatology, Palaeoecology (ahead-of-print publication)
Peel, J.S. & Willman, S. 2018. The Buen Formation (Cambrian Series 2) biota of North Greenland. Papers in Palaeontology, 4(3):381-432.
Pegel, T.V. 2018, Cambrian paleobiogeography and evolution of trilobite biofacies zoning on the Siberian platform. pp.106-109, In: Podobina, V.M. (ed.) Evolution of Life on the Earth: Materials of the V International Symposium November 12–16, 2018. Tomsk: Publishing House of Tomsk State University
Peng, S.C. 2018. New oryctocephalid taxa from the Cambrian Balang Biota in NW Hunan with a review on the classification of oryctocephalids. p. 506. In: 5th International Palaeontological Congress IPC5
Peng, S.C., Babcock, L.E., Bagnoli, G., Shen, Y., Mei, M., Zhu, X., Li, D., Zhang, X., Wang, L., 2018. Proposed GSSP for the base of Cambrian Stage 10 (Furongian Series) at FAD of *Lotagnostus americanus* in the Wa'ergang section, Hunan, South China. pp.76-78. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi'an.
Peng S.C., Babcock, L.E., Zhu, X., Dai, T. 2018. A new oryctocephalid trilobite from the Balang Formation (Cambrian Stage 4) of northwestern Hunan, South China, with remarks on the classification of oryctocephalids. Palaeoworld, 27(3):322-333
Pereira, S. 2018. A coleção de trilobites do Museu Nacional de História Natural e da Ciência (Universidade de Lisboa, Portugal). VIII Congresso Jovens Investigadores em Geociências, pp. 73-76.
Pereira, S. 2018. 'Striptease' Paleozoico: exemplos de ecdise em trilobites do Ordovícico Superior de Portugal. [Paleozoic 'Striptease': exemples of ecdysis in trilobites of Upper Ordovician of Portugal.] In: Vaz, N. & Sá, A.A. (eds.) Yacimientos paleontológicos excepcionales en la península Ibérica. XXXIV Jornadas de Paleontología y IV Congreso Ibérico de Paleontología. Cuadernos del Museo Geominero, 27:301-312.
Pereira, S., Gutiérrez-Marco, J.C., Colmenar, J., Rábano, I. 2018, Trilobites del Ordovícico Superior del Macizo del Tremedal (rama castellana de la Cordillera Ibérica). Geogaceta, 64:95-98
Qin, S., Dong, L., Shen, B. 2018. Ontogenetic variation on cranidial shape of the Late Middle Cambrian (Cambrian Series 3) Trilobite *Jiulongshania acalla*. GSA 321978 (GSA Annual Meeting in Indianapolis, Indiana, USA - 2018) Paper No. 39-18.
Rábano, I., Gutiérrez-Marco, J.C., Pereira, S., Bernárdez, E. 2018. El trilobites Dionide (Trinucleoidea) en el Ordovícico de España. [The trilobites Dionide (Trinucleoidea) in the Ordovician of Spain.] In: Vaz, N. & Sá, A.A. (eds.) Yacimientos paleontológicos excepcionales en la península Ibérica. XXXIV Jornadas de Paleontología y IV Congreso Ibérico de Paleontología. Cuadernos del Museo Geominero, 27:313-323
Rice, A. 2018. *Gravicalymene celebra* (Raymond) from the Silurian Laurel Dolostone: Where are the Pieces? GSA 312061 (GSA Southeastern Section - 67th Annual Meeting - 2018) Paper No. 20-3
Schoenemann, B. 2018. The functioning of a trilobite visual system more than half a billion years ago. p. 307. In: 5th International Palaeontological Congress IPC5
Schoenemann, B. 2018. Evolution of Eye Reduction and Loss in Trilobites and Some Related Fossil Arthropods. Emerging Science Journal, 2(5):272-286.
Schoenemann, B. & Clarkson, E.N.K. 2018. How an eye of a phacopid trilobite is constructed, or the solution of Stürmer's enigma.The Palaeontological Association 62nd Annual Meeting - Programme Abstracts
Schöning, H. 2018. Zwei bemerkenswerte Cranidien ordovizischer Trilobiten aus Geschieben des Unteren Roten Orthocerenkalks. [Two remarkable cranidia of Ordovician trilobites from glacial erratics of the Lower Red Orthoceratite Limestone.]. Geschiebekunde Aktuell, 34(1):17-25
Sheldon, P.R. 2018. Fluctuating asymmetry in Ordovician trilobites from the Builth-Llandrindod Inlier, central Wales. The Palaeontological Association 62nd Annual Meeting - Programme Abstracts
Smith, P.M., Paterson, J.R., Brock, G.A. 2018. Trilobites and agnostids from the Goyder Formation (Cambrian Series 3, Guzhangian; Mindyallan), Amadeus Basin, central Australia. Zootaxa, 4396(1):1-67.
Stanley, S.M. 2018. Genal spines functioned to allow Trilobites to right themselves after being overturned. GSA 319781 (GSA Annual Meeting in Indianapolis, Indiana, USA - 2018) Paper No. 199-11.
Stebing, J., & L.M., Mikulic, D.G., Dattilo, B., Havens, J.J. 2018. A new Silurian (Ludlow, Gorstian) Trilobite fauna from Pipe Creek Junior Quarry, Swayzee, Grant County, Indiana. GSA 324770 (GSA Annual Meeting in Indianapolis, Indiana, USA - 2018) Paper No. 39-4.
Stocker, C., Lane, P.D., Siveter, D.J., Williams, M., Oji, T., Tanaka, G., Komatsu, T., Wallis, S. 2018. Silurian and Devonian trilobites of Japan: 'eye witnesses' to the early geological evolution of the Japanese islands. The Palaeontological Association 62nd Annual Meeting - Programme Abstracts
Stocker, C., Siveter, D.J., Lane, P., Williams, M., Oji, T., Wallis, S., Tanaka, G., Komatsu, T., Siveter, D.J., Vandenbroucke, T.R.A. 2018, The paleobiogeographical significance of the Silurian and Devonian trilobites of Japan. Island Arc, (ahead-of-print publication).
Stocker, C., Tanaka, G., Siveter, D.J., Lane, P., Tsutsumi, Y., Komatsu, T., Wallis, S., Oji, T., Siveter, D.J., Williams, M. 2018. Biogeographical and biostratigraphical significance of a new Middle Devonian phacopid trilobite from the Naidaijin Formation, Kurosegawa Terrane, Kyushu, southwest Japan. Paleontological Research, The Palaeontological Society of Japan, 22(1):75-90
Stocker, C., Williams, M., Lane, P., Siveter, D.J., Oji, T., Wallis, S., Tanaka, G., Komatsu, T. 2018. Silurian and Devonian trilobites of Japan: 'eye witnesses' to

the early geological evolution of the Japanese islands. p. 747. In: 5th International Palaeontological Congress IPC5
Sundberg, F.A. 2018. Trilobite biostratigraphy of the Cambrian 5 and Drumian stages, Series 3 (Laurentian Delamaran, Topazan, and Marjuman stages, Lincolnian Series) of the lower Emigrant Formation at Clayton Ridge, Esmeralda County, Nevada. Journal of Paleontology, 92(Memoir 76):1-44.
Taylor, R.S. 2018. A fresh perspective on the middle Cambrian trilobites from Manuels River, Conception Bay South, Newfoundland, Canada. Geological Association of Canada Newfoundland and Labrador Section - 2018 Spring Technical Meeting Atlantic Geology, 54:143-144
Taylor, W., Högström, A., Ebbestad, J.O.R., Høyberget, M., Jensen, S., Meinhold, G., Palacios, T., Novis, L. 2018. Teaching with Trilobites: digital resources to enhance student learning at the Tromsø University Museum. p. 1077. In: 5th International Palaeontological Congress IPC5
Tortello, M.F. 2018. Redescription of a *Lotagnostus–Mendoparabolina* faunule (Trilobita; late Furongian) from Quebrada San Isidro, Precordillera of Mendoza, Argentina. Paläontologische Zeitschrift, 92:373-386
Tortello, M.F., Zeballo, F.J. & Monti, D. 2018. A late Furongian trilobite assemblage from the eastern Cordillera Oriental (Santa Rosita Formation; Jujuy, Argentina) and its biostratigraphic significance. Revista del Museo Argentino de Ciencias Naturales N.S., 20 (2):271-282.
Vaccari, N.E., Waisfeld, B.G., Canelo, H.N., & Smith, L. 2018. Trilobites from the Iscayachi Formation (Upper Cambrian - Lower Ordovician), Cordillera Oriental, South Bolivia. Biostratigraphic implications. In: Fósiles y Facies de Bolivia - Riglos, M.S., Farjat, A.D., & Leyton, M.A.P. (eds.) Sincronía Diseño & Publicidad, Santa Cruz de la Sierra, 3:36-58
Vannier, J., Vidal, M., Marchant, R., El Hariri, K., Kouraiss, K., El Albani, A., Mazurier, A., Martin, E. 2018. Collective behaviour in trilobites from the Lower Ordovician of Morocco. p. 328. In: 5th International Palaeontological Congress IPC5
Van Viersen, A.P. & Vanherle, W. 2018. The rise and fall of Late Devonian (Frasnian) trilobites from Belgium: taxonomy, biostratigraphy and events. Geologica Belgica, 21(1-2):73-94.
Wang, P., Fatka, O., Sun, Z., Budil, P. & Gao, J. 2018. Fossilized gut of the trilobite *Lioparia bassleri* and the distribution of exceptional preservation in the Cambrian Stage 4–Drumian Manto Formation of North China. Czech Geological Survey Bulletin of Geosciences, (ahead-of-print publication)
Wang, D., Peng, J., Zhang, H. 2018. Interspecific variability in *Redlichia* (*Pteroredlichia*) trilobites from the Balang Fauna (Cambrian Series 2, south China). p. 154. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi’an.
Wang, P., Fatka, O., Sun, Z., Budil, P. & Gao, J. 2018, Fossilized gut of the trilobite *Lioparia bassleri* and the distribution of exceptional preservation in the Cambrian Stage 4–Drumian Manto Formation of North China. Czech Geological Survey, Bulletin of Geosciences, 93:491-498
Webster, M. & Hageman, S.J. 2018. *Buenellus chilhoweensis* n. sp. from the Murray Shale (lower Cambrian Chilhowee Group) of Tennessee, the oldest known trilobite from the Iapetan margin of Laurentia. Journal of Paleontology, 92(3):442-458.
Westrop, S.R., Landing, E. & Dengler, A.A. 2018. Pseudocryptic species of the Middle Cambrian trilobite *Eodiscus* Hartt, in Walcott, 1884, from Avalonian and Laurentian Newfoundland. Canadian Journal of Earth Sciences, 55(9):997-1019
Wei, X. & Zhan, R. 2018. Trilobite fauna from the lowermost Silurian of Meitan, Guizhou and its implications. Acta Palaeontologica Sinica 57(1):25-39.
Wei, X. & Zhan, R. 2018. A new trilobite species from the upper Rhuddanian (lower Silurian) of South China, and its biogeographical implications. Alcheringa, (ahead-of-print publication)
Wei, X. & Zhan, R. 2018. A late Rhuddanian (early Llandovery, Silurian) trilobite association from South China and its implications. Palaeoworld, 27(1):42-52.
Weidner, T. & Ebbestad, J.O.R. 2018. *Anopolenus henrici* Salter, a middle Cambrian (Drumian) centropleurid trilobite from the Alum Shale Formation of Scandinavia. Bulletin of the Geological Society of Denmark, 66:223-228.
Weiner, T., Weinerová, H., Viktorýn, T. 2018. A new find of scutelluid trilobite pygidium from the upper Frasnian of the Šumbera area near Brno-Líšeň (Moravian Karst, Czech Republic). Zprávy o Geologických Výzkumech v Roce, 2018(V.51):121-125.
Witte, M.K. 2018. On the Phylogenetics of the Trilobite Family Phacopidae with Systematic Implications for *Eldredgeops* (Green, 1832). GSA 323531 (GSA Annual Meeting in Indianapolis, Indiana, USA - 2018) Paper No. 13-6.
Yuan, J., Zhao, Y., Yang, X. 2018. Trilobite zonation and correlation of the Cambrian Stage 4 between Jiangnan Slope and Yangtze Platform in South China. pp. 163-165. In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi’an.
Zapalski, M.K. & Klug, C. 2018. Trilobite sclerites as attachment surface for Emsian tabulate corals of Hamar Laghdad (Anti-Atlas, Morocco). Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 290(1-3):111-115.
Zhao, Y., Peng, S.C., Yuan, J., Esteve, J., Yang, X., Chen, Z., 2018. The revised trilobite biostratigraphy for the Balang and “Tsinghsutung” formations, Cambrian Series 2, Stage 4 in the Balang area, Jianhe, Guizhou, South China. pp. 73-74 In: Zhang Xingliang (organizer) 2018. International Conference on Ediacaran and Cambrian Sciences. 12th-16th August 2018, Xi'an
Zhou, Z.Q. & Zhou, Z.Y. 2018. Ordovician trilobites from the lower part of the Dawan Formation (Floian–Dapingian) at Huanghuachang, Yichang, Hubei, southern China. Palaeoworld, (ahead-of-print publication).