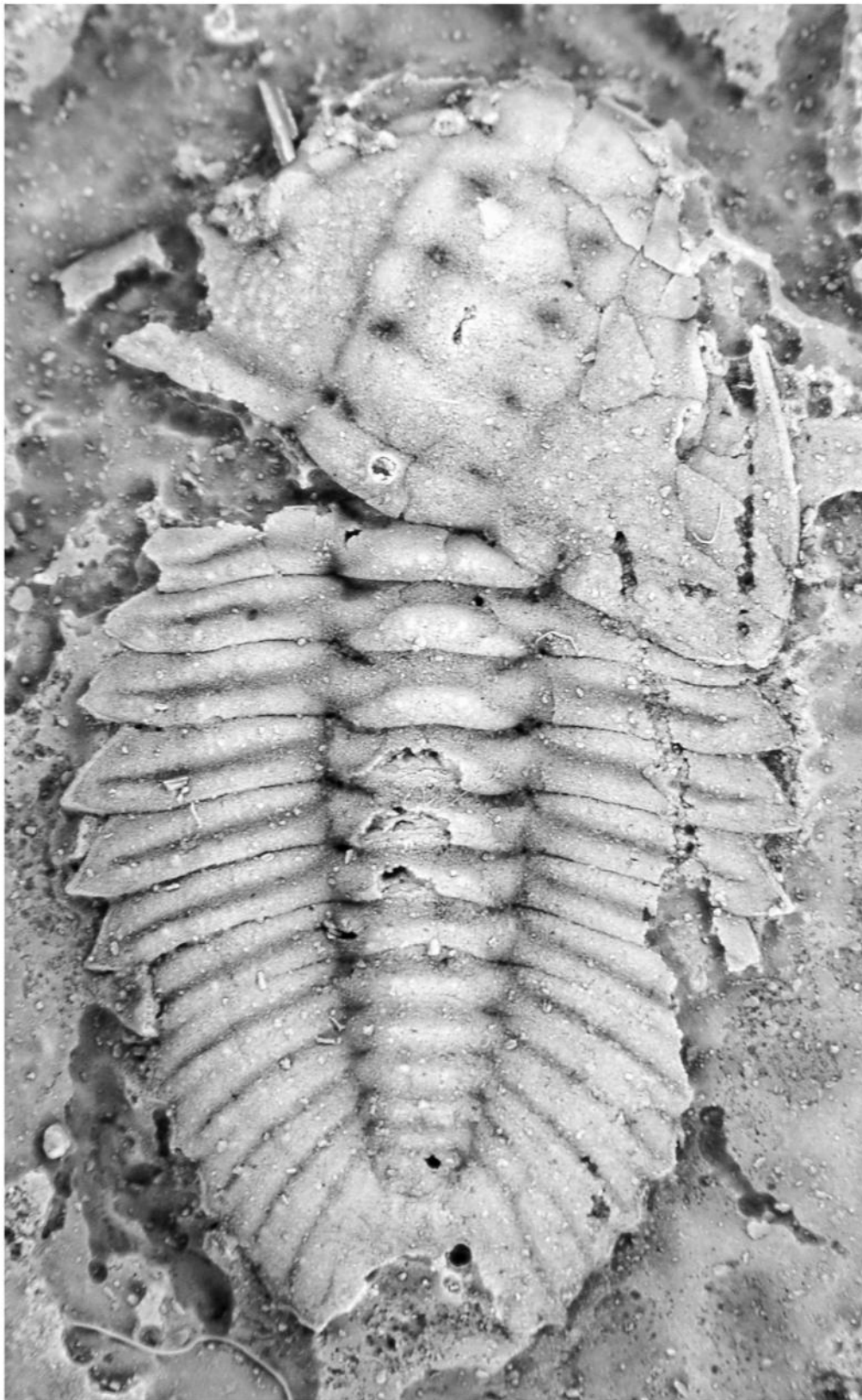


THE TRILOBITE PAPERS 23



An international
newsletter for and by
trilobite paleontologists
February, 2020

Dedicated to Rolf Ludvigsen

The Trilobite Papers Twenty-Three

February 2020

Editorial:

OLD TAXONOMY

One of the ongoing problems with lower and middle Cambrian trilobites (and most likely any aged trilobites) are the type species of genera are poorly known or represented by poorly preserved specimens. I have already pointed out (Sundberg, 2007), the specimen of *Antagmus typicalis* Resser, 1937, which is the type species of *Antagmus*, a commonly reported lower Cambrian genus. The type specimen is a nearly complete, internal mold of a cranidium preserved in a medium grained friable, limonite-cemented specimen. I suggested (Sundberg and McCollum, 2000; Sundberg, 2007) that the genus be considered *nomen dubium*, accepting this causes a chain reaction. *Antagmus* is the genotype of the subfamily Antagminae, which includes *Austinvillia*, *Bicella*, *Crassifimbria*, *Eoptychoparia*, *Luxella*, *Onchocephalus*, *Onchocephalites*, *Periomma*, *Piaziella*, *Poulsenia*, *Proliostracus*, *Sombrerella*, and *Syspacephalus*.

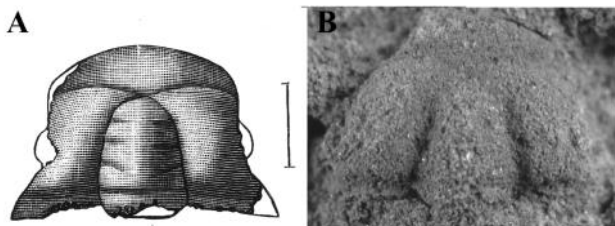


Figure 1. A) Walcott's original figure of *Ptychoparia teucer* (Walcott, 1886, pl. 26, fig. 3) that Resser (1937) used to establish *Antagmus*. B) The type specimen of *Antagmus typicalis* Resser, 1937c, the type species for the genus.

To complicate this even more, Rasetti (1955) tried to make sense of the taxonomy using better preserved specimens from limestone boulders from the Silly Formation. However, almost all of the type species were known from only cranidia (a couple have librigena). Further

more, Rasetti commented that the different forms appear to grade from one to another. Authors have used Rasetti's work to assign there specimens to the genera, but with the gradational nature of the different genera and the lack of other sclerites makes these assignments questionable.

Solutions

- 1) Go out and collect more specimens from the type locality or corresponding horizon. This is what I have done with *Alokistocare subcoronatum* (Sundberg, 1999) to establish the morphological range of the cranidia and to identify the other sclerites of the type species (which is also the genotype for the Family Alokistocaridae).
- 2) Place old genera that are known only from poorly preserved specimens or only from cranidia into *nomen dubium*. This would be followed by naming new genera based on species known from at least cranidia and pygidia, or even better, from entire shields. This is what I have done with *Eokochaspis* in 2000.

Both scientists and avocational collectors could help in the collection of complete specimens of the type species, especially from the type localities.

Fred Sundberg

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Cover photo: The Cambrian trilobite *Ovatoryctocara* cf. *yaxiensis* Yuan et al., 2009 from the *Arcuolenellus arcuatus* Biozone, Harkless Formation, Clayton Ridge, Nevada.

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RESEARCH REPORTS

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My work concentrates on the reconstruction of early and middle Cambrian earth history illustrated by rocks from different regions of this planet, but trilobites play a key role in these research activities. Being in a late, if not latest period of my professional career, I am trying to concentrate on all the left-overs of my own professional travel, but also some problematic trilobite groups and faunas from the Cambrian. This includes studies from the Cambrian as well as some long-term projects from the Frankenwald area (Franconian Forest) in Germany (monographs of the trilobites from the Wildenstein Member of the Tannenknoack Formation and the Triebenreuth Formation); the taxonomy of solenopleurids in general; ptychoparioids from Peary Land, Greenland; and others.

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FRED SUNDBERG, Research Associate, Museum of Northern Arizona, Flagstaff, AZ <freddeb85@cablone.net>

It has been a busy year, again. The morphometric analysis of *Oryctocephalites palmeri* is now published and the papers redefining the Tonto Group of the Grand Canyon and the recognition of overlap between olenellids and paradoxides have been accepted by *Geology* (just looked a galley proofs) and the paper on trilobites from the Lakeview Limestone, Idaho has been submitted (in October). I have been working on the trilobites collected from the Grand Canyon; how much morphological change results in compaction of specimens in shale (morphometric study using landmarks—I could use more specimens of the same taxon

preserved in shale and limestone, if any one has any); *Ovatoryctocara* and fauna from the upper Harkless Formation (with Mark Webster); and a morphometric study of the small eyed ptychopariid trilobites (e.g., *Elrathina*).

- Karlstrom, K.E., Mohr, M.T., Schmitz, M., Sundberg, F.A., Rowland, S., Hagadorn, J., Foster, J.R., Crossey, L.J., Dehler, C., and Blakey, R., 2020, Redefining the Tonto Group of Grand Canyon and recalibrating the Cambrian timescale: *Geology*, v. 48, p. xx-xx.
- Lin, J.P., Sundberg, F.A., Jiang, G., Montañez, I.P., and Wotte, T., 2019, Chemostratigraphic correlations across the first major trilobite extinction and faunal turnovers between Laurentia and South China: *Scientific Reports*, v. 9:17392, 15 p., doi:10.1038/s41598-019-53685-2. [includes trilobite pictures and discussion in supplemental material]
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IMPORTANT REMINDER

Please keep in mind that The Trilobite Papers is not a formal publication and should never be cited. If you wish to use information in this series for a formal publication, please contact the author of the information and then it could be cited only as “personal communication”. This is particularly important for the sections on “Field Notes” and “Taxonomic Notes”.

FIELD NOTES

Trilobites in glacial erratic boulders of northwestern Germany

Adrian Popp & Dieter Luttermann

We both live in northwestern Germany, Emsland county, where the autochthonous trilobite-bearing rocks are either absent or are overlain by younger strata. But here, allochthonous

trilobite-bearing rocks can be found on or close to the surface. Especially, the inland ice glaciations from Baltoscandia (mainly from southern Sweden and Gotland and from the Baltic States, such as Estonia, rarely from Norway) have brought some Paleozoic rocks to our country. In these glacial erratic boulders (= geschiebes) trilobites of Cambrian to Silurian ages occur, often accompanied by a well preserved and diverse invertebrate fauna (brachiopods, ostracods, bryozoans, gastropods etc.). In general, we collect these geschiebes in gravel pits or, when speaking of sand- and siltstones of lower and middle Cambrian ages, can also find them on fields with agricultural processing (mostly stone and gravel heaps). Some sites offer the presence of limestones, which are often weathered to some degree. These are mainly of Ordovician and Silurian ages and come from the Baltic Sea or the surrounding states (e.g. Sweden, Estonia). The trilobites are often preserved with their exoskeleton. It is always interesting and sometimes challenging to determine the rock age by its lithology and fauna. One focuses on every detail of the rock sample in order to get the most information out of it. Many trilobite specimens from the geschiebes were identified as representatives of new species or genera.

In (northern) Germany the “Gesellschaft für Geschiebekunde” is a society specialized in the research on everything related to the glacial erratic boulders, their transport and provenance. Besides that, numerous collectors groups meet up on a regular basis for the research exchange or joint excursions.

Also some sediments of the so-called Baltic River System were deposited in our country. This system is thought to have drained Baltoscandia (and beyond). In gravel pits (Fig. 1), close to the German border with the Netherlands, we can collect Upper Ordovician fluvial erratics, which have not been primarily transported by glaciers as the geschiebes. These are represented by either single specimen of silici-

fied sponges, silicified bioclastic limestones or pure chert (= “hornstein”). The trilobites and the accompanying fauna are mainly preserved as internal or external molds. The rocks are collected in the field and later processed at home, mostly using a magnifying glass or a



Fig. 1: Gravel pit with sorted boulders, here with mixed deposits from the Baltic and the Mid-German river systems. Black 10-liter bucket for scale.

microscope. It is highly interesting to search for trilobite fragments with well-preserved details (Fig. 2) or to prepare extremely well preserved minute specimens.

Numerous collectors, mainly from the Netherlands, have specialized in searching fossils in these fluvial erratics. Once a year, an informal meeting of collectors from the Netherlands and Germany gather in Almelo (The Netherlands) and present the latest finds and works about

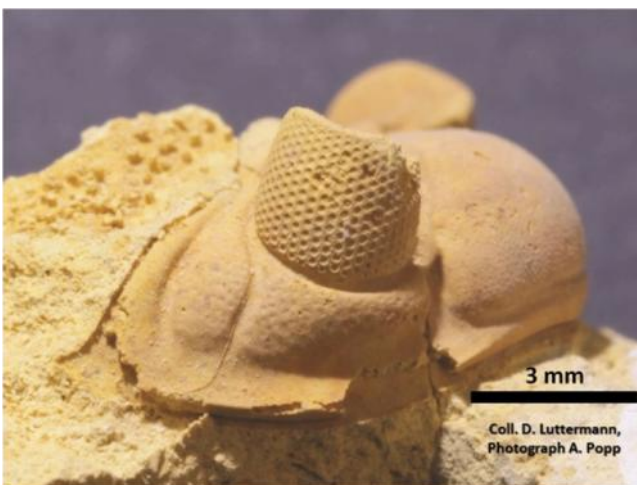


Fig. 2: Exquisitely preserved *Oculichasmops muticus* (Schmidt, 1881) from a silicified bioclastic limestone erratic of Upper Ordovician age (Coll. D. Luttermann). Note the typically short librigenal spine and the inflated frontal lobe.

the fauna of this material.

When collecting trilobites from geschiebes or other (fluvial) erratics, the main trick is to pick up the right rock types. Some trilobite-bearing rocks are more common than others, some are more resistant to weathering, some are easier to spot than others, due to their typical color or way of splitting etc. This can be a long-time learning process, which is shortened when you join experienced collectors during excursions and visit their collections.

We both have currently some other ongoing projects dealing with trilobites from geschiebes and fluvial erratics. But we are planning a joint contribution for the Trilobite Papers.

Who are we:

Adrian Popp, PhD, geologist, started as a passionate trilobite collector and studied Geology (Dipl.) at the University of Hannover, Germany. His PhD topic focuses on “Ordovician Proetid trilobites from Baltoscandia and Germany” and was conducted at the Technical University of Tallinn, Estonia. Adrian’s main focus still lies on the Ordovician Period and on representative geschiebes and erratic boulders, their provenance, trilobite remains and accompanying fauna. He loves travelling to Estonia, Denmark, Sweden and Norway. Adrian Popp, Email: Adrian.Popp@t-online.de

Dieter Luttermann is a technical officer by profession and passionate trilobite collector. His main focus lies on the trilobites of the Ordovician Period and on representative geschiebes and erratic boulders. He also studies the glacial geology and sediments of the central Emsland area. The preparation of trilobites out of the geschiebes and erratics is his passion. Dieter Luttermann, Email: DLuttermann@t-online.de

'Wales' real heritage: an undescribed Lower Cambrian fauna uncovered

by Richard Birch

Wales has '*been done*', I'm told. As the type locality on which the Cambrian system was based (Sedgwick & Murchison, 1836), it has been assiduously explored and collected, and there can be nothing new to discover. But this is obviously not true, as forthcoming works from the likes of Botting, Muir, McCobb and Pates will attest. As our knowledge increases, even well studied rocks are worth a second look.

In August 2019, the Llanberis Slate formed part of the '*Slate Landscape of Northwest Wales*' (<https://www.gwynedd.llyw.cymru/en/Council/Documents---Council/Have-your-say/Slates/Slate-Landscapes-ENG-190809.pdf>) a UNESCO nomination aimed at designating the cultural and industrial landscape of this part of North Wales as a World Heritage Site. It is a comprehensive application, befitting the fact that Welsh Slate 'roofed the nineteenth century world', but it entirely neglects the palaeontology. The Llanberis slates of Penrhyn quarry, Bethesda, North Wales, have yielded a suite of early Cambrian fossils first described by Woodward (1888) and comprehensively by Howell & Stubblefield (1950). More recently a 'Burgess Shale' component has been unearthed. This history is given in greater detail in an account in pp. 27-28 of TTP 21 (February 2019) by Rush-ton & Birch.

The Llanberis slate follows an NE-SW strike along the western edge of Snowdonia, with the fossiliferous 'Green Slate Horizon' at the top of the sequence exposed in the still-active Penrhyn quarry, as described by previous authors. It is not restricted to there, however. Outcrops occur at Marchlyn, Nantlle and Talysarn, progressively further south, with a similar but scant fauna historically noted from Nantlle by Wood (1969). This fauna has never been described in detail, probably on account of the poor preserva-

tion, and it warranted a trip to see if anything new might be found.

Further visits extended the diversity of organisms. By far the most abundant are wormlike trace fossils which often follow cleavage, suggesting that at times they extended downwards into the sediment. At Talysarn, cleavage is perpendicular to sediment, meaning that trilobites are rarely found articulated (as in Fig. 1a). Usually just the pleurae appear as 'M'-shaped profiles on the split rock – like slicing through a loaf of bread – but cranidia are fairly frequent (Fig. 1g). However, the substrate does not appear to have been bioturbated to any great degree, and as a result there are indications of weakly-sclerotised and soft-body preservation (Fig. 1c-f). This has been observed elsewhere in the Llanberis slate (Birch, 2020), although distortion of the rock during the mountain-building event that affected all of Snowdonia at the end of the Ordovician has affected quality and uniformity. At Talysarn, the slate is inadequate as a roofing material and entirely lacks the hydrophobic quality for which Llanberis slate is famed. Where it is still commercially quarried there, it is used as ballast or decorative fill. The fossiliferous zone retains more of the characteristics of a mudstone or shale than a slate, and fossils have a 3-dimensional quality which is not present elsewhere in the green slate horizon.

The collection from Nantlle and Talysarn now exceeds 150 individual specimens, mostly extracted from spoil. So far, the eponymous trilobite *Pseudatops viola*, for which the green slate is renowned, has not been definitively identified, but *Serrodiscus* cf. '*bellimarginatus*' has been confirmed from multiple specimens (Fig. 1i), and characters that conform to *Strenuella* cf. *strenua* are also observed in many cranidia. This is sufficient to assign Nantlle and Penrhyn to Stage 3 (Series 2) of the international Cambrian stratigraphy, and provides direct correlation with sites in England, and further afield in Spain (Collantes & Gozalo 2018) and Eastern Canada

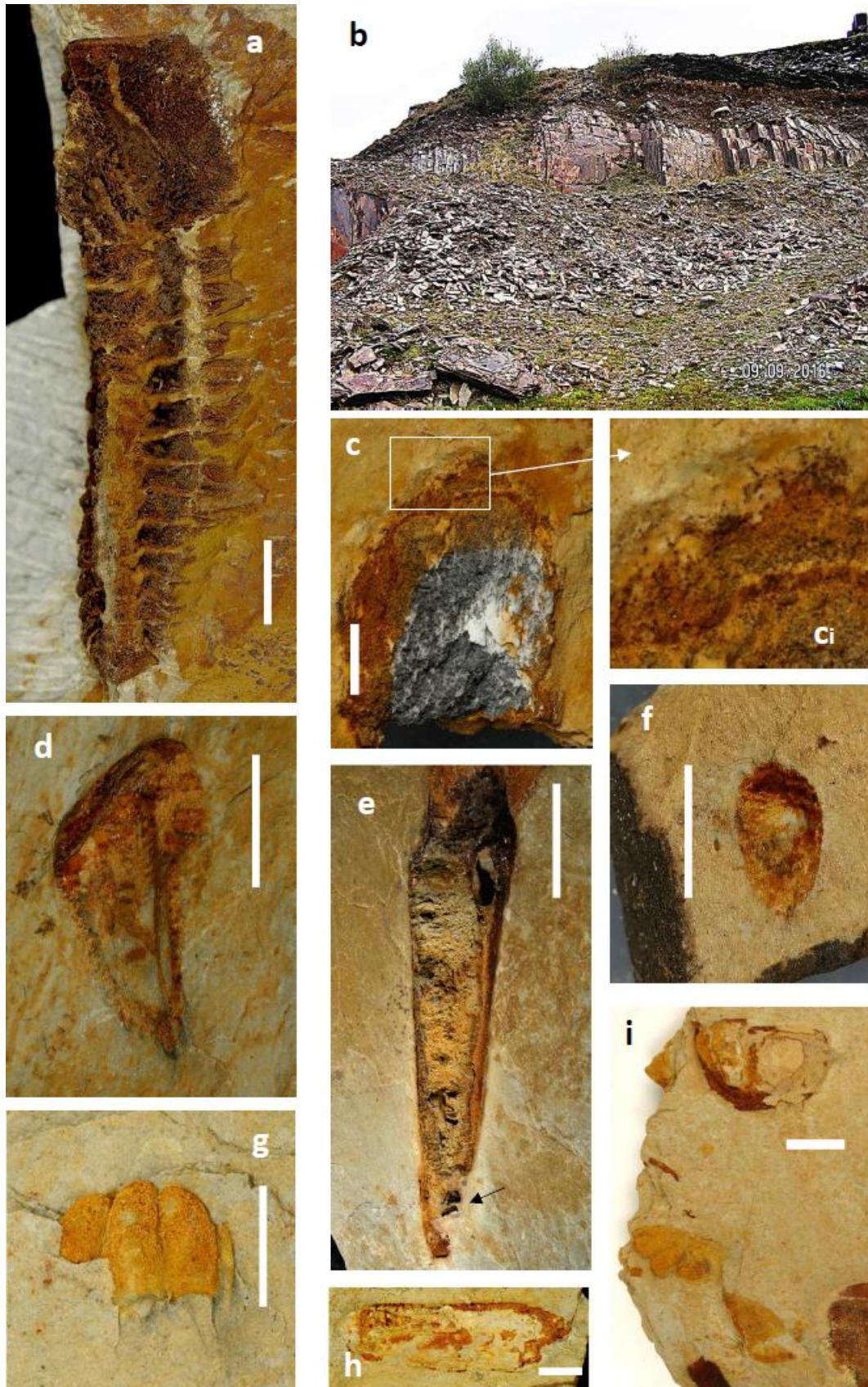


Figure 1. a) Articulated trilobite (*Strenuella* sp.) from the Geological Survey collection. b) Fossiliferous green slate horizon at Talysarn (53.07, -4.22). c) Pyritised sponge with monaxons visible around margin (ci). d) Unidentified non-trilobite arthropod. e) Un-named hyolithid with spiral gut preserved as void in infill (arrowed). f) Unidentified ovate organism (possible bradoriid). g) Unidentified trilobite cranidium (?*Protolenus* sp.). h) Large phyllocarid-like integument. i) Death assemblage of *Serrodiscus* cf. '*bellimarginatus*'. Scale bar = 5mm

(Westrop & Landing 2000).

There are many reasons why this site is significant, for example:

- The green slate horizon yields the only diverse and comprehensive early Cambrian fauna from Wales, complementing the Middle and Upper Cambrian faunas which are well characterised from locations in North & South Wales;
- The presence of weakly-sclerotised organisms, specifically including sponges and non-trilobite arthropods from Talysarn, qualifies it as a lagerstätte alongside the internationally-important Cambrian lagerstätten elsewhere (although it is not disputed that preservation is inferior).

And yet... and yet.

When the entire collection of all 150+ Talysarn and 400+ Penrhyn fossils (currently included in the National Museum of Wales collection ref. **NMW:2014:29G**), are spread out over a desk it has so far failed to convince anyone that it is important enough to:

1. Fund research into;
2. Designate as a nationally-important palaeontological horizon;
3. Include in the UNESCO World Heritage package.

That applies even here in Wales – the country called *Cambria* by the Romans, and which gives its very name to the first geological epoch (and also, indirectly, to the succeeding two). Of course, this may change if the enthusiastic but independent and amateur research group working on this are published in the peer-reviewed journals, but there is always a serendipitous element at play in these situations. UK politics has created an insular feel to palaeontological research: it feels as if we are now on the periphery. And let's face it; trilobites lack the sex-appeal of dinosaurs! Although the green slate

has yielded specimens of *Isoxys* and a decent vetulicolian (Birch, 2020), it hasn't yet provided a gob-smacking anomalocariid. The sooner it does so, the better, as there are planning applications for a funicular railway and visitor facilities that look set to close access to the best sites. There's never a Champion when you need one.

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IT'S ALL ABOUT TIMING

Fred Sundberg

The traditional lower-middle Cambrian boundary has been long known to be a problem. This boundary was originally defined on the first appearance datum (FAD) of *Paradoxides* (*s.l.*) in Europe, Morocco, Siberia, and Avalonia. In Laurentia, the boundary was defined on the last appearance (LAD) of *Olenellus* (*s.l.*) and in China and Australia the LAD of *Redlichia* (*s.l.*)

(see Lin et al., 2019 for review). We have known for some time that these events are not necessary synchronous (see Sundberg et al., 2016 for review). This is one reason that the Miaolingian Series, Wuliuan Stage was defined in South China at the FAD of *Oryctocephalus indicus* (Reed, 1910), just above the extinction of redlichiids (Zhao et al., 2019).

Recent research indicates just how much these events differ in timing. Based on dating of zircons from both tuffs and clastic rocks (detrital zircons, which provide a maximum depositional age), we are beginning to understand:

- 1) Paradoxidids appeared around 509 Ma; olenellids disappeared around 506.5 Ma; and redlichiids disappeared around 506 Ma (Sundberg et al., 2020)
- 2) Olenellids and redlichiids extinctions were not synchronous, but lagged about 0.5 m.y., but these extinctions were probably tied to a major negative carbon isotope shift (Redlichiid Olenellid Extinction Carbon Excursion, or ROECE) (Lin et al., 2019).
- 3) Olenellids and redlichiids went extinct at least 3 m.y. after the appearance of paradoxidids.
- 4) The base of the Miaolingian Series is not 509 Ma as previously reported (Zhao et al., 2019), but rather 506 Ma.

These results are further supported by the occurrence of *Ovatoryctocara* cf. *O. yaxiensis* Yuan et al., 2009 (see cover photo), *Oryctocephalus frischenfeldi* Lermontova, 1940 and ?*Protoryctocephalus arcticus* Geyer and Peel, 2011, occurring the *Arcuolenellus arcuatus* Biozone of Webster (2011a, b) from the Harkless Formation, Clayton Ridge, Nevada (work in progress). This genera or species occur in the *Ovatoryctocara* Biozone Siberia, which also contains the occurrence of *Paradoxides* (s.l.) (Korvnikov and Shabanov, 2008; Shabanov et al. 2008). This again illustrate a considerable overlap in the occurrences of olenellids and paradoxidids.

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TAXONOMIC NOTES

Reflections on *Dohmiella* (Trilobita, Proetida; early Middle Devonian)

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Dohmiella was erected by Lütke (1990) as a member of Proetinae, with *Proetus* (*Euproetus*) *dohmi* Richter & Richter, 1918 from the middle Eifelian of the Eifel as the type species. The majority of *Dohmiella* species were described in the Ardenno-Rhenish Mountains. Other confirmed records come from the Holy Cross Mountains (Kielan, 1954) and Moravia (Smyčka, 1895). As such its palaeogeographical distribution is the northern part of the Rheic Ocean, South of the Old Red Sandstone Continent. Potential other species have been identified in southern Uzbekistan, Siberia and Inner Mongolia (Owens et al., 2010), i.e., outside of the Rheic Ocean. All of these are of early Middle Devonian age, the stratigraphically highest

records coming from Eifelian/Givetian transitional beds in the Eifel (Basse, 2002). Regrettably, *Dohmiella dohmi* being the type species of the genus, is a stratigraphically comparatively young member displaying convergences on other proetine genera. This species had previously been considered by Owens (1973) to be intermediate between *Proetus cuvieri* (the type species of *Gerastos*) and *Proetus tenuimargo* (the type species of *Longiproetus*), both from the middle Eifelian in the Eifel. *Dohmiella* was regarded by Adrain (1997) as “exceedingly similar to *Gerastos*” and subsequently listed as a junior subjective synonym by Jell & Adrain (2003). New *Dohmiella* species (Fig. 1) have since been described which contributed significantly to our knowledge of this genus.

The specimens that are refigured here come from the Ardenno-Rhenish Mountains and help to illustrate hypothesised general morphological trends of regionally occurring species (this compilation is by no means intended as an evolutionary lineage). All of these have cephalic sculpture concentrated on the posterior parts of the glabella and librigenal fields, lateral occipital lobes isolated by firmly incised furrows, genal angles with spines (except for the stratigraphically youngest known member, *D. cf. bacchus* of Basse, 2002), median tubercles on the anterior two to five (of seven plus one) posteriorly flexed (sag.) pygidial axial rings, abaxially well-demarcated pygidial pleural fields, and densely spaced granules on the dorsoventrally high pygidial border. The oldest known members come from the lower Eifelian; these are characterised by distinct median nodes on the occipital, pygidial and thoracic axial rings, narrow pygidial pleural fields bearing granules halfway (tr.) along the pleural ribs, and moderately long (sag., exsag.) cephalic and pygidial borders (*D. prescheri*, *D. dewildei*). The early middle Eifelian *D. stumpporum* has a morphology intermediate between stratigraphically older species and the slightly younger *D. acanthonota*. The latter has short, posteriorly directed median spines on the thoracic and pygidial axial rings.

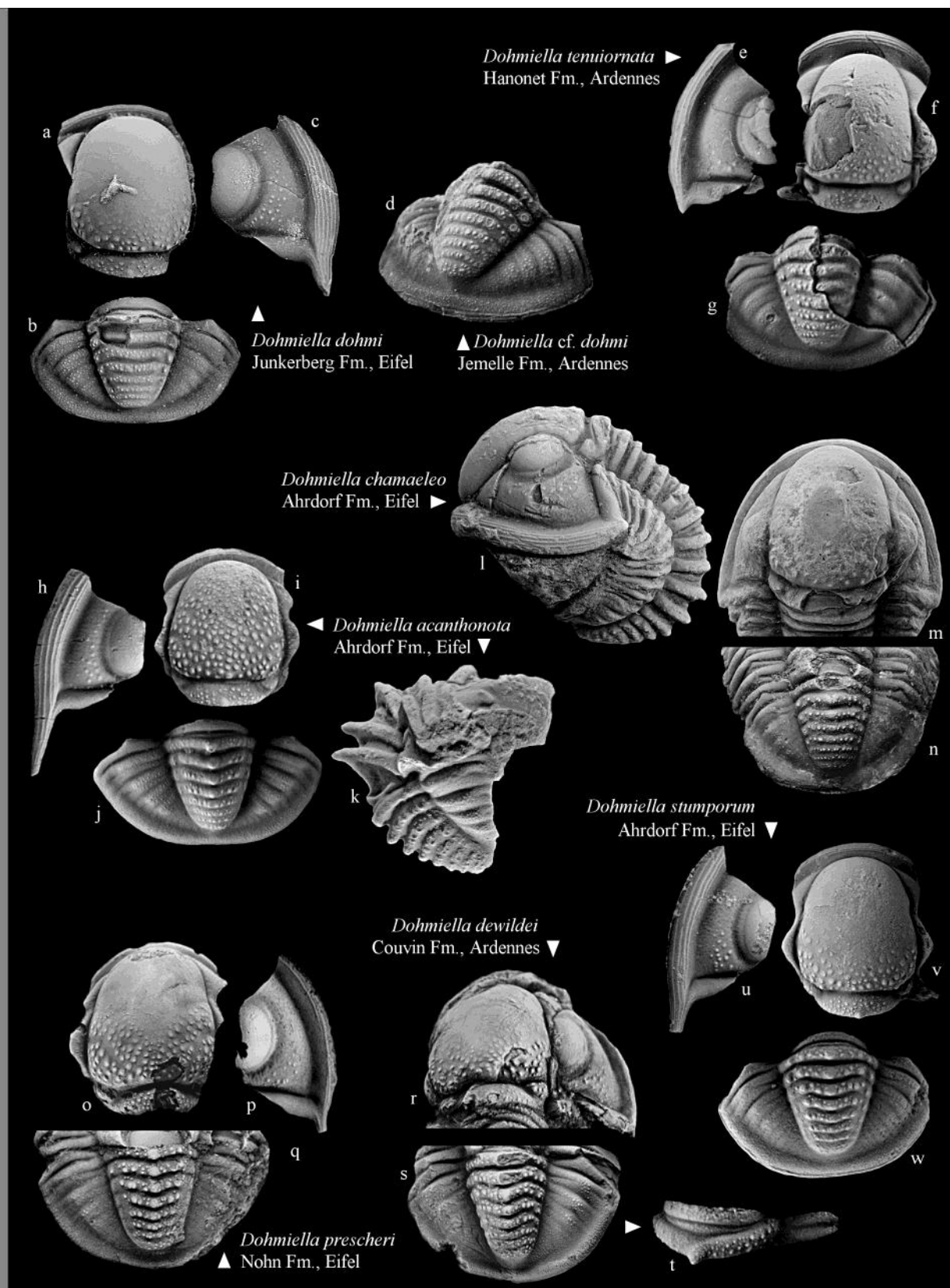


Figure 1, Caption next page.

Dohmiella chamaeleo occurs in the classic “Trilobitenfelder” locality near Gees (Eifel); it has a parabolic cephalic outline, short genal spines, and generally reduced sculpture although exceptionally well-preserved specimens may

show spines on the posterior thoracic axial rings. The late middle Eifelian *D. dohmi* has further reduced sculpture with barely recognisable median tubercles on the pygidial axial rings. A possibly conspecific pygidium (Fig. 1d) recorded



Fig. 1. Selected *Dohmiella* species from the Ardenno-Rhenish Mountains. Positions of species names along the vertical axis (lower to upper Eifelian in the left column) indicate their relative ages. **a–c**, *D. dohmi* (Richter & Richter, 1918), Junkerberg Formation, Eifel, a) SMF 27137, cranidium, b) SMF 27135, pygidium, c) SMF 27139 librigena. **d**, *D. cf. dohmi*, Jemelle Formation, Ardennes, NHMM 2011099, pygidium. **e–g**, *D. tenuiornata* van Viersen & Prescher, 2008, Hanonet Formation, Ardennes, e) SMF 58587, paratype librigena, f) IRSNB a12586, paratype cranidium; g) IRSNB a12591, paratype pygidium. **h–k**, *D. acanthonota* van Viersen & Prescher, 2010, Ahrdorf Formation, Eifel, h) IRSNB a12771, paratype librigena, i) IRSNB a12764, paratype cranidium, j) IRSNB a12766, holotype pygidium, k) IRSNB a12770, paratype incomplete specimen. **l–n**, *D. chamaeleo* (Richter & Richter, 1918), Ahrdorf Formation, Eifel, l) SMF X260F3, complete specimen, m–n) SMF X260F2, complete specimen. **o–q**, *D. prescheri* van Viersen, 2006, Nohn Formation, Eifel, o) SMF 58600, paratype cranidium, p) SMF 58596, paratype librigena, q) SMF 58594, holotype thoracopygidium. **r–t**, *D. dewildei* van Viersen, 2006, Couvin Formation, Ardennes, r–s) SMF 58564, holotype complete specimen, t) SMF 58579, paratype thorax segment. **u–w**, *D. stumporum* van Viersen & Prescher, 2008, Ahrdorf Formation, Eifel, u) IRSNB a12597, paratype librigena, v) IRSNB a12594, paratype cranidium, w) IRSNB a12602, paratype pygidium. Institutional abbreviations: SMF = Forschungsinstitut und Naturmuseum Senckenberg; NHMM = Natuurhistorisch Museum Maastricht; IRSNB = Institut royal des Sciences naturelles de Belgique.

by van Viersen et al. (2012) from coeval strata in the Ardennes shows rudimentary median tubercles on the anterior two pygidial axial rings. The latest Eifelian *D. tenuiornata* has a long (sag., exsag.) anterior border (a feature commonly seen in juvenile *Dohmiella* specimens) whereas the median tubercles on the pygidial axial rings are much better developed than in *D. dohmi*.

Based on these features species of *Dohmiella* are easily discriminated from allied proetines such as co-occurring *Gerastos*, *Longiproetus* and *Rhenocynproetus*. However, the classifications and contents of those genera remain a topic of debate (van Viersen et al., 2012; Basse & Müller, 2016). The unique sandglass-shaped rostral plate of *Dohmiella* was regarded by Lütke (1990) as diagnostic of the genus but its phylogenetic implications have yet to be explored. The presence of median tubercles on the pygidial and thoracic axial rings was regarded by van Viersen (2006) as a potential apomorphy of *Dohmiella* that needs to be tested in a phylogenetic analysis. This feature was not mentioned in the original description published by Lütke (1990), perhaps because it is not well-discernible in *D. dohmi*. The trend of reduced median axial tubercles during the middle Eifelian might be taken as evidence to suggest that their absence in the type species is due to secondary loss and that it does not pertain to the significance of this feature. Additional *Dohmiella* specimens from Middle Devonian strata

in the Ardenno-Rhenish Mountains that include new species have become available for study. These will be described in future publications.

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A new look at *Longianda termieri* (Neltner & Poctey, 1950) (Trilobita: Saukiandidae) and its consequences for the saukiandid trilobites of Morocco

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Abstract. Based on new material, this study summarizes the morphology of *Longianda termieri* from the lower Cambrian of the Anti-Atlas, Morocco, particularly in respect to its thoracic and pygidial characters. It also discusses the morphology of the genera *Saukianda* and *Pseudosaukianda* and the differences between these genera and *Longianda*. It also summarizes the biostratigraphic significance. In addition, substantial malformations in a specimen of *Longianda termieri* are described and discussed.

1. Introduction

Pierre Hupé (1907–2003) had started his career as a trilobite paleontologist not long ago when he boosted himself among the most productive authors on trilobites by his publications between

1953 and 1955, unfortunately then fading more or less away. His monograph on the Moroccan lower Cambrian trilobites (Hupé, 1953a) may rank among the most important publications on Cambrian trilobites, but suffers from the small size of the figures, insufficient photographic documentation, some inconsistencies related to a rapid production process, and generally too few specimens of the presented species. As a consequence, a number of the newly introduced species and genera were insufficiently portrayed and are not known in enough morphological details to date to contribute to a characterization of generic and suprageneric taxa with appropriate precision.

Collection of trilobites in Morocco for economic purposes started with Ordovician and Devonian specimens, but since almost 30 years includes numerous Cambrian species as well. Although the fossil market offers mainly trilobite specimens from the *Paradoxides*-bearing (thus traditional “Middle Cambrian”) strata of the Jbel Ougnat region in the eastern Anti-Atlas, lower Cambrian trilobites are quarried as well near, mostly at Tazemmourt and in the Issafen Syncline in the western Anti-Atlas. Thereby the Issafen Syncline is the only region in which Cambrian Stage 4 trilobites are commercially collected so that nearly all specimens of the spectacular “large redlichioids” *Gigantopygus*, *Longianda*, *Saukianda* and *Pseudosaukianda* come from this region.

Gigantopygus, *Longianda* and *Pseudosaukianda* are genera that were introduced in Hupé (1953a), whereas *Saukianda* was first described by Richter & Richter (1940) from the Sierra Morena range in southern Spain. The first three genera were identified by Hupé (1953a) from the Issafen Syncline, but *Saukianda* was subsequently found in the same stratal succession. Hupé (1953a) distributed the four genera among the then newly established three families Neoredlichiidae Hupé, 1953 (*Gigantopygus*), Latiredlichiidae Hupé, 1953a (*Pseudosaukianda*), and Saukiandidae Hupé, 1953 (*Saukianda* and

Longianda). A modern systematic approach (Chang et al., 1997) distributes the four genera among the families Gigantopygidae Harrington, 1959 (*Gigantopygus*) and Saukiandidae [*Saukianda* with its two subgenera *S. (Saukianda)* and *S. (Pseudosaukianda)*, and *Longianda*].

Unfortunately, fairly well-preserved pygidia were only known from *Gigantopygus* when Hupé (1953a) described the species so that the generic characters (and thus the distribution to the different families) was based exclusively on characters of the cephalon. The generic diagnoses furthermore emphasize character differentiations within the respective family so that the three closely related genera (or subgenera) *Longianda*, *Saukianda* and *Pseudosaukianda* were insufficiently compared in Hupé (1953a) and subsequent publications by Hupé. The original reconstructions of the cranidia in Hupé (1953a, fig. 36,11, 36, 19 and 36,20) are very much influenced by the sparse material so that lateral compressions or deformation is not entirely eliminated and contributes to the differences.

Consequently, uncertainty exists in the precise morphology of the three genera *Saukianda*, *Pseudosaukianda* and *Longianda*, but particularly on *Pseudosaukianda* and *Longianda*. A number of requests on determinations of collected material arrives me every year. Newly discovered specimens of *Longianda termieri* that was brought to my knowledge now offers the opportunity to portray the characters of this species and also show a specimen with remarkable malformations.

2. Material and localities

Plenty of specimens were offered on the commercial fossil market since ca. 2005, and the number of specimens appears to slightly grow every year. I have examined ca. 30 complete and quite nicely preserved dorsal exoskeletons over the last decade, mostly in private collections. Most of the fine specimens were obviously col-

lected from a section to the east of the village of Timghit near the center of the Issafen Syncline.

The two excellent specimens (PAIS 8446 and PAIS 8447) presented herein are property of M. Païs (mediterranic.com) and will be offered for sale in due course. It can only be hoped that the specimen will end in a museum collection because of their scientific value.

Other material figured in this discussion includes type specimens of Neltner & Poctey (1950) and Hupé (1953a), which are housed in the Museum Nationale d'Histoire Naturelle in Paris (acronym MNHN), in the collections of the Ministère de l'Énergie, des Mines et de l'Environnement, Rabat (MEM) and in the Geological Museum of the University of Rennes (SGM), as well as specimens in private collections of Gérard Barbe (Champillon, France; CGB), Georges and Joëlle Devoille (Pierrefeu-du-Var, France, DEV), the late Patrick Bommel (Bize-Minervois, France, BOM), and Russell Jacobson (Urbana, IL, USA, RJC).

3. Newly discovered specimens of *Longianda termieri*

3.1. Specimen PAIS 8446

Description. Cranidium subredlichoid in outline, with conspicuously laterally extended posterior branches of the facial suture and moderately extending anterior branches, moderately curved anterior margin. Glabella moderately convex in transverse profile, of ca. 83% cephalic length (including occipital ring), faintly tapering forward, with faintly curved lateral margins indicating a slight constriction across the level of S1. Three pairs of subevenly spaced lateral glabellar furrows. S1 well impressed near axial furrows, distinctly backward directed from near lateral margin of glabella and faintly curved, fades rapidly when approaching central portion of the glabella and connected only by a shallow transverse furrow, which is marked also by the less well developed prosopon. S2 slightly rearwardly directed from lateral margin of glabella,



Fig. 1. *Longianda termieri* (Neltner & Poctey, 1950), specimen PAIS 8446, dorsal exoskeleton, Issafen Syncline, probably from Timghit section, Issafen Formation, *Sectigena* Zone, *Gigantopygus-Longianda* Subzone. A, dorsal view of entire specimen. B, slightly oblique dorsal view on the posterior part of the thorax and the pygidium. C, oblique lateral view on the posterior half of the thorax and the pygidium. D, oblique lateral view on the thorax illustrating the changes in the morphology of the axial rings and the pleural spines. Scale bars 10 mm in A, 5 mm in B–D.

shallow, connected across the center of the glabella by an obsolescent furrow; S3 faint, only developed as a pair of slightly obliquely arranged lunate impressions (convex curvature towards the anterior). Frontal lobe with anterior margin with low curved evenly in dorsal view; transverse width of frontal lobe ca. 80% max. width of occipital ring. Occipital ring with gently curved posterior margin, but with reduced curvature in a section across sagittal line; maximum sag. length ca. 16% cephalic length, width ca. 60% cranial width across center of palpebral lobes; with low sagittal convexity; with moderately large, slightly longitudinally extended node in a subterminal position. Occipital furrow composed of shallow median section and slightly deeper and slightly oblique lateral sections.

Palpebral lobe moderately well elevated, relatively slender (tr.), (sub)evenly convex in transverse section, exsag. of ca. 33% max. cephalic length, centre opposite origin of S1, anterior end of ocular suture opposite posterior part of L3, posterior end opposite origin of occipital furrow or slightly anterior to it; shape crescentic with moderately curved margin along ocular suture, with subeven width throughout. Palpebral lobe confluent with eye ridge without a distinct angulation to it. Eye ridge with slight curvature, directed obliquely anteriorly from its connection with palpebral lobe, tapering and less convex in its anterior half, fading adjacent to lateral margin of frontal lobe.

Intraocular genae comparatively narrow, of ca. 20% max. cranial width across center of palpebral lobes and ca. 42% max. cephalic length adjacent to axial furrow; slightly convex, but with shallow oblique depression, extended into slightly elevated ridge between posterior ends of palpebral lobes and occipital ring, which itself extends into a very narrow, transversely directed postocular wing of fixigena.

Preglabellar field very narrow, confluent with anterior border furrow. Preocular areas irregu-

larly subtriangular, slightly convex.

Anterior branches of facial suture directed obliquely anterolaterally from its origin at anterior ends of ocular suture, straight for the adaxial half, curving slightly anteriorly in the abaxial half of its course. Posterior branches fairly long, directed nearly perpendicularly to the length axis from posterior to palpebral lobes, abaxial section with distinct, narrow rearwardly directed curvature.

Anterior border exfoliated for nearly entire course in the present specimen, slightly elevated in the original condition and then surface with low convexity (sag., exsag.); of ca. 15% cephalic length on sagittal line, subequal in width throughout.

Posterior border relatively thin, slightly growing in width towards facial suture, moderately elevated, with slight sigmoidal curvature in dorsal view. Posterior border furrow a moderately well developed, moderately broad groove throughout its course on the cranidium.

Librigena with wide ocular platform. Lateral border moderately broad (tr.), subequal in width throughout, bar-like elevated, but with low convexity in tr. profile, grades into a short to moderately long, stout, continuously tapering genal spine of low to gentle curvature, its base moderately wide, without a change in curvature of the lateral margin; posterior tips of genal spines are located opposite thoracic segment 2. Posterior border moderately wide (exsag.), posterior margin directed nearly perpendicular to sagittal axis from facial suture so that the relatively narrow genal corner lies opposite the occipital ring. Ventral doublure of lateral genal border and genal spine exposed on right side, covered with coarse, roughly subparallel terrace ridges.

Thorax known consists of 15 segments, roughly of subequal morphology, but with some differentiation of pleural spines and axial nodes/spines. Thorax widest (tr.) at segment 2 or 3, consecu-

tively narrowing rearward. Axial ring widest (tr.) at segment 1, where it is even slightly wider than the occipital ring and of 31% width of entire segment, successively narrowing to segment 15, where it has half width of axial ring at segment 1, but 34% width of entire segment 14.

Axial rings with nearly straight anterior and posterior margins for most of its extension, but lateral portions near axial furrows faintly swollen and anterolaterally extended, indicating the attachment sites of ventrally located muscles. Articulating half-ring moderately wide (sag., exsag.) (see segments 4–6 in Fig. 1A), apparently successively narrower towards the posterior.

Axial rings with low, longitudinally extended and thus crest-like node in a median to subterminal position developed on segments 1 through 11. Axial rings of segments 12–15 extended into spectacular, broadly blade-like spines of moderate length, directed steeply dorsally and then curving rearward (Fig. 1C).

Thoracic pleurae divided by a moderately deep but well developed and broad pleural furrow which starts adaxially near the anterolateral corners of the axial ring and runs slightly oblique to the axis to terminate at approximately two-thirds the exsag. width at the base of the pleural spines. Pleural furrows subequal in exsag. width on their course in the anterior segments, with a tendency to a wider adaxial and a narrower abaxial part in the posterior segments. The anterior margin of the pleural furrow is slightly steeper and better marked by comparison to the less well defined posterior margin formed by a sloping area. Boundary between pleural spine and adaxial part of pleura clearly marked by a minute triangular fulcral process at the anterior margin, which is unfortunately difficult to recognize in the specimen, without a correspondent notch-like indentation at the posterior margin. Pleural spines generally falcate, moderately rearward curving in the anterior segments, but with its tips steeply backward directed from segments 3 to 15.

Segment 1 with a slightly anomalous specific

morphology: Axial ring with a slight rearward swing of the anterior margin. Pleura with a nearly straight anterior margin in the adaxial third, abaxially proceeded by sigmoidal curvature which creates a constriction of the distal part of the pleural furrow and a narrower (exsag.) base of the pleural spine. Consequently the fulcral process at the anterior margin of segment 1 sits in a distinctly proximal position (Fig. 1A, arrow). This rearward direction of the border enables a flexure of the distal portions of the cranial posterior border against the anterior end of the thorax.

Ventral doublure of pleural spines large, reaches adaxially to the location of the connective device between adjacent segments; covered by relatively coarse terrace ridges.

Pygidium subtrapezoidal to roughly subhexagonal in outline, posterior margin subdivided by distinct spines, nearly straight in its central portion; ratio maximum width to length ca. 1.40, greatest tr. width at about two-thirds length from the anterior end. Axis well elevated, consists of four rings plus a very short terminal axial piece and a moderately broad (sag.) articulating half-ring. Axial rings progressively taper backward, lateral margins of axis slightly curved; axial rings 1 and 2 well defined by a transverse and fairly well developed transverse furrow, axial ring 3 less so, axial ring 4 nearly fused with terminal axial piece and only marked by a shallow median depression. Posterior end of axis distant from posterior margin of pygidium, extends into a short, weakly demarcated sagittal swelling.

Pleural fields have at least five ribs (corresponding to three segments), which are fairly distinct in the anterior part, but less so in the posterior half; ribs almost straight for most of its course, obliquely rearwardly directed, commencing from very close to the axis and with a slight curvature at its adaxial origin, slightly fading rearward, but extending to the or almost to the lateral margin of the pygidium, its processes forming three pairs of marginal spines

(Fig. 1B). No pygidial border and border furrow developed.

Exterior of cuticle either covered with relatively coarse, occasionally medium-sized granules on the elevated parts of the cephalic, thoracic and pygidial axis, on the cephalic borders, the fixigenae, palpebral lobes, ocular platform, and pleurae. All furrows smooth, as well as pleural spines, pleural fields on the pygidium and probably also the axial spines. Doublures of borders and pleural spine with terrace ridges.

3.2. Specimen Pais 8447

This specimen (Figs. 2, 3) is a nicely preserved dorsal exoskeleton of *Longianda termieri* with a typical glabella as described above for PAIS 8446. Its thorax consists of 15 segments as in PAIS 8446, and the axial rings also carry a longitudinally extended node on the segments 1 through 11 and large, blade-like spines on segments 12 through 15. The pygidium is fairly well preserved and has the characters as in PAIS 8446.

What makes this specimen unique are malformations on some of the thoracic pleurae. The majority of these deformations are located on the left side (Fig. 2B), but at least two pleurae are affected on the right side as well (Fig. 3A, B). Only the most spectacular of these features are described in the following paragraphs.

A particularly spectacular malformation in the form of a gross distortion can be seen in the segments 1–4 on the left side (Fig. 2B): The pleurae of segment 1 shows two pleural spines of different lengths, with the pleural furrow bifurcating at approximately midlength. As a consequence, the space for the pleural spine in the adjacent segment 2 was insufficient to allow normal growth so that the pleural tip of segment 2 is short and terminates more adaxially than the pleural furrows of the adjacent segments. To fill the emerging gap, the pleura of segment 3 is bent forward in its abaxial part, with the small fulcral process located close to the pleural tip of

segment 2. The same forward curvature of the distal pleural portion can be seen in segment 4.

The left pleural tips of segments 5 and 6 are fused and combined to form only one, apparently normal-shaped pleural spine. However, these pleurae show a normal contact and separation over the proximal ca. two-thirds of their transverse stretch, but then form a bulbous structure made up by the posterior part of segment's 5 pleura and the anterior part of segment's 6 pleura. This callus-type thickening can be taken as a strong indication for a healed injury.

Remarkably, the resultant forward curvature of segment's 6 posterior margin exposes nicely a relatively distinct flange that illustrates the nature of the species' articulation. A similarly clear flange is also visible at the anterior margin of segment 8.

Also fused are the pleurae on the left sides of segments 11 and 12, but the pleurae closely retain their original morphology.

Comparison of the pleural spines' and pleural furrows' morphology indicates that injuries obviously served for some minor alterations of the original morphology on the right side of the thorax, such are less curved and short spines as well as slightly shorter pleural furrows. Noteworthy is an oblique furrow near the base of the right pleural spine of segment 9.

More conspicuous, however, is the slightly shorter and smaller spine in segment 12 and the lack of a pleural spine in segment 13 with the pleural tip directed slightly anteriorly (Fig. 3A, B). Small distortions also exist on the pleurae of segments 14 and 15, with the pleural furrow of all these segments (12–15) shorter than normal.

It is obvious that the described deformation testifies injuries at at least four different sites of the thorax: (1) one centered at the left side of segment 2; (2) one on the left side of segments 5 and 6; (3) one on the left side of segments 11

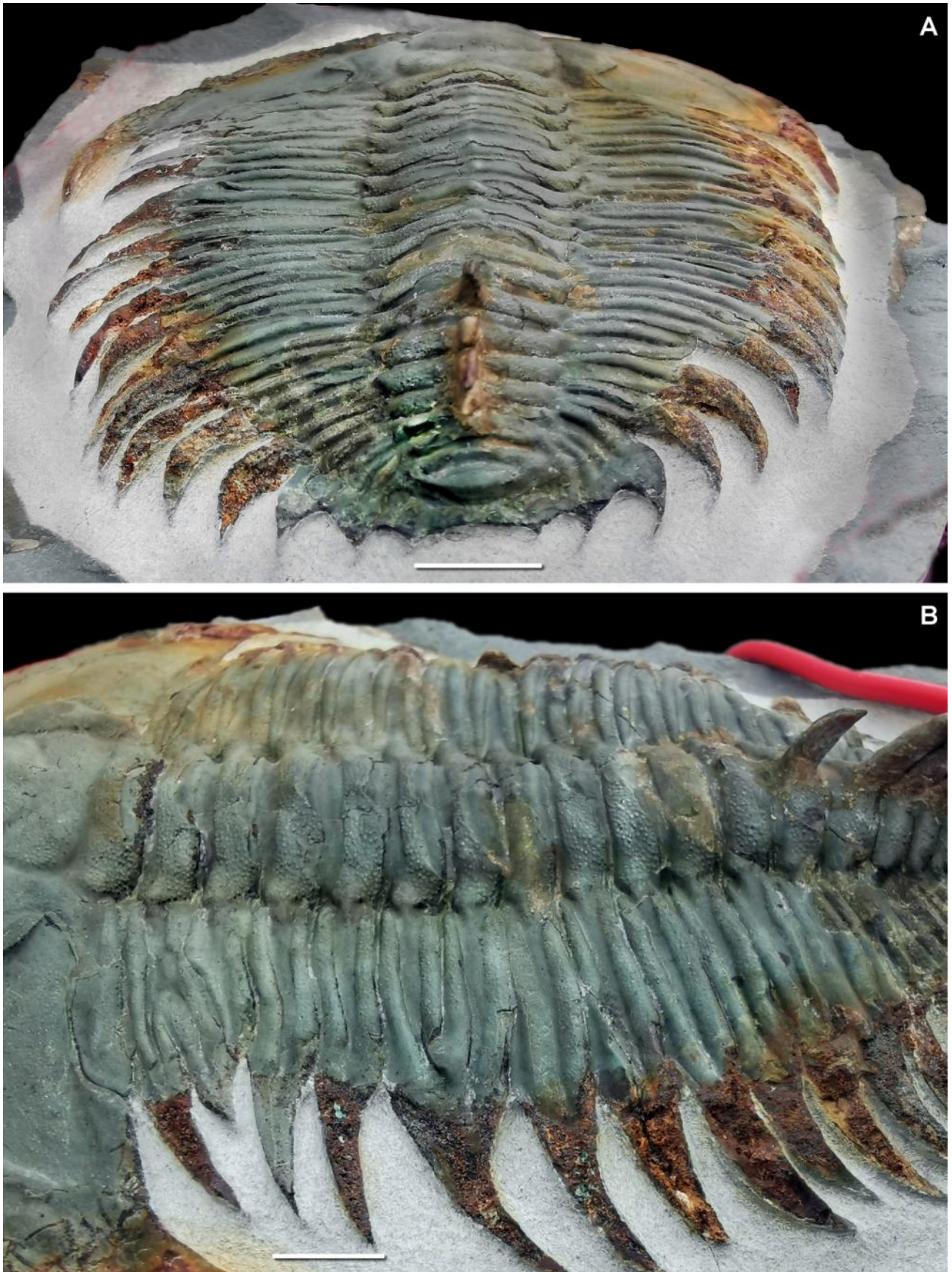


Fig. 2. *Longianda termieri* (Neltner & Poctey, 1950), specimen PAIS 8447, dorsal exoskeleton, Issafen Syncline, probably from Timghit section, Issafen Formation, *Sectigena* Zone, *Gigantopygus*-*Longianda* Subzone. A, oblique posterior view showing overall convexity and morphology of the pygidium. B, oblique lateral view showing malformations on the left flank of the thorax. Scale bars 10 mm.

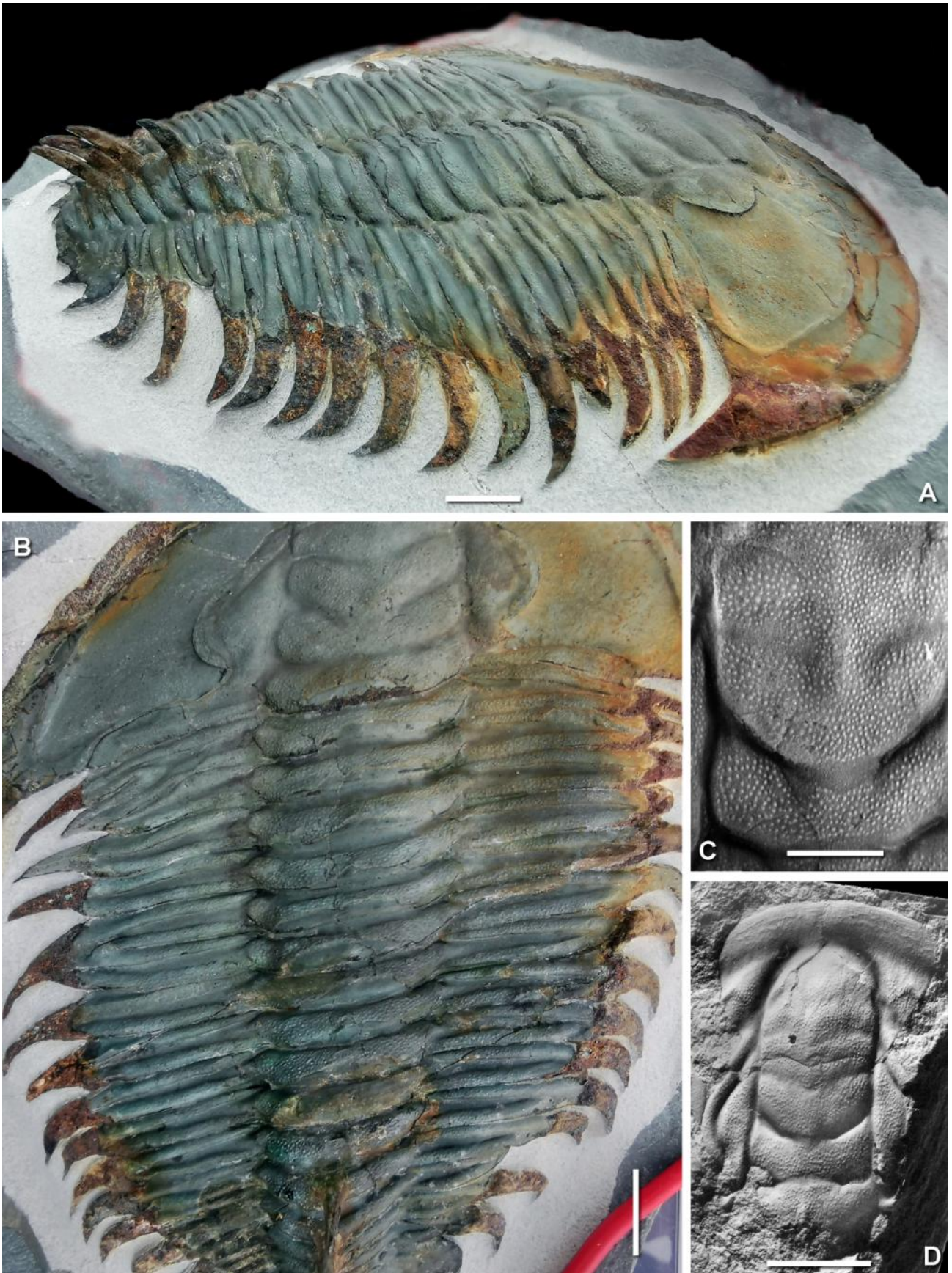


Fig. 3. *Longianda termieri* (Neltner & Poctey, 1950). A, B, specimen PAIS 8447, dorsal exoskeleton, Issafen Syncline, probably from Timghit section, Issafen Formation, *Sectigena* Zone, *Gigantopygus-Longianda* Subzone. A, oblique lateral view showing malformations on the right flank of the thorax. B, dorsal view of the posterior part of the cephalon and the thorax. Scale bars 10 mm. C, MNHN R.50913, lectotype (see Fig. 4B), detail of glabella illustration surface ornament of granules. Scale bar 5 mm. D, cranium, laterally compressed, with granulation on palpebral lobes; figured in Hupé (1959, pl. 16, fig. 5) as a new species. Specimen appears to be lost. From Timghit section ("section 3"), sample horizon F8. Scale bar 10 mm.

and 12; and (4) one centered on the right side of segment 13. The anomalous morphologies of the affected spines and pleurae are almost certainly the result of atypical regeneration of the exoskeleton of the segments (and commonly termed “hyperplasia”). The described malformations differ distinctly from teratological or pathological features known from trilobites although abnormal rib patterns like those in segments 1–2 and 5–6 are known from specimens with teratological abnormalities (e.g., Babcock 1993). The distribution of the malformations on several locations on the left as well as the right side of the exoskeleton thus indicates that they are most probably healed injuries resulting from a predaceous attack despite the fact that no obvious bite traces are preserved.

4. Discussion on the morphology of *Longianda termieri*

Longianda has been introduced by Hupé (1953a, p. 201), based on the type species *Callavia termieri*, which had been erected by Neltner & Poctey (1950, pl. I, figs. 2–4). The lectotype chosen by Hupé (1953a, p. 202, pl. VIII, fig. 2) is housed in the Muséum Nationale d’Histoire Naturelle in Paris and refigured herein (Fig. 4B). According to Hupé (1953a) this specimen comes from the type lot of Neltner & Poctey (1950), mainly collected by J. Bondon between 1932 and 1934, but it has not been figured or particularly mentioned in Neltner & Poctey (1950).

Specimen PAIS 8446 nicely portrays the morphology of the dorsal exoskeleton of *Longianda termieri*. The specimen (as well as PAIS 8447) supplements the morphology seen the holotype,

particularly for the posterior part of the thorax and the pygidium, and this morphology is also seen in other specimens collected in the Issafen Syncline and now housed in private collections. Such specimens are shown in Figs. 5 and 6, and they also indicate some caveats suggested by readily prepared specimens from the fossil market, which are also discussed below.

4.1 Size

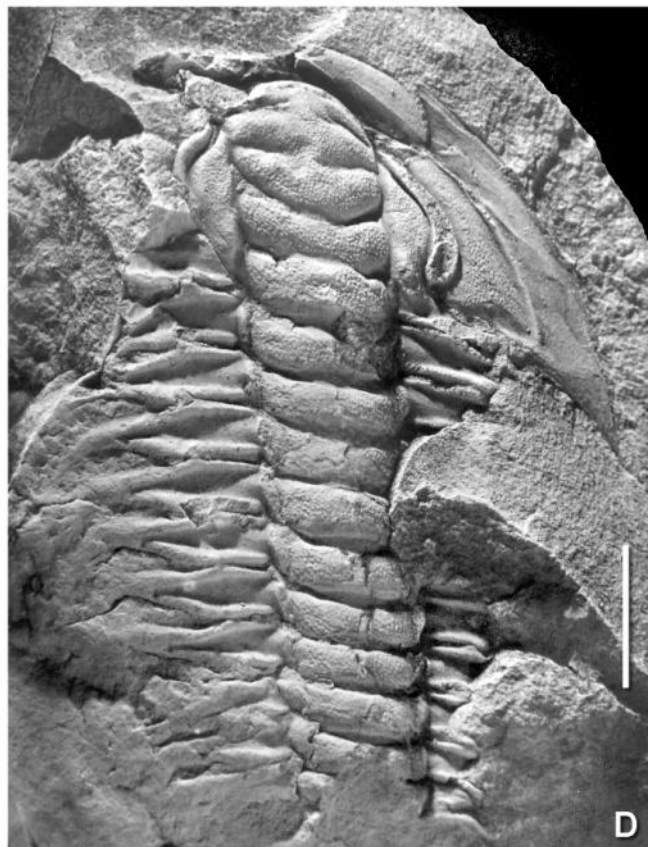
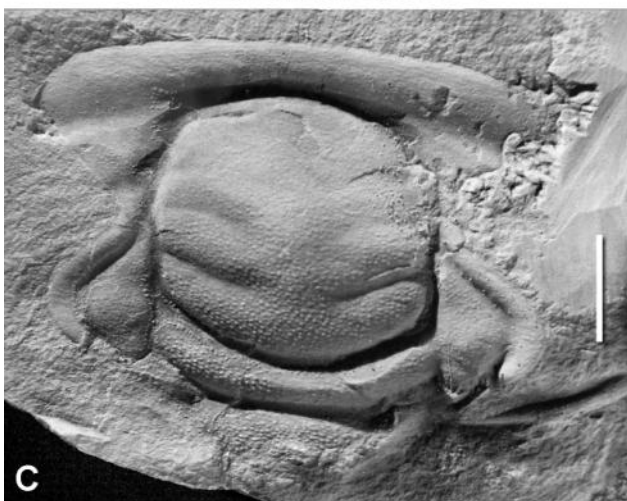
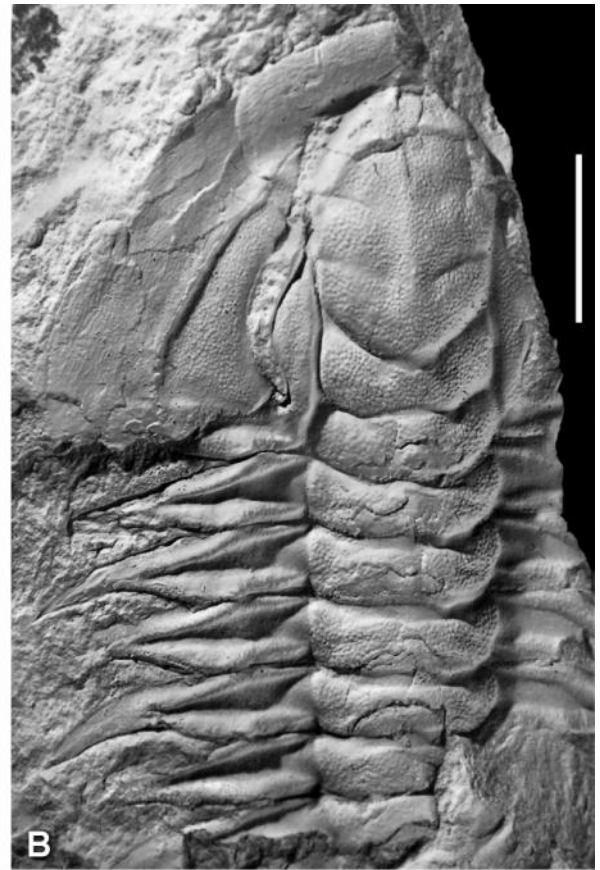
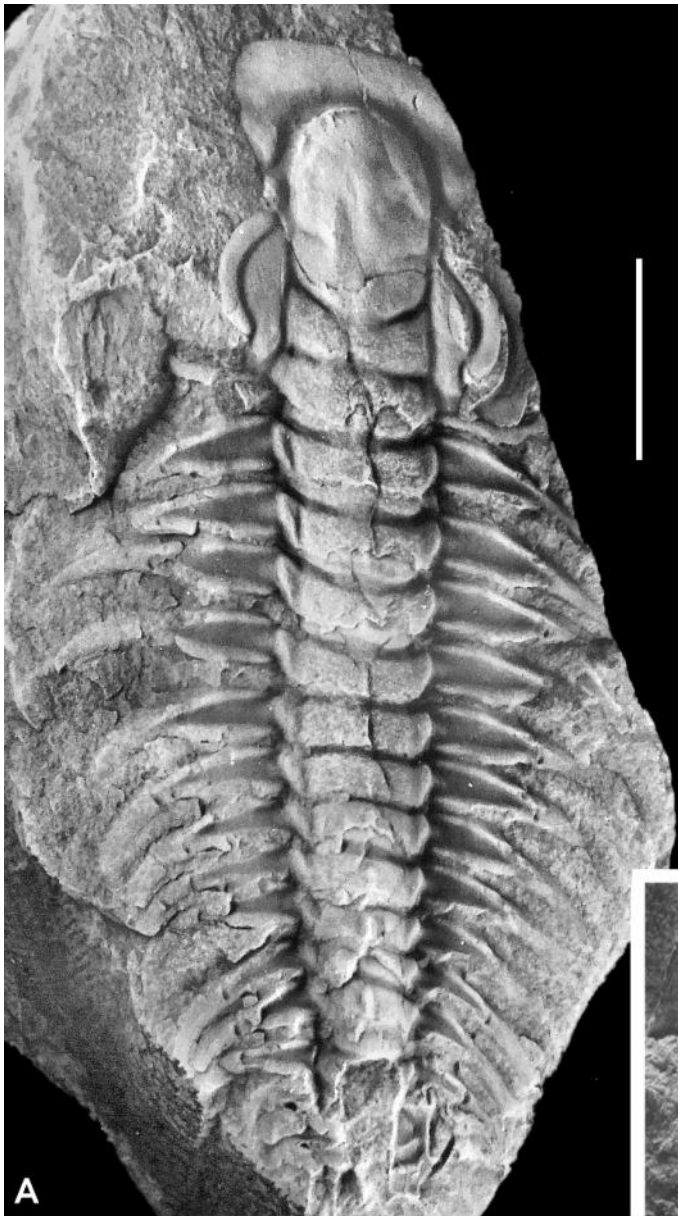
The largest complete exoskeletons known to me are ca. 180 mm long. The average size of specimens in collection ranges in the order of 65 to 90 mm in length, and the smallest complete specimen that I have seen was approximately 30 mm long.

4.2 Thorax

Number of segments. The thorax of adult individuals of *Longianda termieri* consists of 15 segments, and this number of thoracic segments is already developed in relatively small specimens. Fig. 5A, C shows one of only two specimens with only 13 segments known to the author.

Pleural spines. Incomplete specimens with only the anterior part of the thorax preserved generally show pleural spines with tips that are only weakly curved and thus more laterally than rearwardly directed. In the posterior part of the thorax, the pleural spines are more and more rearwardly directed, but significant differences can be seen between the specimens. Careful examination suggests that these differences in the rearward curvature of the pleural spines partly result from incorrect preparation that may lead to an

Fig. 4. *Longianda termieri* (Neltner & Poctey, 1950). All specimens from Issafen Syncline, Issafen Formation, *Sectigena* Zone, *Gigantopygus-Longianda* Subzone. A, MEM Tr779, paratype, incomplete dorsal exoskeleton; originally syntype of *Callavia termieri* of Neltner & Poctey (1950), figured in Termier & Termier (1950, pl. CLXXXVI, fig. 17) as “*Callavia andalousiae*” and in Hupé (1953a, pl. VIII, fig. 8) as *Longianda termieri*. Note differences in the shape of the pleural spines (even on different sides of the same segment) depending on the specific preservation. Scale bar 10 mm. B, MNHN R.50913, lectotype (selected as “holotype” by Hupé, 1953a, p. 202, for the genus!), partial dorsal exoskeleton; figured in Hupé (1953a, pl. VIII, fig. 2). From Timghit section (“section 3”), sample horizon unknown. Scale bar 10 mm. C, cranidium, slightly longitudinally compressed; figured in Hupé (1959, pl. 16, fig. 3) as *Pseudosaukianda lata*. Specimen appears to be lost. From section 3 km SE of Timghit (“section 5”), sample horizon unknown. Scale bar 5 mm. D, incomplete dorsal exoskeleton, glabellar lobes enforced by oblique compression; figured in Hupé (1959, pl. 16, fig. 2). Specimen appears to be lost. From Timghit section (“section 3”), sample horizon F8. Scale bar 10 mm.



erroneous shape of the pleural spines, including a removal of parts of relatively broad pleural tips in some specimens. Nevertheless, this is not always the case: Considerable differences in-

deed appear to exist between different specimens. Whether these differences possible reflect taxonomic differences, differences between males and females or are a result of differences



in living conditions remains uncertain for the moment. A sort of gradient of the shape of the pleural spines between specimens of different size appears to exclude taxonomic differences so

that all specimens in question are regarded as representing the same species, *Longianda termieri*.

Fig. 5. *Longianda termieri* (Neltner & Poctey, 1950). All specimens from Issafen Syncline, Issafen Formation. Exact localities unknown if not noted otherwise. A, C, CGB T. 45, dorsal exoskeleton of a small individual with thorax composed of 13 segments, showing strongly extended, obliquely rearwardly directed, nearly straight axial spines on thoracic segments 9 through 13. A, dorsal view of entire specimen; note extremely extended spine on axial ring 12; B, oblique lateral view of posterior part of thorax and pygidium. B, RJC 594, dorsal exoskeleton of moderately large individual(s), dorsal view; specimen composed of parts from two different specimens; arrows point to line of contact. From section southwest of Timghit. D, DEV C 23.2, dorsal exoskeleton of relatively small individual, oblique lateral view of posterior part of thorax and pygidium showing distinctly extended, but slightly curved axial spines. From section east of Timghit. E, CGB Tr. 46, dorsal exoskeleton of relatively large individual, dorsal view of posterior thorax and pygidium, showing axial spines starting with small spine on axial ring 8. Scale bars 10 mm in A–D, 5 mm in E.



Axial spines. Specimens PAIS 8446 and 8447 as well as a number of additional specimens that were offered on the fossil market over the last few years all show a spectacular and apparently unique arrangement of axial spines on the posterior part of the thorax. As described above, these spines on the axial rings of segments 12–15 are extended into blade-like spines of moderate length, which are directed steeply dorsally and then curving rearward (Fig. 1C). Other specimens show a similar pattern of axial spines, but apparently more delicately developed with ovoid transverse section (Fig. 6E). Particularly the blade-shaped spines appear to be unique because the broad, oblique leave-shape in lateral view with a narrowly curved tip would be almost unique among trilobites and does not provide a cogent functional aspect. Indeed, other specimens with the thorax partly sticking in the matrix and specimens with a partially enrolled posterior thorax indicate that the original spines were distinctly longer and had delicate, strongly rearwardly directed tips arranged in a compact series (Fig. 5C, D). It is thus evident that the specimens for sale with the elegant rounded tips are just a product of the preparator's imagination. The longest axial spines (on segment 14) extend clearly beyond the posterior margin of the pygidium (Fig. 5A).

In addition, some specimens also indicate that the anterior of the extended axial rings may already exist on segment 11 (see Fig. 5C).

4.3 Pygidium

The pygidial morphology is nearly perfectly illustrated by specimens PAIS 8446. Another in-

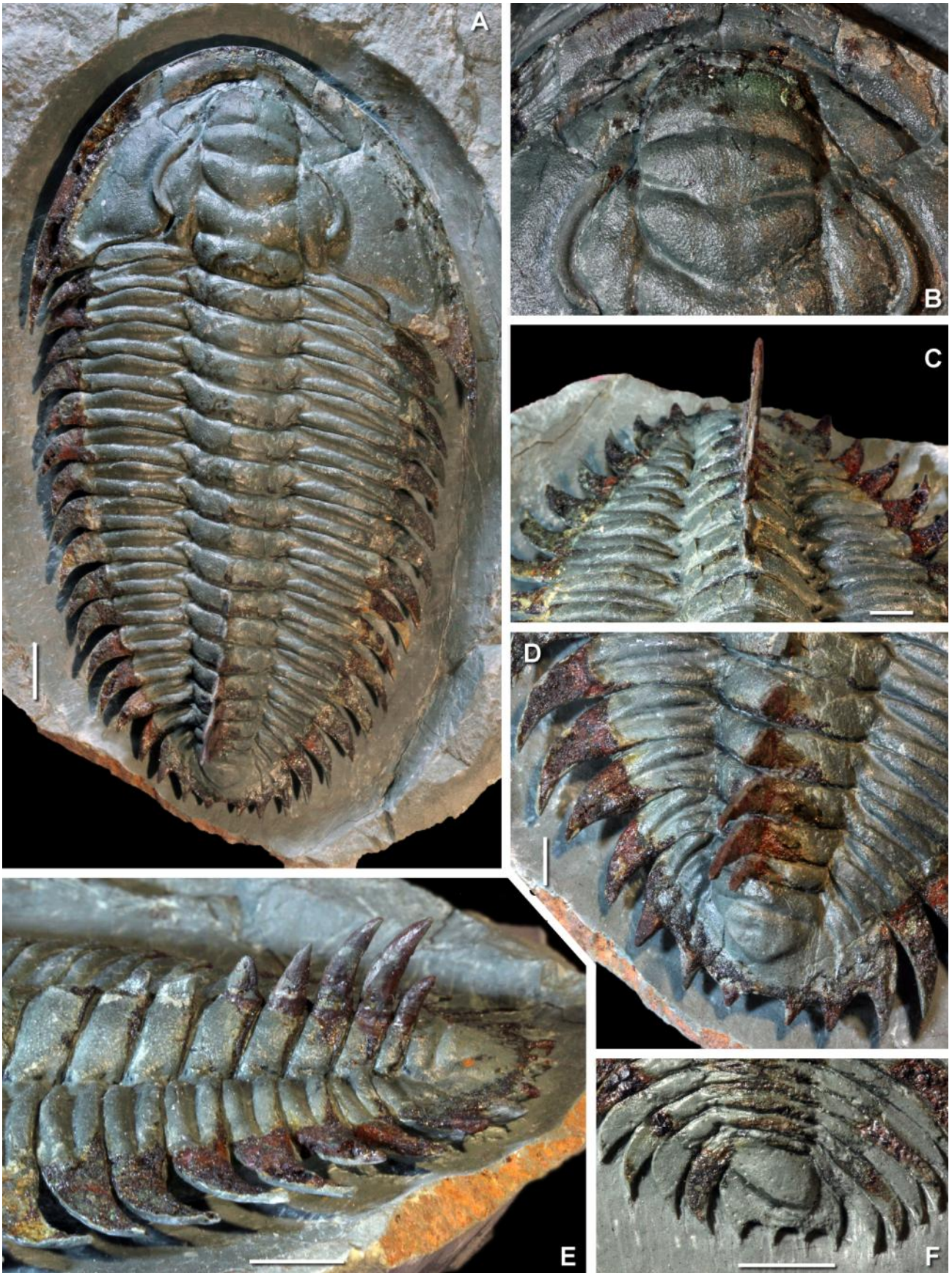
formative specimen is shown in Fig. 5E, illustrating the morphology that is generated in dorsoventrally compacted specimens. In such specimens, the pleural fields are deformed so that the pleural ribs are poorly preserved, and axial furrows exaggerated against the situation in the living animal.

Commercial specimens frequently show pygidia, which are wrongly prepared to show a morphology with little resemblance to the original morphology. In most cases, the lateral spines are manipulated in several ways, usually to show a pair of short spines between which are posterior margin of the pygidium is straight or nearly so, and a second pair of slightly shorter lateral spines, with a third pair interpreted to belong to thoracic segment 13. One example for a totally erroneous application of such an artificial morphology is shown in Fig. 6F, which is a sculptured “*Longianda*-type” pygidium on a dorsal exoskeleton of *Neltneria jacqueti*.

In some cases, this preparation results in a notable asymmetry as illustrated in Fig. 5B. It should also be emphasized that the specimen in Fig. 5B is composed of the remains of two different specimens, cephalon and anterior part of the thorax merged with the posterior thorax plus pygidium of another one.

4.4 Rostrohypostomal unit

A few specimens are known from the Issafen Formation of the Issafen Syncline, which represent rostrorhynchid units unequivocally belonging to saukiandid trilobites. Three of such sclerites have been figured in Hupé (1959), and



two of them are refigured herein (Fig. 7A, B). They are characteristic in its broad (sag., exsag. and tr.) rostral part of the sclerite and in the hypostomal part having a distinctly elevated ante-

rior lobe, and conspicuous, broad-based, thorn-like lateral spines as well as small posterolateral tips.

Fig. 6. A–E, *Longianda termieri* (Neltner & Poctey, 1950), specimen CGB T. 47, dorsal exoskeleton, Issafen Syncline, probably from Timghit section, Issafen Formation, *Sectigena* Zone, *Gigantopygus-Longianda* Subzone. A, dorsal view of entire specimen. B, close-up of cephalon showing pattern of glabellar furrows and prosopon of densely arranged, relatively coarse granules. C, oblique anterior view of posterior part of thorax and pygidium illustrating the arrangement of axial spines. D, dorsal view of the posterior part of the thorax and pygidium. E, slightly oblique lateral view of the posterior part of the thorax and the pygidium illustrating the length of the axial spines and the relief of the pygidium. F, *Neltneria* cf. *jacqueti* Hupé, 1953a, specimen CGB T. 48, dorsal exoskeleton, Issafen Syncline, probably from Timghit section, Issafen Formation, *Antatlasia guttapluyiae* Zone. Dorsal view of posterior part of the thorax and pygidium; pygidium sculptured to a fantasy shape during preparation, probably influenced by the shape of pygidia of *Longianda termieri*. Scale bars 10 mm in A, E, 5 mm in C, D, F.



Hupé (1959) assigned both specimens to *Pseudosaukianda lata* without any explanation. Although this assignment cannot be ruled out absolutely, the precise width of the rostral part and the obviously higher frequency of its presence strongly suggest that this type of rostrhypostomal unit belongs to *Longianda termieri* rather than *Pseudosaukianda lata*.

5. Taxonomy of the *Saukianda* group

Insufficient descriptions by Neltner & Poctey (1950) and Hupé (1953a, 1953b, 1953c, 1953d, 1955, 1959) and the incompletely known morphology of the dorsal exoskeleton of *Longianda*

termieri (as discussed above) did not allow an unequivocal discrimination from closely related genera such as *Saukianda* and particularly *Pseudosaukianda*. Chang et al. (1997, p. 454) provided a comparison with those genera (or subgenera). They characterized the genus *Longianda* as follows (modified here from the short descriptions of all three genera/subgenera): Glabella subtruncate to slightly rounded in front and constricted at level of S1; S3 obsolete; S2 very short; S1 deep, broad; occipital furrow bent forward at middle; occipital ring of uniform length (sag. and exsag.), no occipital spine; preglabellar field absent. Thorax with backward

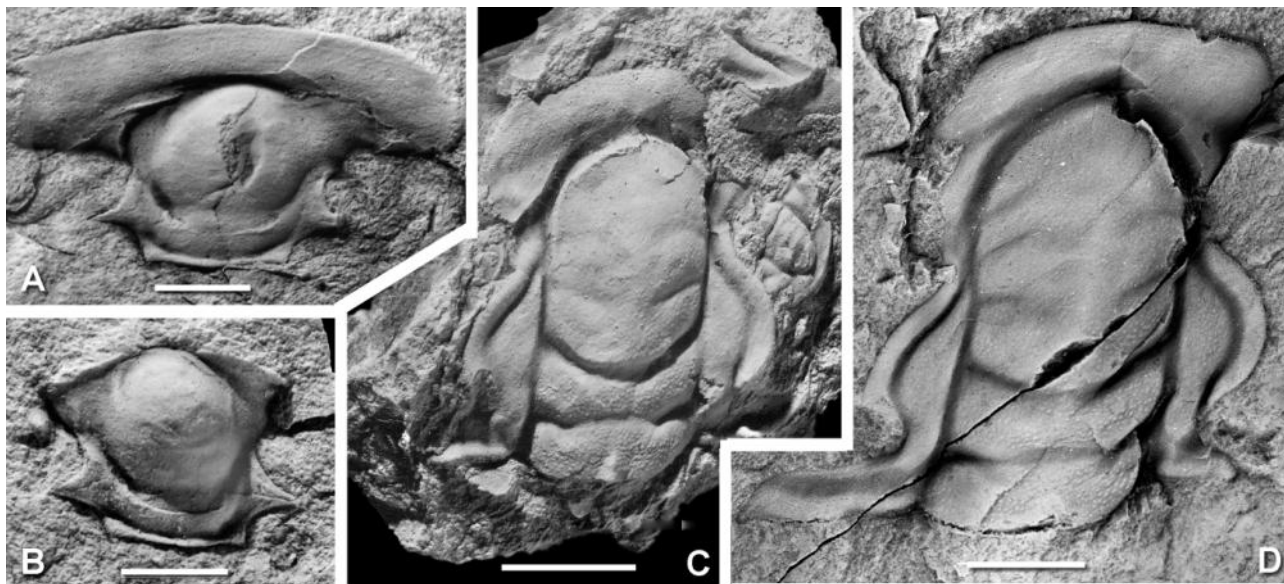


Fig. 7. *Longianda termieri* (Neltner & Poctey, 1950). All specimens from Issafen Syncline, Issafen Formation, *Sectigena* Zone, *Gigantopygus-Longianda* Subzone. A, rostrhypostomal unit; figured in Hupé (1959, pl. VIII, fig. 9) as *Pseudosaukianda lata*. Specimen appears to be lost. From section SE of Timghit ("section 5"), sample horizon unknown. Scale bar 5 mm. B, rostrhypostomal unit with incompletely preserved rostral part; figured in Hupé (1959, pl. VIII, fig. 10) as *Pseudosaukianda lata*. Specimen appears to be lost. From section SE of Timghit ("section 5"), sample horizon unknown. Scale bar 5 mm. C, small incomplete cranidium, associated with small cranidium of *Termierella latifrons* Hupé, 1953a (to the right), figured in Hupé (1959, pl. 17, fig. 5) as a new species *Longianda acuminata* (nom. nud.). Specimen appears to be lost. From Timghit section ("section 3"), sample horizon F8. Scale bar 5 mm. D, MNHN R90512, paratype, incomplete cranidium; originally syntype, figured in Neltner & Poctey (1950, pl. I, fig. 4) as "*Callavia Termieri*". Scale bar 10 mm.

curvature of pleural spines progressively increasing posteriorly. Pygidium with three axial rings, short terminal axial piece, and four ribs.

This does not characterize the genus in a way to discriminate it unequivocally from *Saukianda* and *Pseudosaukianda*. *Saukianda andalusiae* Richter & Richter, 1940, the type and only formally described species of the genus, is a frequent trilobite in the Alanís Formation of the Sierra Morena mountain region in southern Spain, where it is usually tectonically distorted in a way that makes the recognition of specific character difficult. However, the same species is obviously present in the strata with *Longianda* and *Pseudosaukianda* in the Anti-Atlas of Morocco. The genus and species is clearly distinguished from *Longianda* in having a relatively narrow anterior border; more slender palpebral lobes of subequal transverse width throughout of their course and fairly well-developed palpebral furrows; a moderately long occipital spine; and longer genal spines. *Saukianda* lacks distinct spines on the posterior thoracic axial rings. To my knowledge, no specimen of *Saukianda* is known with a complete dorsal exoskeleton, and its pygidium is thus known only from isolated sclerites found with the cranidia of *Saukianda andalusiae* in the Sierra Morena. These pygidia are multisegmented, with an axis of at least nine axial rings plus a terminal axial piece, with an equivalent number of pleural furrows and a simple lateral and pygidial margin without any spines. This type of pygidia distinctly differs from the pygidium described about from PAIS 8446 and PAIS 8447, and it resembles closely some pygidia known from the *Resserops* group (Family Despujolsiidae; see Geyer 2020). However, *Saukianda* has a prosopon composed of large granules very similar to that known from *Longianda*, and some of the pygidia from the Sierra Morena also appear to have a granulose surface.

Pseudosaukianda must be regarded as insufficiently known. Only five specimens can be attributed confidently to the genus and its type

species *P. lata*. All of them lack the posterior part of the thorax and a pygidium. The glabella of *Pseudosaukianda lata* tapers forward in all four specimens with preserved cranidium, and the dorsal surface of the cuticle is pustulose but appears to have been covered with slightly smaller and more densely arranged granules (Fig. 8). The anterior and lateral cephalic border of *Pseudosaukianda* is broad and probably even a bit wider than that in *Longianda*, but the palpebral lobes and palpebral furrows match the shape developed in *Longianda*. The pleural spines in the anterior part of the thorax are slender and not very much reclined, and an isolated and more or less complete thorax attributed to *Pseudosaukianda lata* (Hupé 1953a, pl. IX, fig. 4) indicates that this shape of the pleural spines does not change much towards the posterior part.

Hupé (1953a) introduced a second species as *Pseudodaukianda* (?) *spinifera*, which was figured only by a single specimen (Hupé 1953a, pl. IX, fig. 3), an incomplete cephalon with attached partial thorax (Fig. 8D). The only difference to *P. lata* emphasized by Hupé (1953a, p. 198) is the presence of nodes on the occipital ring and the axial rings of the thoracic segments. These nodes are similar in shape to those known from *Longianda termieri*, and *Pseudosaukianda lata* almost certainly had the same type of nodes, but they are worn off in most cases in the preserved specimens of that species. Therefore, *P. ? spinifera* is almost certainly identical with *P. lata* and should be regarded as a junior synonym.

Ironically, rare specimens of *Pseudosaukianda* are offered on the international fossil market, which certainly belong to *P. lata*, but show a different shape of the pygidium. Such pygidia (Fig. 9) are a product of the phantasy of the preparatory rather than showing a natural morphology. However, one cannot deny that human inventiveness is responsible in those cases for unanticipated esthetic qualities.

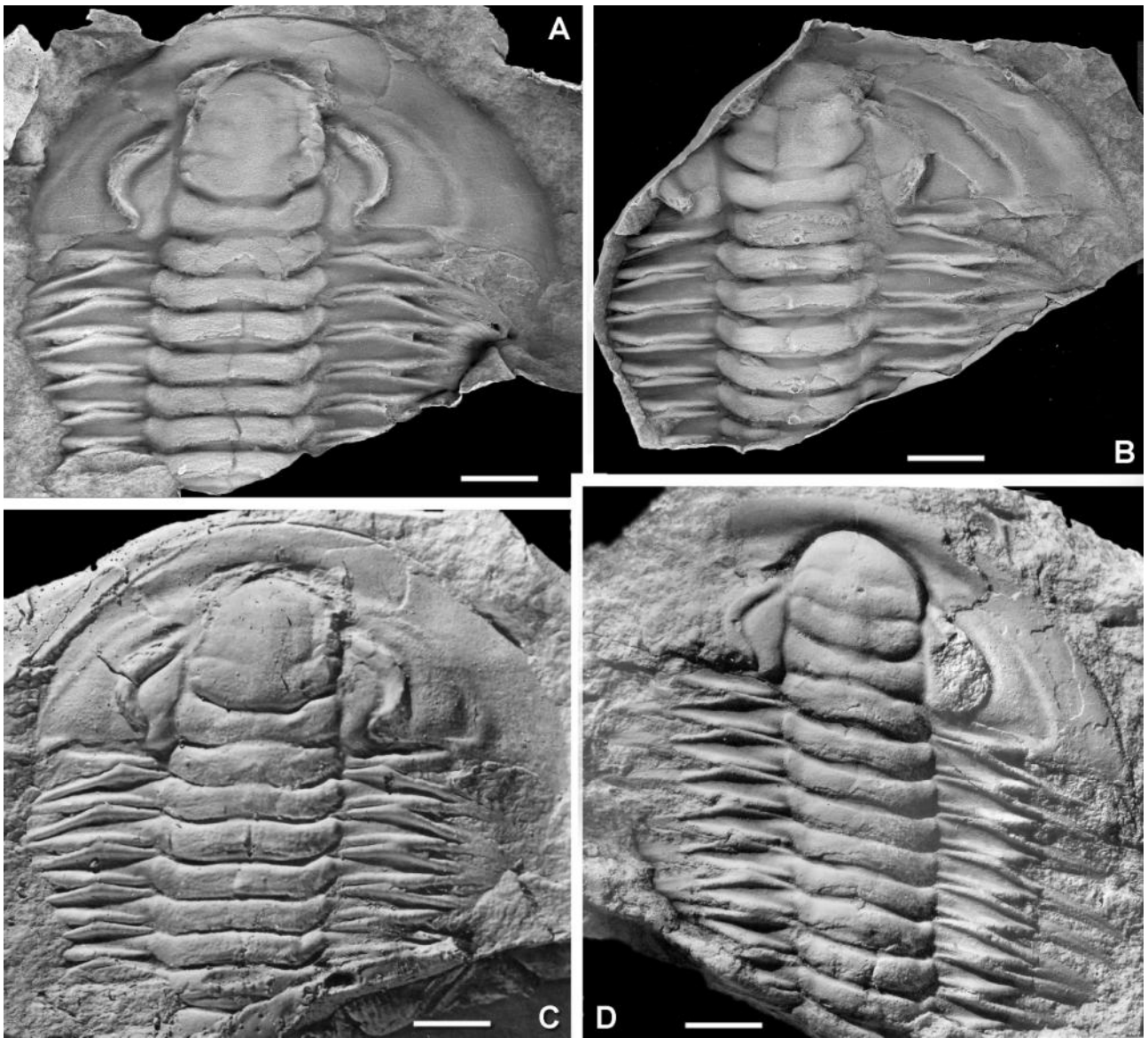


Fig. 8. *Pseudosaukianda lata* Hupé, 1953a. All specimens from Issafen Syncline, Issafen Formation. Exact sampling locality and horizon unknown unless noted otherwise. A, C, MNHN R. 50867, holotype (Hupé, 1953a, pl. VIII, fig. 7), also figured in Termier & Termier (1950, pl. CLXXXVI, fig. 17) as “*Callavia andalousiae*”; cephalon with attached partial thorax, casts of internal molds. A, latex cast of presently available specimen. C, silicone rubber cast made by Hupé; note differences in the axial nodes and palpebral lobes. Almost certainly from Timghit section, collected by Neltner. B, MNHN R.50905, incomplete cephalon with attached partial thorax, latex cast of internal mold. Holotype of *Pseudosaukianda? spinifera* in Hupé (1953a, pl. IX, fig. 3). Probably from Timghit section, collected by J. Bondon. D, incomplete cephalon with attached partial thorax, silicon rubber cast of internal mold; figured in Hupé (1959, pl. 16, fig. 1). Specimen appears to be lost. From section 3 km south of Timghit (“section 5”). Scale bars 5 mm.

An emended diagnosis for *Longianda* (as characterized by *L. termieri*) is suggested here:

Genus of the Saukiandidae with a glabella with subparallel sides in the anterior half, slightly wider across L1 and the occipital ring; occipital ring with subterminal node; palpebral lobes crescent-shaped, anterior and posterior ends slightly narrower than median parts; anterior and lateral cephalic border relatively broad, ele-

vated, but with only low transverse convexity; genal spines broad-based, relatively short; thorax consists of 15 segments with moderately large pleural spines; axial rings of thoracic segment 1–11 with subterminal node of longitudinally elongated shape; axial rings of thoracic segments 12–15 with conspicuous, blade-like, posteriorly curving spine; pleural spines progressively rearwardly curved from segment 1 to 15; pygidium subtrapezoidal, with axis com-

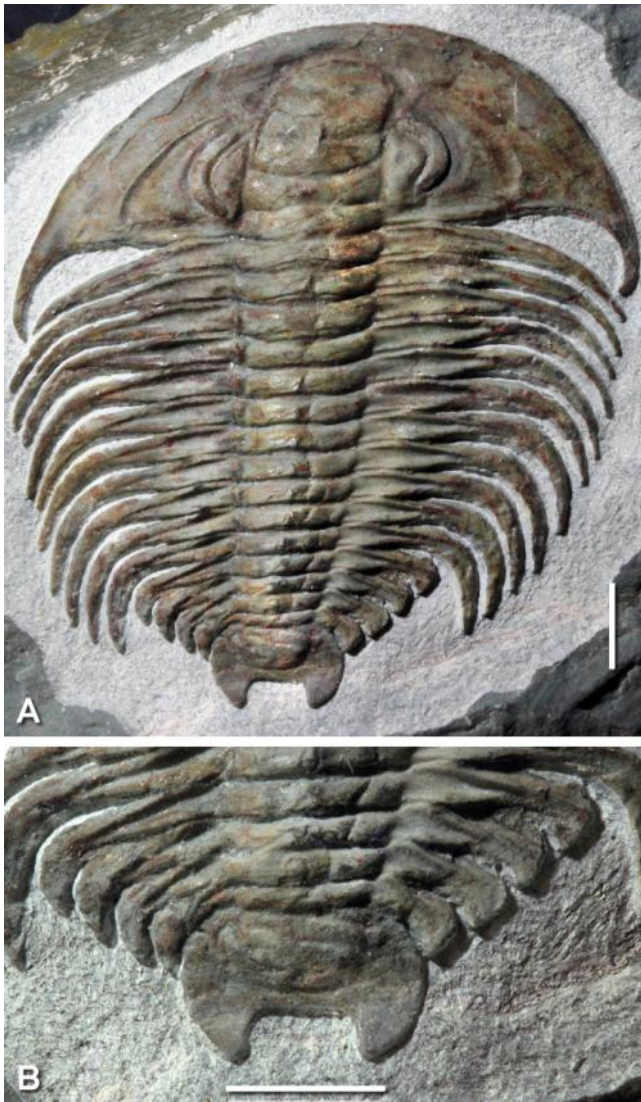


Fig. 9. *Pseudosaukianda lata* Hupé, 1953a, CGB T. 49, dorsal exoskeleton with artificially sculptured pygidium; A, entire specimen; B, close-up of posterior part of thorax and pygidium. From Issafen Syncline, Issafen Formation. Exact sampling locality and horizon unknown. Scale bar 10 mm in A, 5 mm in B.

posed of ca. four rings and terminal axial piece, pleural fields with ca. five, obliquely rearwardly directed ribs and three pairs of distinct marginal spines; without lateral and posterior border; cuticle coarsely granulose.

6. Stratigraphy

Hupé's (1952, 1953a) biostratigraphic subdivision of the Lower Cambrian in the Moroccan Atlas ranges identified a "zone à *Longianda* et *Gigantopygus*" from which he reported a lower assemblage with "*Callavia callavei*, *Longianda termieri*, var. *minor*, *Strenuella rasettii* et *Antatlasia* cf. *hollardi*"; a middle assemblage with the

"nice fauna from Issafen" with "several species" of "*Gigantopygus* et *Pseudotermierella*, *Longianda termieri*, *Saukianda* cf. *andalusiae*"; and an upper part with only *Longianda termieri* (Hupé, 1953a, p. 82). This subdivision is obviously based on limited data from only the Issafen Syncline, and a *Gigantopygus*-*Longianda* Zone cannot be recognized with certainty from anywhere outside the Issafen Syncline and nearby areas (Geyer, 1990).

Although a precise bed-to-bed inventory of the fossils in the Issafen Formation of the Issafen Syncline is lacking, the available data (Hupé, 1953a, 1959; Geyer, unpubl. data) indicate that the most reliable data on the stratigraphic ranges of the trilobites come from partial sections near Timghit in the central part of the Issafen Syncline (Hupé's section 3) and from a section ca. 3 km to the south of Timghit (Hupé's section 5). These data prove that *Gigantopygus*, *Saukianda*, *Pseudosaukianda* and *Longianda* all occur more or less synchronously. They are present in a ca. 30 m-thick interval near the top of the Timghit section (Hupé's section 3), which does not include the top of the formation. These strata with the *Gigantopygus*-*Longianda* assemblage in this section overlie the strata with *Antatlasia guttapliviae* (indicative of the *A. guttapliviae* Zone; Geyer 1990), but are separated from this fossiliferous level by a succession of ca. 30 m of barren rocks in section 3. In contrast, an overlap of the *Gigantopygus*-*Longianda* assemblage with *A. guttapliviae* Zone trilobites is clearly visible in section 5. However, *Neltneria* and *Bondonella*, used by Hupé (1952, 1953a) as index fossils for his *Bondonella*-*Neltneria* Zone (Zone V, "Zone à *Bondonella* et *Neltneria*"), are not found in association with *Gigantopygus* and *Longianda*.

Occasional findings of *Termierella* together with *Gigantopygus* and *Longianda* in the upper part of the *Gigantopygus*-*Longianda* assemblage in section 3 and a distinct overlap of *Termierella* with *Gigantopygus* and *Longianda* in section 5 indicate that the onset of *Termierella* appears to

be driven by differences in lithofacies and thus depositional environments. As discussed in Geyer (1990), the (sub)regional *Termierella* (sub)zone recognized by Hupé (1952, 1953a) (Zone VII, “Zone à *Termierella*”) shows distinct differences in its stratigraphic extension and can only be recognized in limited areas so that it lacks a general utility and was abandoned by Geyer (1990).

Nevertheless, a *Gigantopygus-Longianda* Subzone (of the *Sectigena* Zone; Geyer 1990) is a significant and useful biostratigraphic unit in the western Anti-Atlas as suggested by Hupé (1952, 1953a: Zone VI, “Zone à *Longianda* et *Gigantopygus*”), *Longianda termieri* constitutes the main index species of this subzone.

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Martin Basse & Peter Müller

In the year 1849, the famous Sandberger brothers, Guido and Fridolin, published part one (of eight) of their monograph on Devonian, and some Carboniferous, fossils of the Lahn/Dill-Eder Synclines, which are major structural units in the southeastern part of the Rhenish Massif, German Variscides. This great classical work stands for the begin of the paleontological discovery of this area. As for trilobites, the following new species names have resulted from this work: The Devonians *Cylindraspis?*

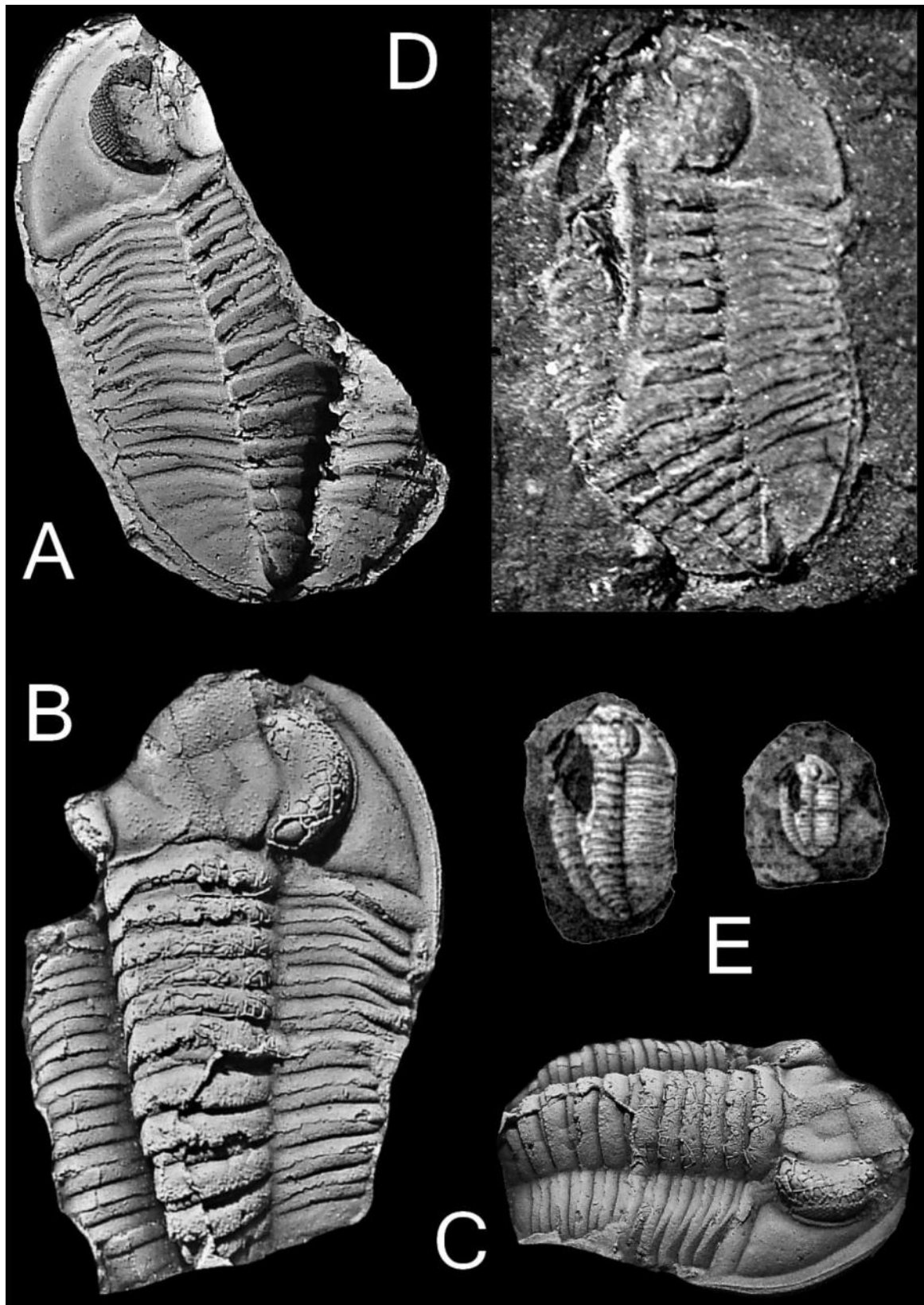
macrophthalmus (see below), *Homalonotus crassicauda* (later assigned to *Digonus*), *H. obtusus* (assigned to *Wenndorfia*), *H. oniscus* (nomen nudum), *Harpes gracilis* (secondary homonym, replaced by *Harpes neogracilis* Richter & Richter, assigned to *Eskoharpes*), *Phacops brevicauda* (in need of revision), and the Carboniferous *Cylindraspis latispinosa* (replacement name for *Archegonus aequalis* (v. Meyer, 1831), thus invalid).

Among these, *Cylindraspis? macrophthalmus* is the hitherto last which underwent modern revision, performed by Basse & Müller (2016) in their monograph of the Rupbach Shale trilobites (Lahn Syncline). This revision has provided interesting new data. In contrast to the Sandbergers, who regarded the monotypic find of this species as being early Carboniferous (Mississippian) in age, we referred to modern geological maps showing that the area including the type locality of this species exposes exclusively Early to Middle Devonian beds. This age is supported by the results of the taxonomic revision which have led us to regard *C.?*

macrophthalmus as representative of the cornu-proetine *Macroblepharum* (recently regarded by van Viersen & Lerouge tentatively as junior subjective synonym of *Sculptoproetus*). This genus occurs in the Rhenish Massif only around the Early/Middle Devonian boundary. Earlier workers assigning *M. macrophthalmus* to the late Paleozoic genus *Phillipsia* were evidently strongly influenced by the originally wrong stratigraphic framework.

In 2016, we were unable to present more than a photograph poor in details of the internal mold of this species (text-fig. D), which allows only to prove the identity of this specimen with the very exact drawings provided by the Sandbergers (text-fig. E). Meanwhile, casts of the original finds are available (text-figs A–C). They allow additional insights. For example, they confirm the revised generic assignment as being correct, demonstrated by the exsagittally very long eye, by the sigmoidal course of the lateral margin of the glabella which is covered with fine granules but lacking striation, by the low number, nine, of thorax segments as well as by the outline of the pygidium and the type of segmentation of the pygidial pleural area.

Unfortunately, important morphological features, as the shape of the anterior border of the cranium, the course of the anterior facial suture, and the dorsal morphology of the pygidium, are not preserved. This renders it difficult to provide a full species diagnosis and thus to compare this find with other *Macroblepharum*. In 2017, Basse & Müller gave an overview of species of this genus from the German Variscides, most of which coming from shaly limestones of the nearby Lahn Syncline. With one exception, *M. pmuelleri*, which has a unique glabellar outline, these species are not readily distinguishable from *M. macrophthalmus*. As to small differences present, the granulation of the glabella is worth mentioning, which appears to be coarser and higher in number of elements in most other species. However, since an ontogenetic origin for these differences cannot be ex-



Text-figs A–E. Monotypical holotype of *Macroblepharum macrophthalmus* (Sandberger & Sandberger, 1849), original specimens have inventory numbers 18a, b (housed in the Naturhistorisches Museum, Wiesbaden, Hesse), from south of Manderbach town (likely from “Manderbacher Löhren” area), northwest of Dillenburg town, mapsheet 5215 Dillenburg, Hesse, Dill-Eder Syncline, Rhenish Massif, German Variscides, Wissenbach Shales, final Late Emsian or Early Eifelian, Early or Middle Devonian. **A–C.** Plaster casts of internal (A) and external molds (B, C), different views. Fine ledge-like structures on palpebral area and some axial rings have erosional character. **D.** Original internal mold, scan of Basse & Müller (2016: Pl. 31, fig. 306). **E.** Scan of drawings of Sandberger & Sandberger (1849: Pl. 3, figs. 5, 5a). Cast A is 13,5 mm in length. Casts will later be transferred to the Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main. Photographs A–C by P. Müller.

cluded, their taxonomic meaning has to remain unclear.

To solve these problems the authors attempt to recollect the type locality, if still accessible, or its vicinity, to get new finds filling the morphological gaps existing.

TRILOBITE HALL OF FAME

W. T. DEAN

Memories of trilobitologists by Richard Fortey

Dr W. T. “Bill” Dean was my predecessor at the Natural History Museum in London, and a distinguished trilobite scholar. Many of his works were published in the *Bulletin* of what was then known as the British Museum (Natural History) Geology Series. He was a classical stratigraphic paleontologist. From the 1950s he concentrated on making sense of the succession of trilobites through the type Caradoc Series in Shropshire, Welsh Borderland. Recall that at that time the global standard for the Ordovician System was in Great Britain, where, after all, Charles Lapworth (one of our unsung geological geniuses) had originally defined it as a way of settling the controversy over what strata might be embraced by the Cambrian or the Silurian Systems. The fact that the Ordovician is now recognized as a pivotal period of biotic change is a measure of Lapworth’s sound judgment. Bill worked his way up many of the famous river sections – like that of the Onny - west of the of the charming town of Ludlow. He was following on from the distinguished brachiopod specialist B. B. Bancroft, whose biozones and stadial divisions enjoyed wide currency in the mid twentieth century. The trilobites were now added into the picture. Many species and generic names (the trinucleid *Onnia*, obviously among them) derive from this area. For year after year Bill followed the pattern of collecting in the spring and summer and writing up the results in the winter

months. His series of publications on the trilobites of this area appeared regularly for more than a decade.

Bill enjoyed fieldwork greatly, and developed a research project in southern France, in the wine growing region of the Montagne Noire, where rocks of earlier Ordovician age are well exposed. He managed to persuade the Natural History Museum to allow him to disappear for extended periods during the summer months with his young family, who lived in caravan accommodation while he worked his way through the shales of the Landeyran Valley, eventually summarizing the trilobitic results in a landmark monograph published by the Museum in 1966. Back home, he had able assistance in the palaeontology department from S. F. (Sam) Morris, who was at that time the curator for fossil arthropods. Sam’s name will be familiar to those who have used his indispensable bibliographic supplement to British trilobites published by the Palaeontographical Society in 1988. Sam tirelessly incorporated Bill’s types into the Museum collections, where his neatly handwritten labels can be appreciated to this day. Bill was becoming interested in taking his studies further into what was then known as the Mediterranean Province, and set up collaborations with geologists working in Turkey, especially his good friend Olivier Monod. Turkey is an important area of Ordovician rocks that had hardly been touched in the sixties. His publications on the area continued for more than thirty years, and proved an intriguing mixture of trilobites that had been recognized much further east in south-western China, as well as genera known from the Baltic regions and France. At the same time, he had embarked on major monograph of the late Ordovician trilobites of the Irish Chair of Kildare Limestone, one of the most diverse British faunas, which he completed with characteristic dispatch during the nineteen seventies. Bill was always an outstanding example of reliable publishing productivity.

A major change in Bill’s life happened in 1969.

Bill left the Natural History Museum in London. He went to work for the Geological Survey of Canada, based in Ottawa. The reasons may be complex, but part of the reason (as Sam Morris recounted) was that he was disappointed at not being appointed as head of the Natural History Museum's Palaeontology Department, a position then known as Keeper. In those bad old days, appointments were made by seniority, and Bill Dean was not quite the senior applicant to replace the distinguished fossil fish specialist Errol White as Keeper. Dr H.W. Ball accordingly became the head honcho (and it has to be said that Dr Ball was no match for Bill as a scientist). A position for Bill Dean was offered in Canada and he took it up. This is why publications on North American, and especially Canadian trilobites and stratigraphy became an important part of his output during the 1970s and 1980s. He explored both the eastern and western seaboards of that huge country, and became familiar with a different set of trilobite taxa. One small consequence of Bill's departure was that a position opened up in London for a trilobite specialist, at just the time I was getting near to completing my own doctoral thesis. If Bill had not left, I would probably have remained unemployed.

The move to Canada was not an unqualified success for Bill Dean, although his scientific productivity continued unabated. His family settled there and became assimilated, but Bill never quite settled. When he left the employment of the Geological Survey he returned to the United Kingdom, but his family stayed behind as Canadian citizens. The later years of his life were lightened considerably by a relationship with the well-known palynologist Francine Martin, with whom he also published scientifically. He joined the National Museum of Wales in an emeritus role from which position he continued to travel to Turkey and publish on the Ordovician trilobites well into the 21st Century. His collaborations with Chinese palaeontologists like Zhou Zhiyi during the nineties made important additions to our knowledge of the Ordovician faunas

of the Far East. Added together, it would be hard to think of any other Ordovician trilobite worker with a wider compass.

Bill Dean was always an amiable companion. He tended to be rather reserved about what he was actually doing. You could say he played his cards close to his chest. I never understood why: I would have appreciated discussing details of his trilobite work with him. He has left an important legacy of publications that will surely be consulted as long as there are trilobite workers. It is perhaps regrettable that the stratigraphic palaeontologist is becoming something of a threatened species, because there are fewer workers around who can appreciate the magnitude of the contributions made by the likes of Bill Dean.

GUNTHER HALL OF FAME

A Tribute to Robert ("Bob") Carroll

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

I've had the opportunity and privilege to collect Devonian trilobites with Bob Carroll at his Black Cat Mountain locality in the small town of Clarita, Oklahoma, and to watch him prep one of my finds. We first met a thousand miles north of there, on the spoil piles of an abandoned quarry in Michigan. We were both searching for Devonian *Phacops* (now *El-dredgeops*) *rana*. Since then, I've encountered Bob several times: in Michigan, at the MAPS fossil show (held in Illinois at the time), at the Tucson Show, and in Oklahoma at his locality and in his prep lab.

Prior to Bob Carroll's move from Michigan to Oklahoma in the mid-1980s, the Devonian trilobites of Oklahoma had not been studied extensively. Now, after three decades of Bob's collecting prowess and his generous donations, the Haragan Formation and its caramel-brown trilo-



Figure 1. Picture of Bob Carroll at his Black Cat Mountain locality. With him is Jessica Laton Hesske, a dedicated collector who has visited the quarry often from her home back east.

bites are well known by trilobite enthusiasts around the globe. And his Black Cat Mountain locality and the small town of Clarita have been thrust onto the world stage of paleontology.

While Bob is a commercial collector of Oklahoma trilobites, his diligent excavation of the Haragan Formation has revealed two new species. And another (*Cyphaspis carrolli*) was named in his honor. He has donated dozens of specimens to museums and universities. Several of the trilobites he collected and prepared are type specimens in research collections. He famously named a rare trilobite “Bug X” since he could not find it described anywhere. He donated specimens of Bug X to the University of Kansas for study. It turned out that it had been described back in the late 1800s. Still, Bob was involved in placing a name on this small Lichid: *Ancanthopyge consanguinea*.

Bob also shares his Black Cat Mountain locality with other collectors. He has hosted many amateurs and professionals in the several decades he has worked the Haragan strata. See Figure 1. I was among his guests: Many years ago, while I was driving through the area, he graciously took me to his quarry for a day of collecting. And he prepped my best find. See Figure 2.

So who is Bob Carroll? He is a Vietnam-era

Navy veteran. After his honorable discharge, he settled in Michigan and began collecting trilobites as a hobby. But once the fossil bug bit him, trilobites became his full-time passion. With guidance from other trilobite preparers, Bob quickly became an expert with air chisels, air scribes, and air abrasives to extract perfectly prepped specimens from their rocky graves. Because of his skill, and because he is a perfectionist in his prep work, he soon became widely known as one of the best “shooters” in the world.



Figure 2. *Kettneraspis williamsi*, Devonian, Haragan Formation, Clarita, Oklahoma. The trilobite is 2.5 cm long. (Self collected. Prepared by Bob Carroll).

Each year, Bob takes his latest collection of exquisitely prepared specimens to the Tucson Show. But their appearance at the show is brief, because buyers rapidly snatch them up for private and institutional collections. I must admit to being one of those buyers to add selected items to my own collection. I look forward to seeing his material at the show every year.

To Bob, I offer, “Good hunting.”

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