

Morphological trends and new species of *Cyphaspis* (Trilobita, Otarioninae) in the Devonian of Morocco, Turkey, Germany and Belgium

Supplementary materials

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ABSTRACT. New species of the otarionine trilobite *Cyphaspis* are recorded from Pragian to Givetian localities in Morocco and Belgium. The material carries a wealth of new insights into the diversity of *Cyphaspis* during the Devonian. In an attempt to bring structure to the vast assortment of species, selected taxa are clustered into three informal groups that need to be validated in future analyses: the *agayuara* group for Siluro-Devonian species that retain a “primitive” morphology, the *hamidi* group for comparatively small, Emsian to Eifelian species with convergences on *Otarion*, and the *ceratophthalmus* group which encompasses the type species of *Cyphaspis*, *C. ceratophthalmus* (Goldfuss, 1843), and similar species. Morphological trends in each of the groups are briefly elaborated on. Twelve new species are recorded from Morocco: *C. bluhmi* sp. nov., *C. eximia* sp. nov., *C. founzguidensis* sp. nov., *C. heisingi* sp. nov., *C. ihmadii* sp. nov., *C. juergenhollandi* sp. nov., *C. khraidensis* sp. nov., *C. kippingi* sp. nov., *C. lerougei* sp. nov., *C. maharchensis* sp. nov., *C. smeenki* sp. nov., *C. tadachachtensis* sp. nov. One additional species, *C. boninoi* sp. nov., is recorded from Belgium. Topotypical material of *C. ceratophthalmus* from Germany and the holotype of *C. goerlichii* (Haas, 1968) from Turkey are illustrated for comparisons to the other species. The holotype of *C. ceratophthalmus* could not be traced and a neotype is designated.

For the full text, see: <http://dx.doi.org/10.20341/gb.2016.008>.

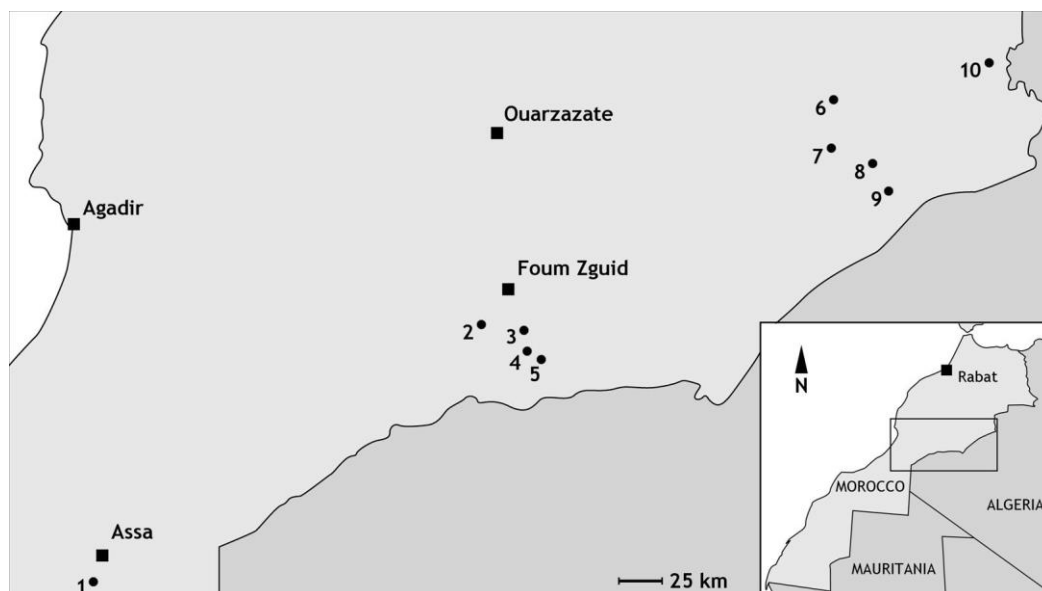


Figure 1. Simplified map of the studied area in Morocco. Localities are Tadachacht (1), Foun Zguid (2), Mdâour el Kbîr (3), Khraid (4), Zguilma (5), Issoumour / Boudib (6), Oufatène (7), Maharch (8), Zireg (9) and Talawarite (10).

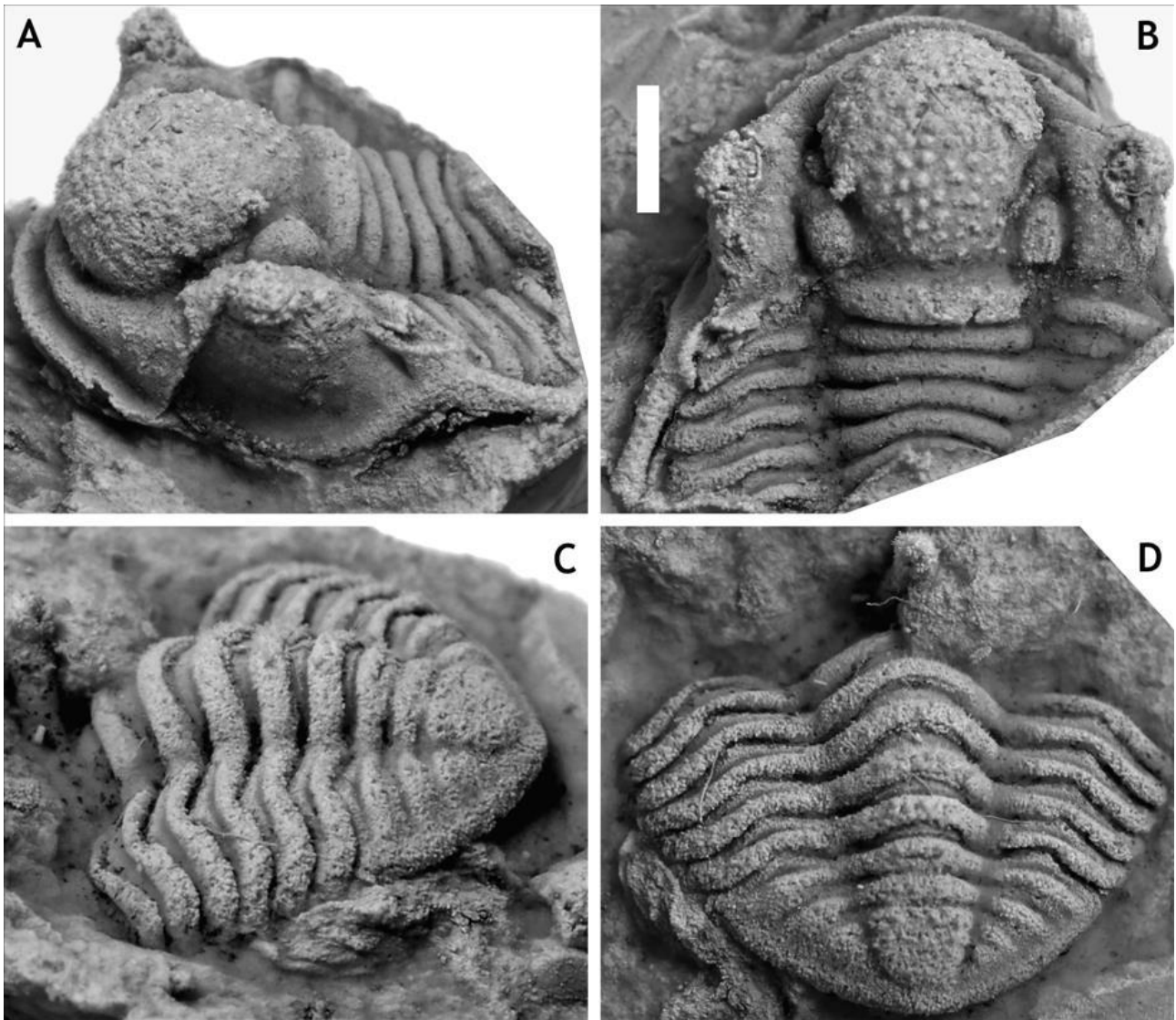


Figure 2. *Cyphaspis* sp. J. from the Chavées Member, Jemelle Formation at Jemelle, middle Eifelian, Belgium. Silicone cast of external mould of a complete specimen IRSNB a13022, in anterolateral (A), dorsal (B) views on cephalon, and lateral (C), dorsal (D) views on pygidium. Scale bar is 2 mm.

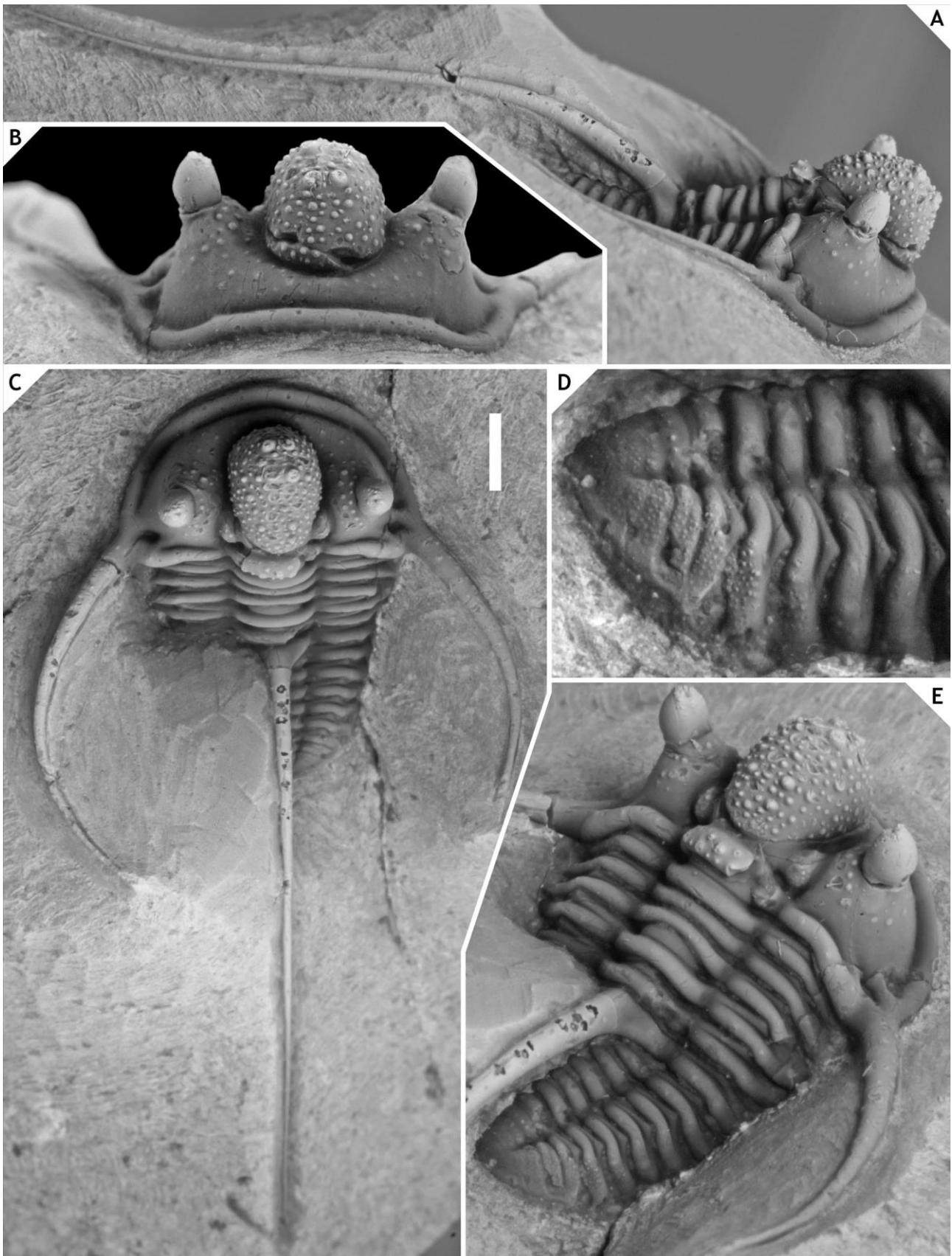


Figure 3. *Cyphaspis ceratophthalmus* (Goldfuss, 1843) from the Gees Subformation, Ahrdorf Formation at the Trilobitenfelder, middle Eifelian, Germany. Complete specimen (proposed neotype) IRSNB a13017, in lateral (A), anterior (B), oblique dorsal (C), close-up of pygidium (D), oblique posterolateral (E) views. Scale bar is 2 mm.



Figure 4. *Cyphaspis ceratophthalmus* (Goldfuss, 1843) from the Gees Subformation, Ahrdorf Formation at the Trilobitenfelder, middle Eifelian, Germany. Complete specimen (neotype) IRSNB a13017 in dorsal view. Scale bar is 2 mm. The brownish colour is common among trilobites from this locality.

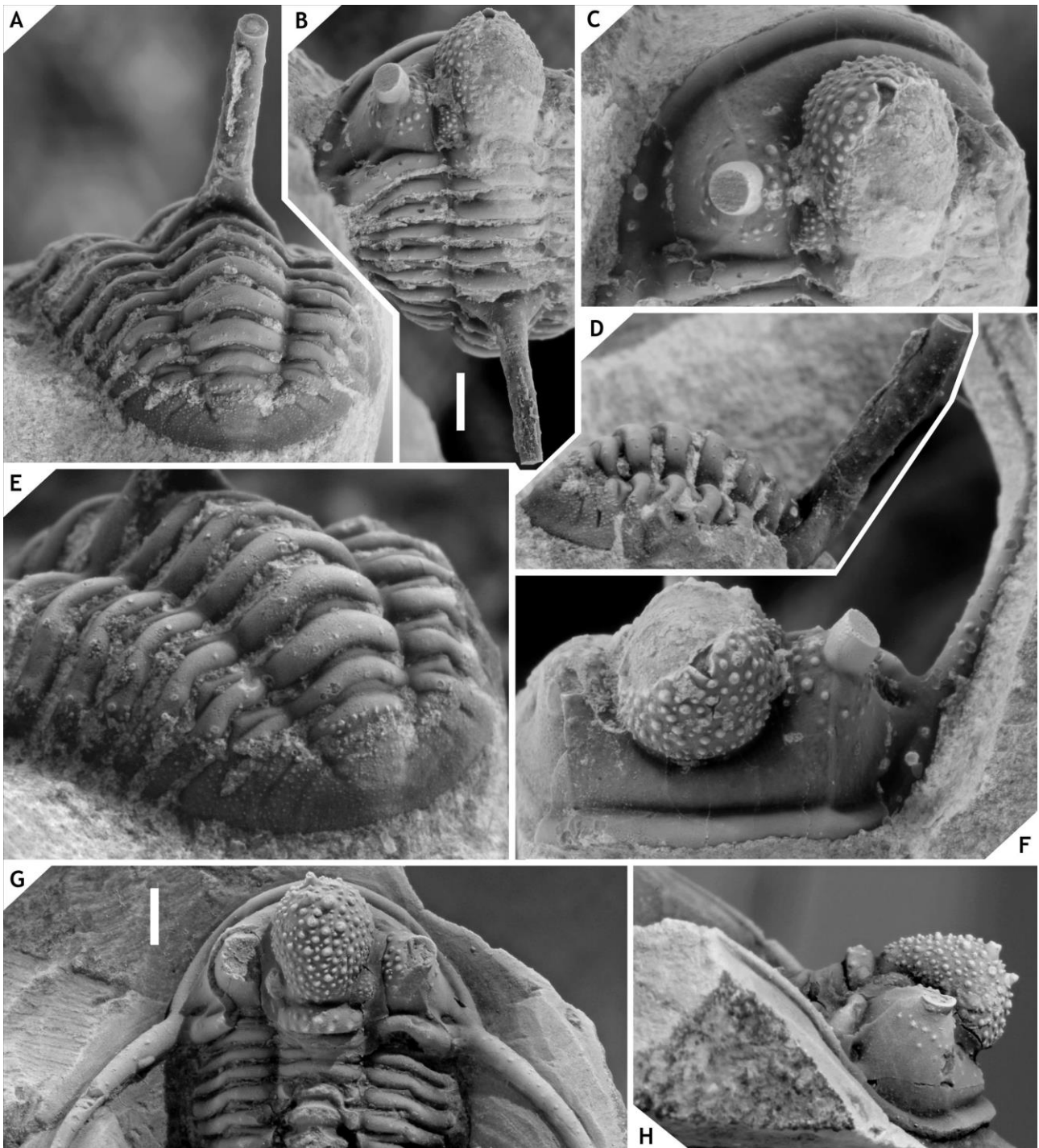


Figure 5. *Cyphaspis ceratophthalmus* (Goldfuss, 1843) from the Gees Subformation, Ahrdorf Formation at the Trilobitenfelder, middle Eifelian, Germany. Complete specimen IRSNB a13018, in posterior (A), dorsal (B), dorsal close-up of cephalon (C), lateral close-up of pygidium and posterior part of thorax (D), oblique posterolateral (E), anterior (F) views. Complete specimen NHMM 197954, in dorsal (G) and lateral (H) views (the right axial furrow of the cranidium is filled with glue). Scale bars are 2 mm.

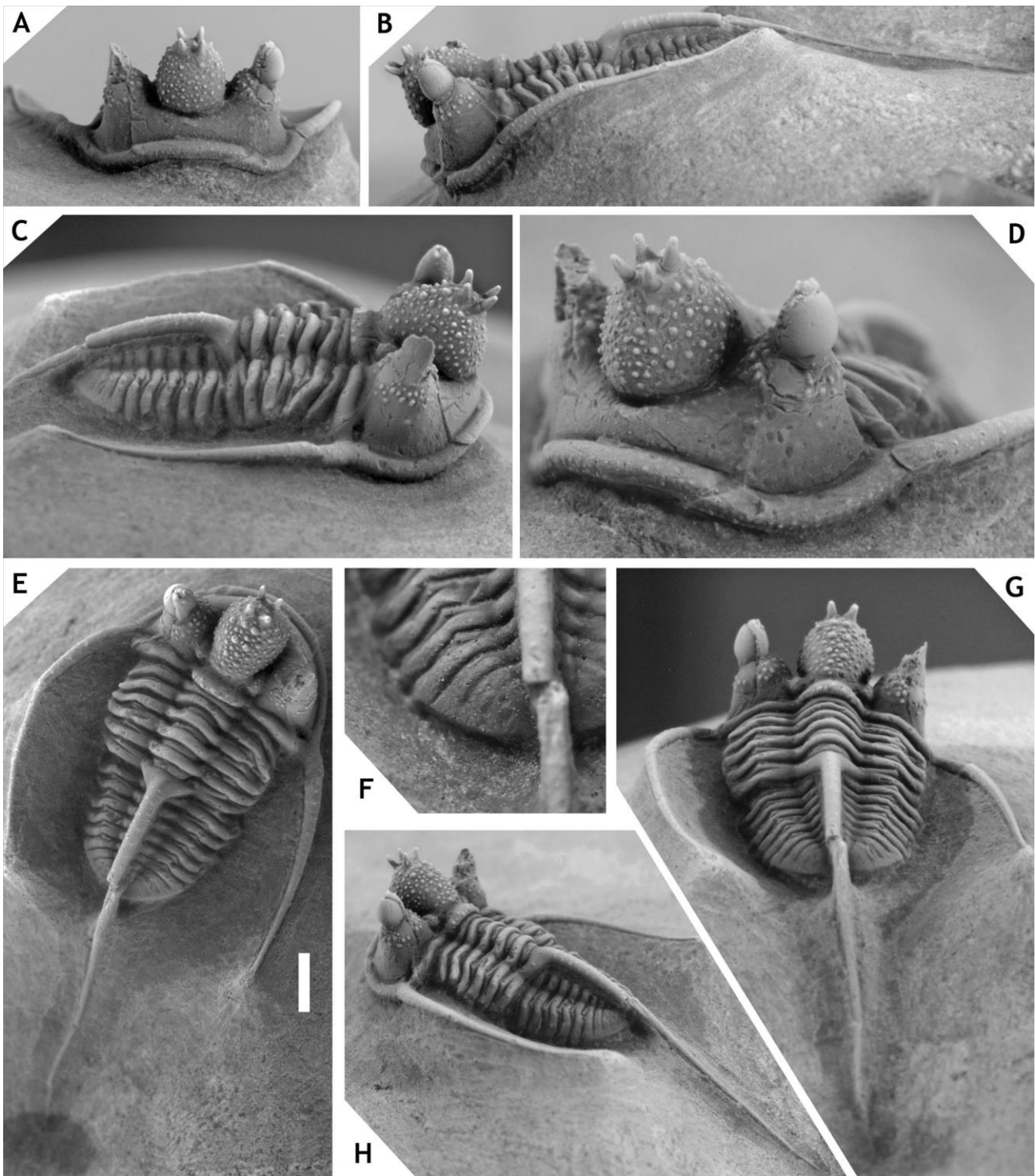


Figure 6. *Cyphaspis eximia* sp. nov. from 15 m above the “*Diademaproetus couche*” at Oufatène, Eifelian, Morocco. Holotype complete specimen IRSNB a13010, in anterior (A), lateral (B), oblique lateral (C), anterolateral (D), dorsal (E), close-up of pygidium (F), posterolateral (H), posterior (G) views. Scale bar is 2 mm.

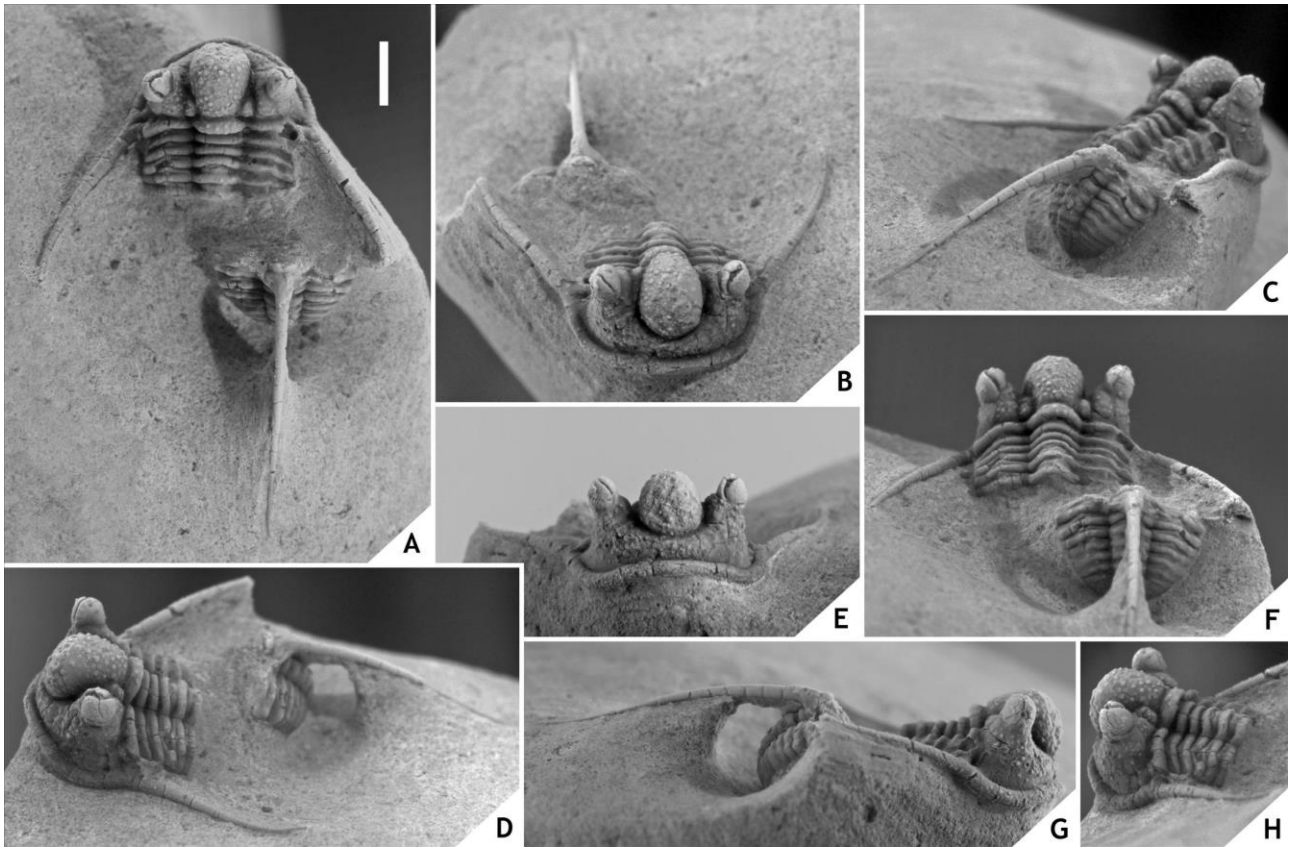


Figure 7. *Cyphaspis bluhmi* sp. nov. from 15 m above the “*Ceratarges couche*”, ?Taboumakhloûf Formation, at Zireg, Eifelian, Morocco. Holotype complete specimen IRSNB a13003, in dorsal (A), oblique anterior (B), right posterolateral (C), oblique left lateral (D), anterior (E), posterior (F), right lateral (G), left posterolateral (H) views. Scale bar is 2 mm.

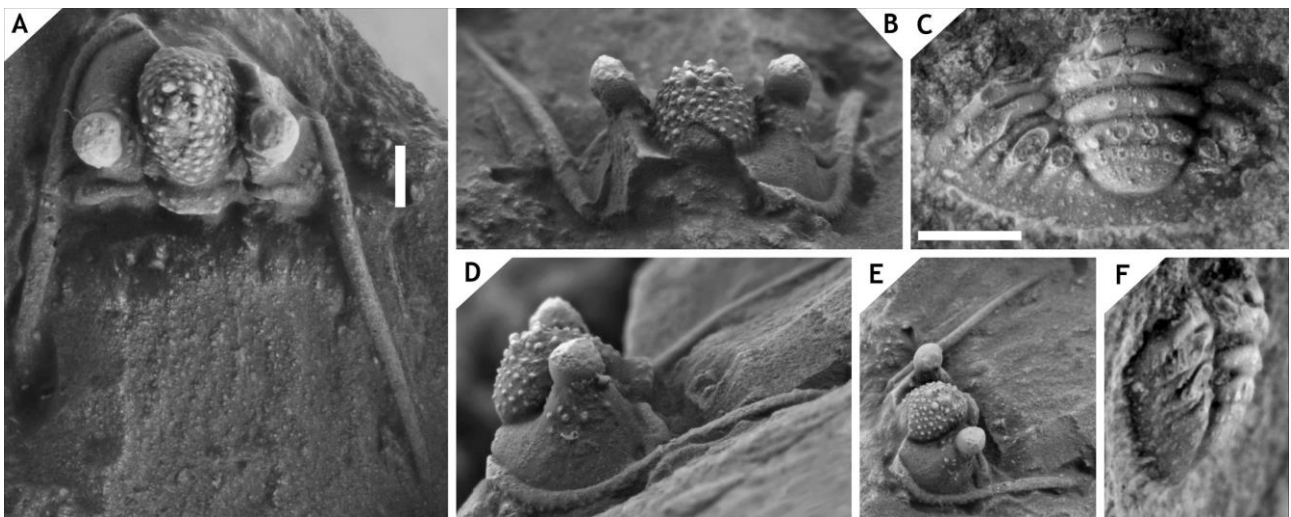


Figure 8. *Cyphaspis boninoi* sp. nov. from the lower part of the Hanonet Formation, at Resteigne, uppermost Eifelian, Belgium. Holotype cephalon IRSNB a13019, in oblique dorsal (A), anterior (B), lateral (D), oblique anterolateral (E) views. Scale bar is 2 mm. Paratype pygidium IRSNB a13020, in dorsal (C), lateral (F) views. Scale bar is 1 mm.

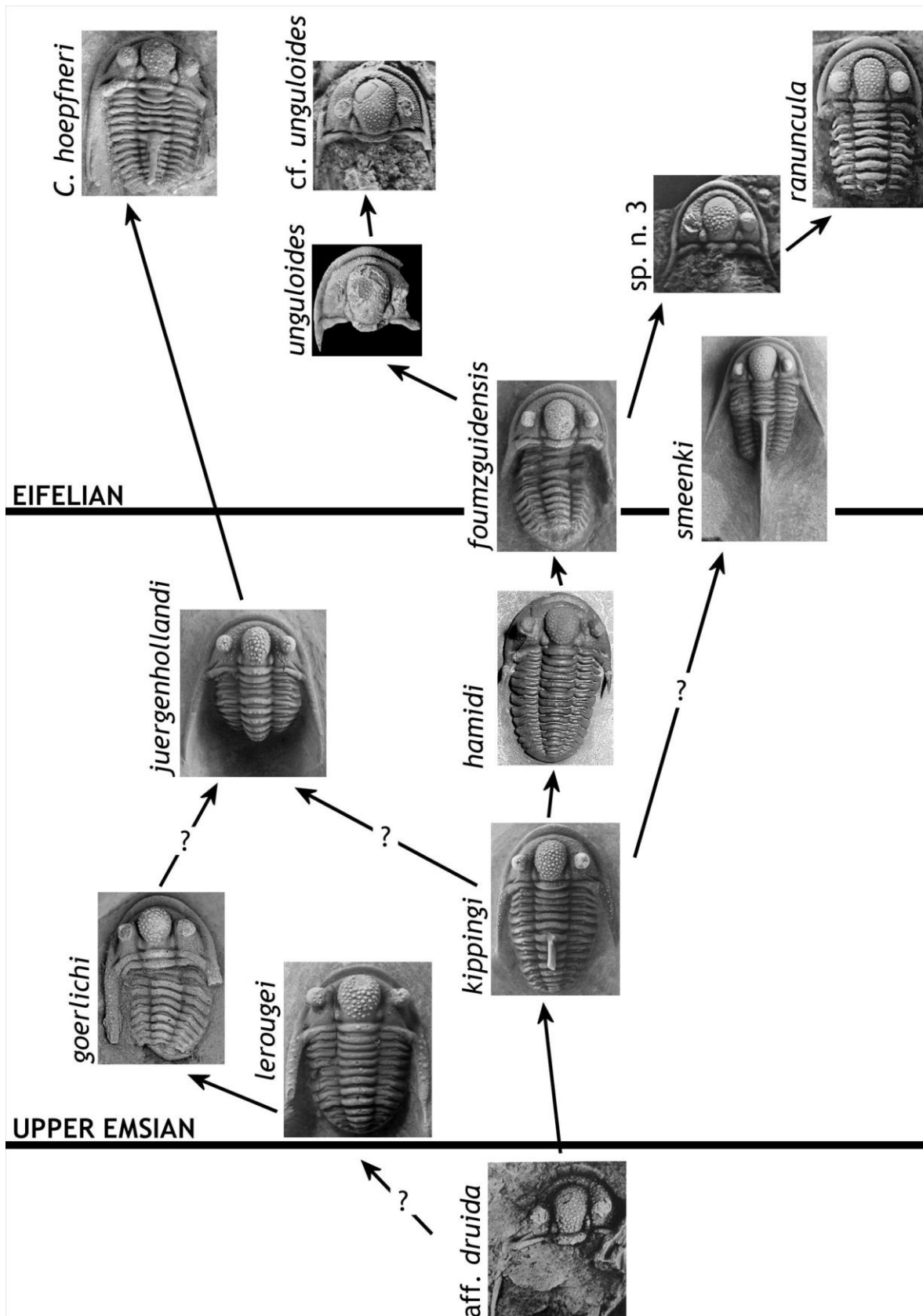


Figure 9. Hypothesised relationships between species of the *hamidi* group. Figures as far as they are not taken from the present note: *C. aff. druيدا* (Smeenk, 1983, pl. 21, fig. 4); *C. hamidi* (topo- and stratotypical; coll. DH); *C. unguiloides* (van Viersen & Prescher, 2007, pl. 1, fig. 2a); *C. hoepfneri* (van Viersen & Prescher, 2007, pl. 2, fig. 10a); *C. sp. n. 3* (Basse, 2002, pl. 29, fig. 588), *C. ranuncula* (holotype; Basse, 2002, pl. 29, fig. 597), *C. cf. unguiloides* (Basse, 2002, pl. 29, fig. 591). At the time of this writing there exists an undescribed species from the middle upper Emsian in Germany which could be ancestral to Eifelian *hamidi* group members in the Ardenno-Rhenish Mountains (M. Basse, pers. comm. in 2015).

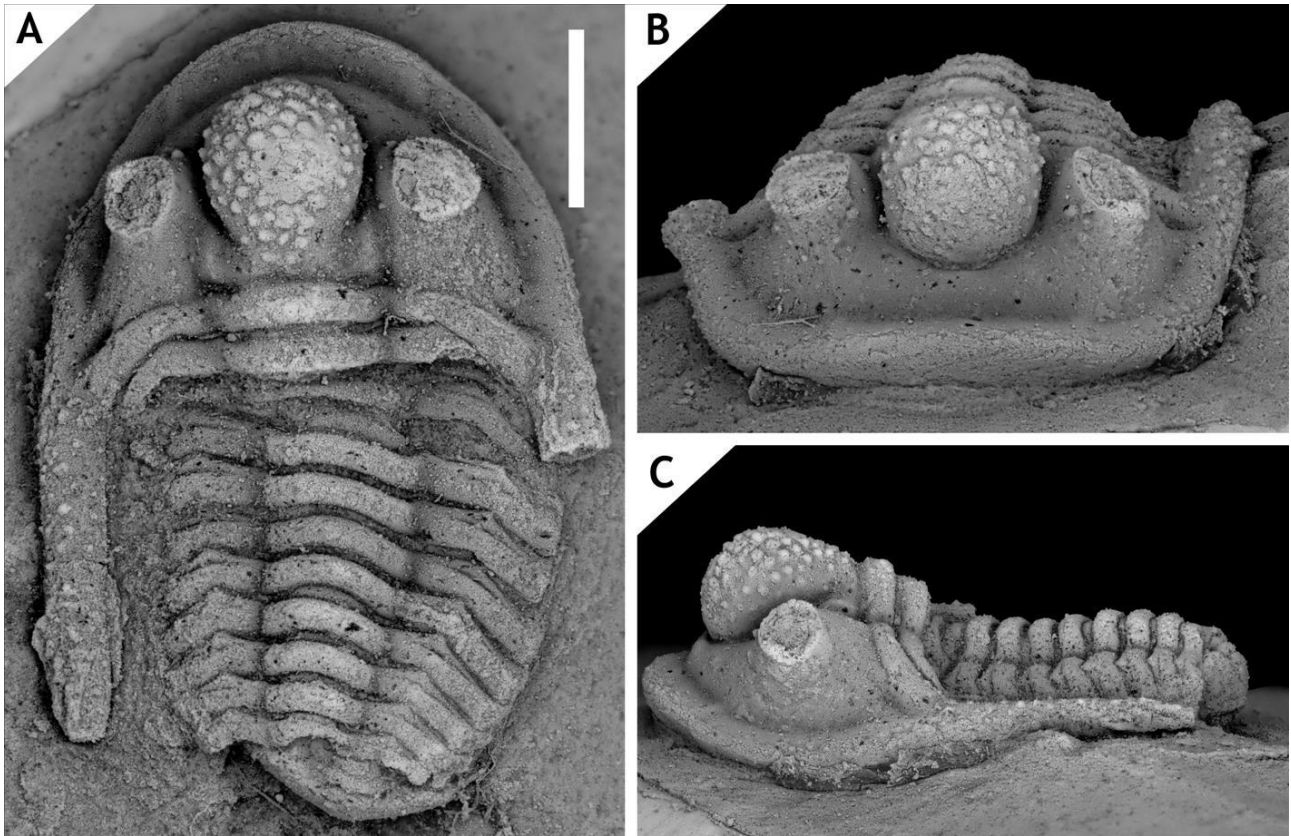


Figure 10. *Cyphaspis goerlichii* (Haas, 1968) from the Gebze Formation at Tuzla, upper Emsian, Turkey. Holotype complete specimen STIPB-HAAS-14/1, in dorsal (A), oblique anterior (B), lateral (C) views. Scale bar is 2 mm.

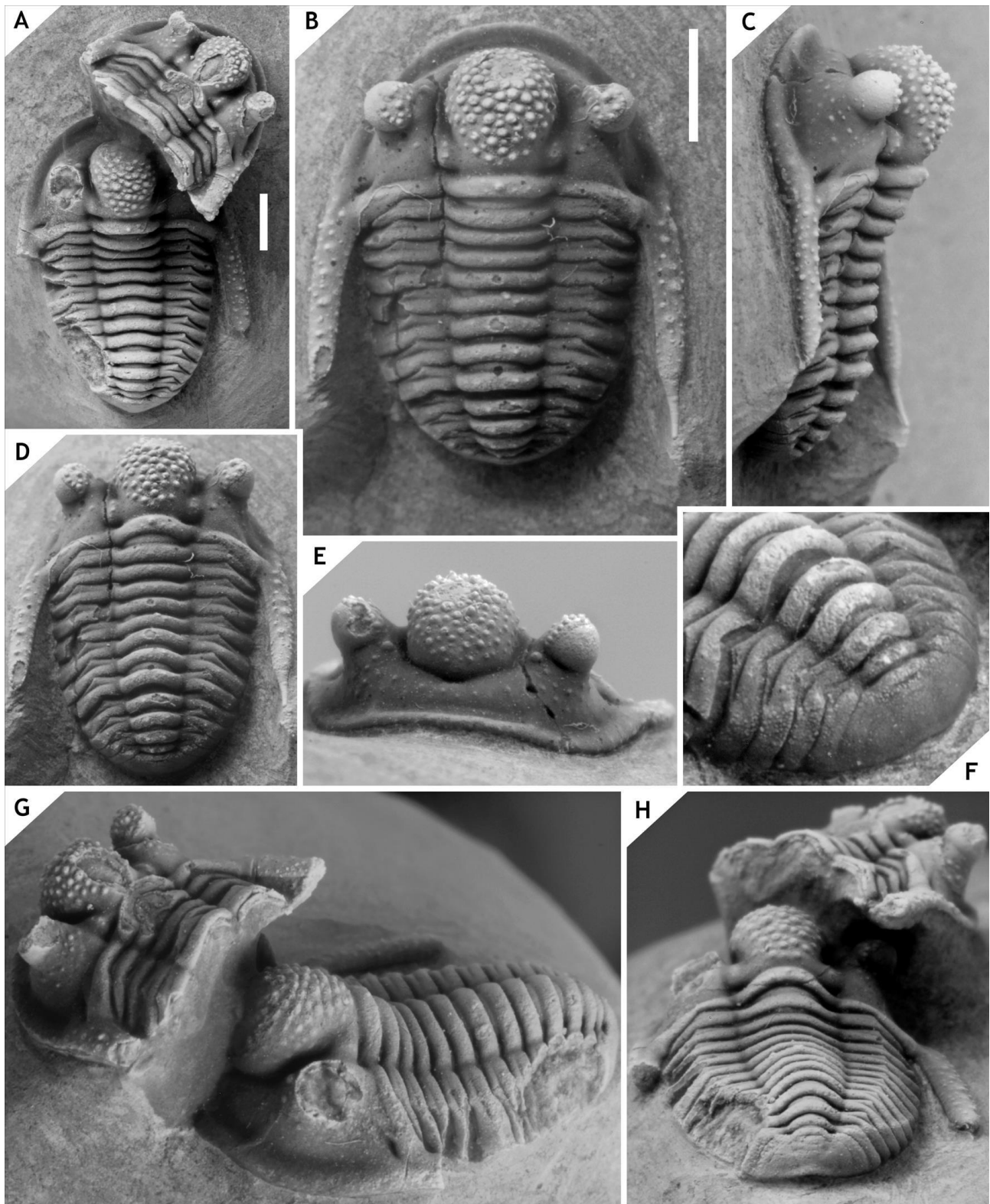


Figure 11. *Cyphaspis lerougei* sp. nov. from the *Hollandops* Limestone, Khebchia Formation, at Tadachacht, basalmost upper Emsian, Morocco. Paratype cephalon IRSNB a13015 and paratype complete specimen IRSNB a13016, in dorsal (A), lateral (G), posterior (H) views. Holotype complete specimen IRSNB a13014, in dorsal (B), lateral (C), oblique dorsal (D), oblique anterior (E), oblique posterolateral (F) views. All specimens are on a single rock slab. Scale bars are 2 mm.

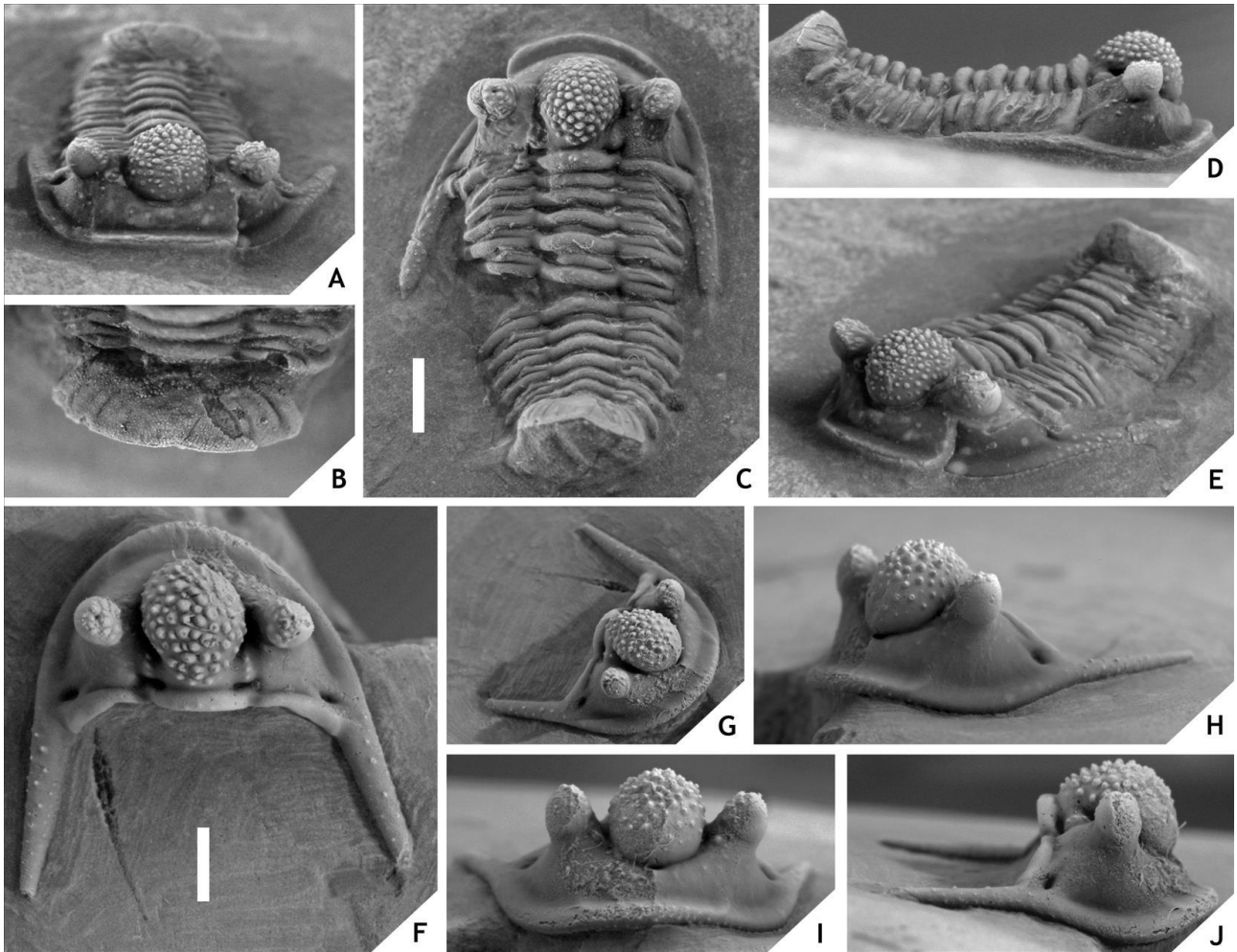


Figure 12. *Cyphaspis lerougei* sp. nov. from the *Hollardops* Limestone, Khebchia Formation, at Tadachacht, basalmost upper Emsian, Morocco. Paratype complete specimen IRSNB a12998, in anterior (A), close-up of pygidium (B), dorsal (C), lateral (D), anterolateral (E) views. Paratype cephalon IRSNB a12999, in dorsal (F), oblique anterolateral (G), anterolateral (H), anterior (I), lateral (J) views. Scale bars are 2 mm.

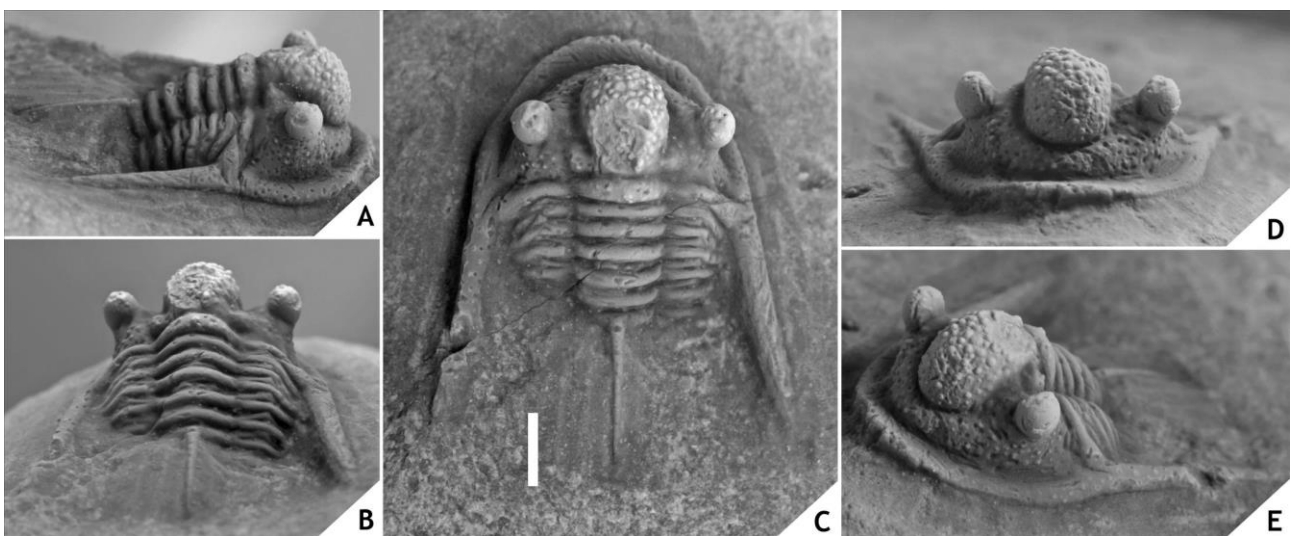


Figure 13. *Cyphaspis* cf. *lerougei* sp. nov. of uncertain stratigraphic origin (Emsian?), at Jbel Issoumour, Morocco. Complete specimen IRSNB a13000, in lateral (A), posterior (B), dorsal (C), anterior (D), oblique anterolateral (E) views. Scale bar is 2 mm.

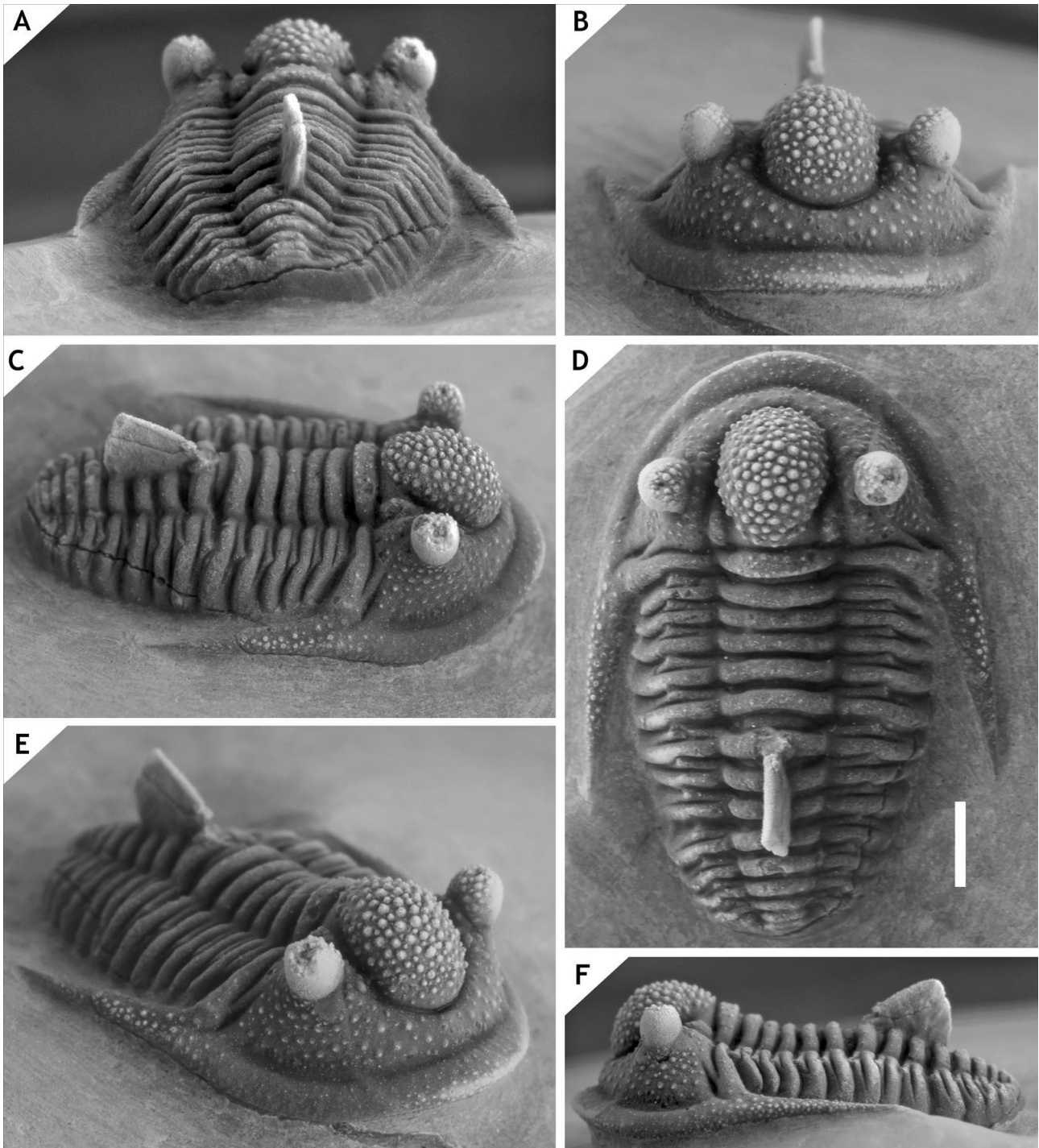


Figure 14. *Cyphaspis kippingi* sp. nov. from level just below the “*Psychopyge couche*”, Tazoulait Formation, at Issoumour1, upper Emsian, Morocco. Holotype complete specimen IRSNB a13012, in posterior (A), anterior (B), oblique lateral (C), dorsal (D), oblique anterolateral (E), lateral (F) views. Scale bar is 2 mm.

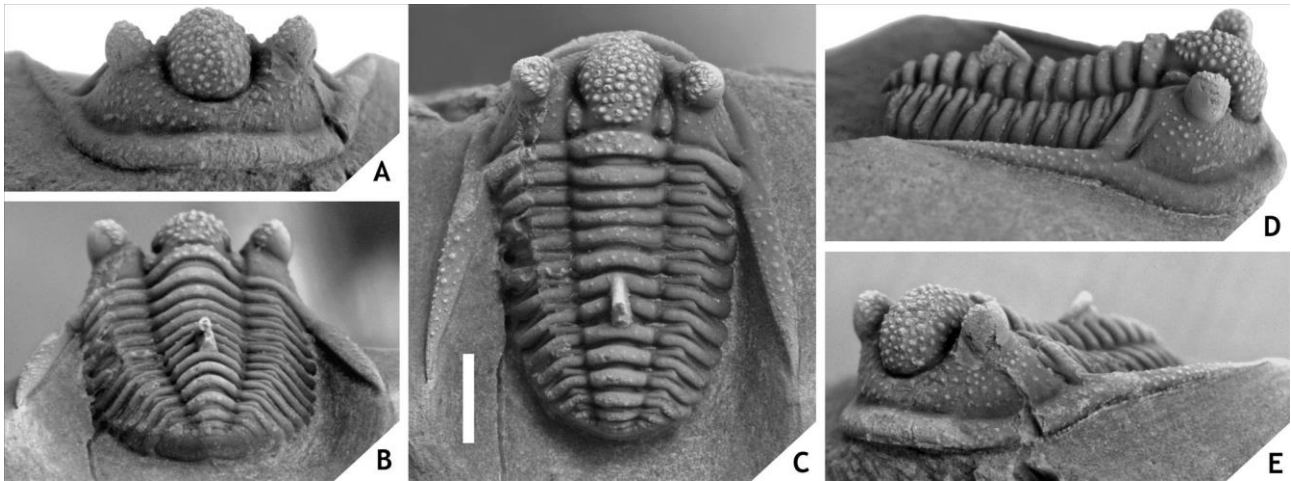


Figure 15. *Cyphaspis kippingi* sp. nov. presumably from level just below the “*Psychopyge couche*”, Tazoulait Formation, at Issoumour1, upper Emsian, Morocco. Paratype complete specimen IRSNB a12997, in anterior (A), posterior (B), dorsal (C), lateral (D), anterolateral (E) views. Scale bar is 2 mm.

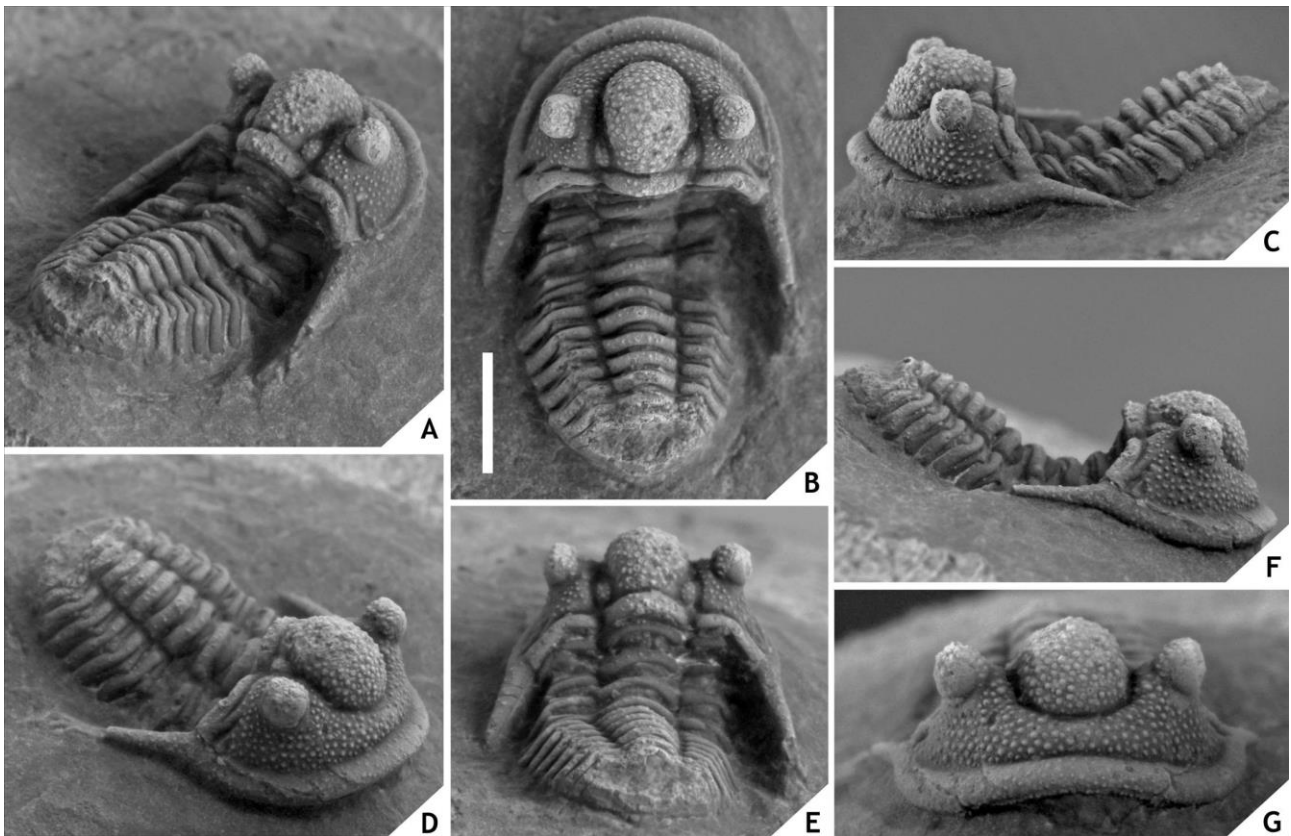


Figure 16. *Cyphaspis fouzguidensis* sp. nov. from ZGEE3, Timrhanhart Formation, at Fouz Zguid, lower Eifelian, Morocco. Holotype complete specimen IRSNB a12996, in oblique posterolateral (A), dorsal (B), left lateral (C), oblique anterolateral (D), posterior (E), right lateral (F), anterior (G) views. Scale bar is 2 mm.

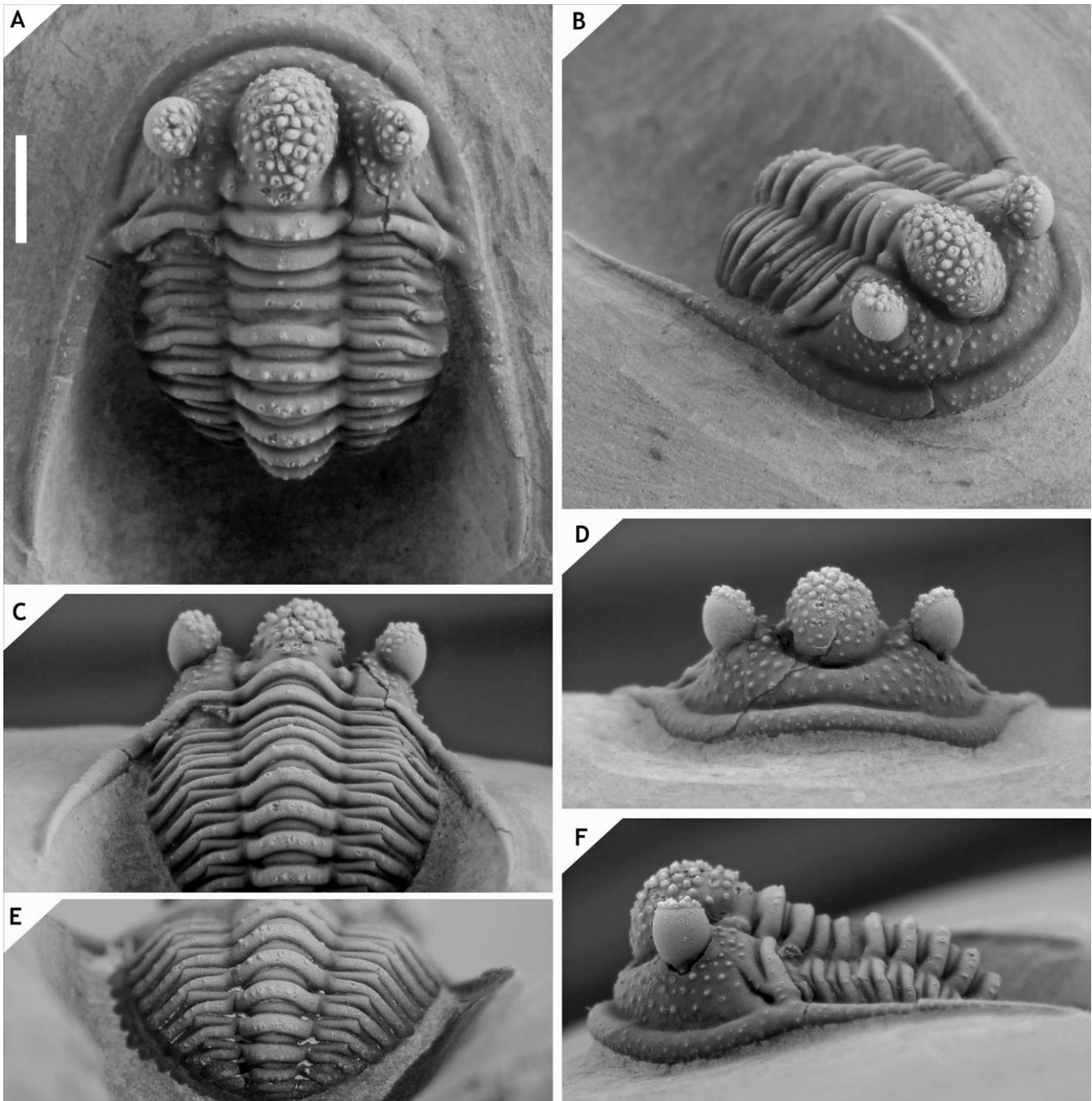


Figure 17. *Cyphaspis juergenhollandi* sp. nov. from interval between the “*Gerastos* and *Hollardops* couches”, Amerboh Group, at Talawarite, upper Emsian, Morocco. Holotype complete specimen IRSNB a13013, in dorsal (A), oblique anterolateral (B), close-up of first nine thorax segments (C), anterior (D), close-up of thorax from sixth segment and including pygidium (E), lateral (F) views. Scale bar is 2 mm.

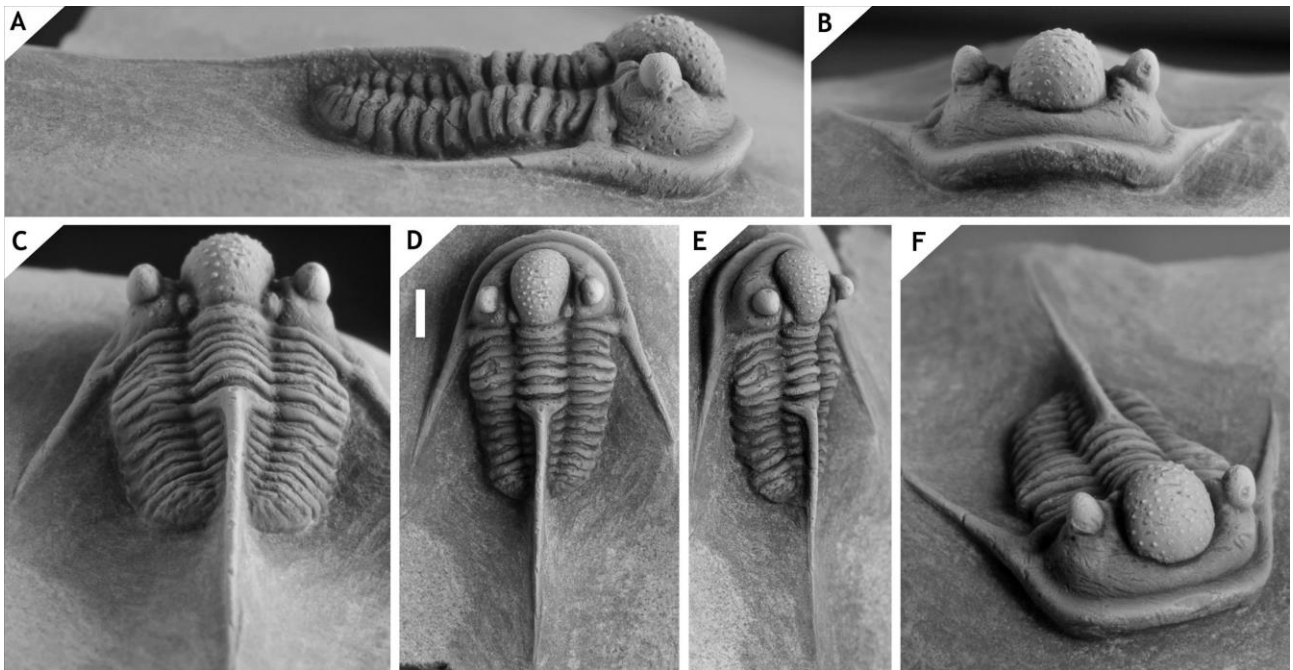


Figure 18. *Cyphaspis smeenki* sp. nov. from the El Otfal Formation at Boudib, Eifelian, Morocco. Holotype complete specimen IRSNB a13009, in lateral (A), anterior (B), posterior (C), dorsal (D), oblique lateral (E), oblique anterolateral (F) views. Scale bar is 2 mm.

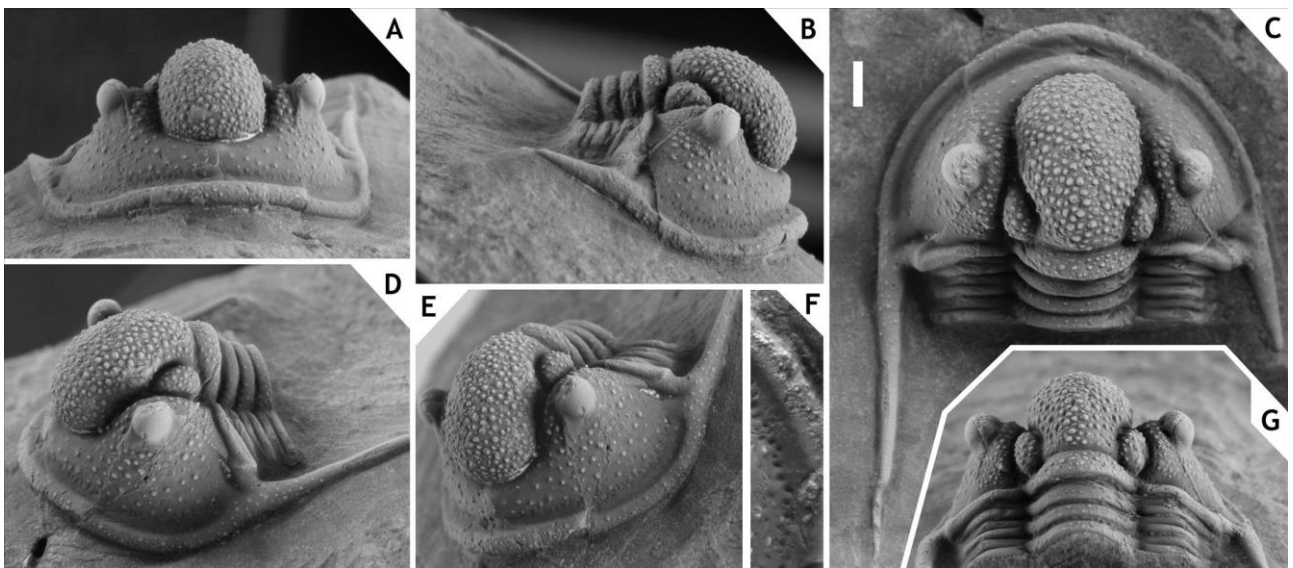


Figure 19. *Cyphaspis* sp. I, from the Eifelian or Givetian at Jbel Issoumour, Morocco. Cephalon with attached thorax segments IRSNB a13008, in anterior (A), lateral (B), oblique dorsal (C), anterolateral (D), oblique anterolateral (E), close-up of right librigenal border furrow with row of pits (F), posterior (G) views. Scale bar is 2 mm. Notice the anomalous right genal spine.

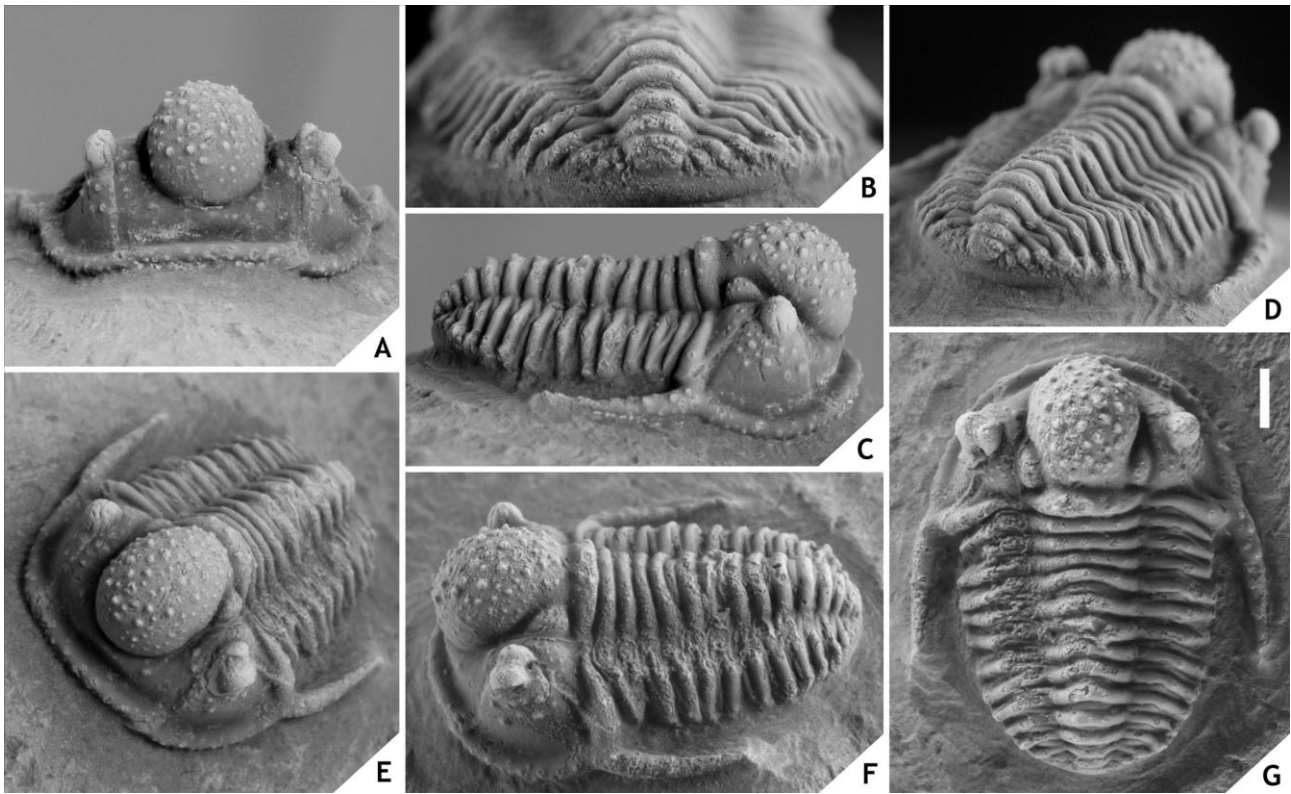


Figure 20. *Cyphaspis maharchensis* sp. nov. from the “Proetid couche”, Ihandar Formation, at Maharch, Pragian, Morocco. Holotype complete specimen IRSNB a13007, in anterior (A), posterior (B), lateral (C), posterolateral (D), oblique anterolateral (E), oblique lateral (F), dorsal (G) views. Scale bar is 2 mm.

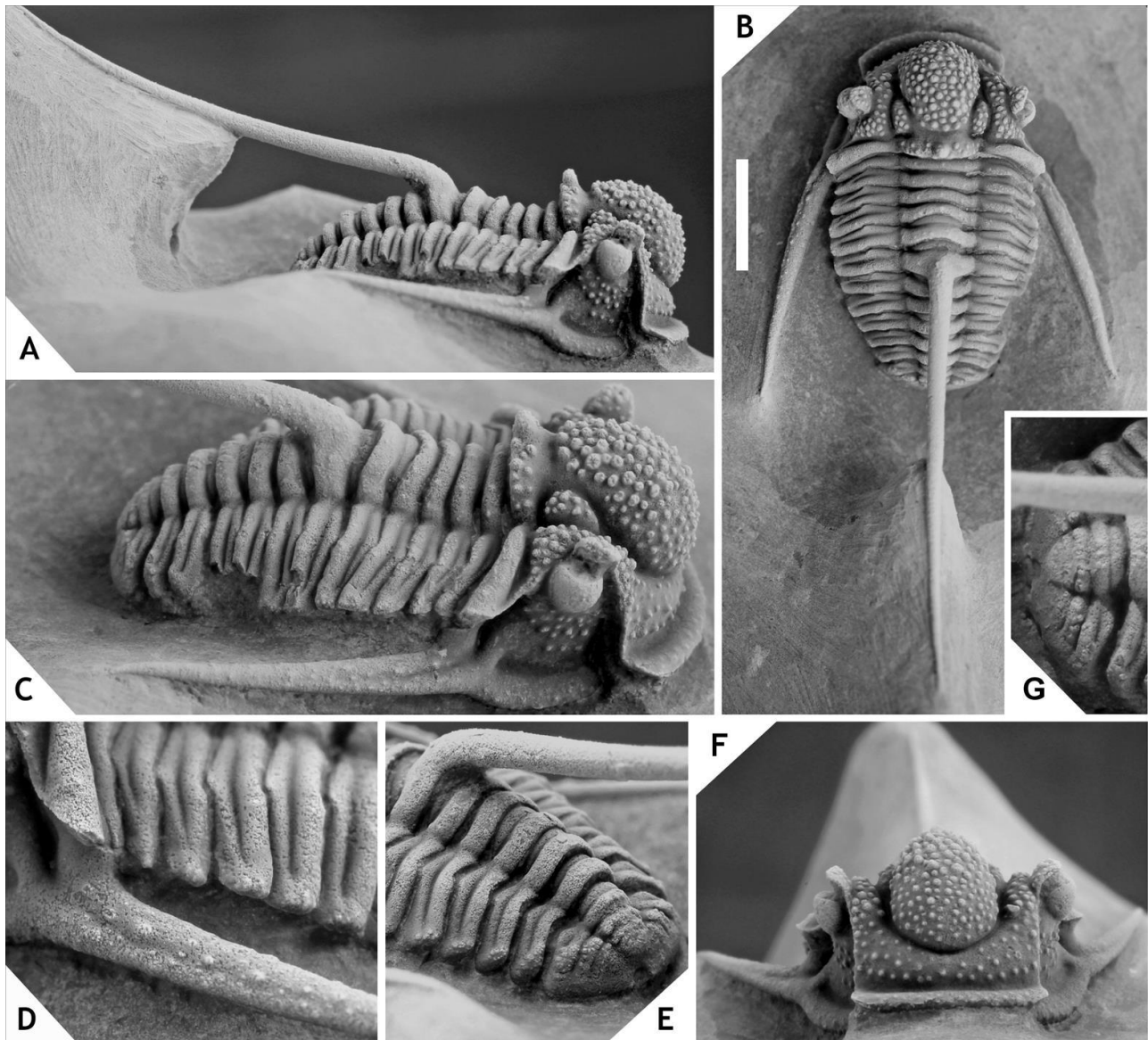


Figure 21. *Cyphaspis heisingi* sp. nov. from the Assa Formation at Mdâour el Kbîr, Pragian, Morocco. Holotype complete specimen IRSNB a13011, in lateral (A), dorsal (B), oblique lateral (C), close-up of left genal spine and anterior five thoracic pleurae (D), oblique posterolateral (E), anterior (F), close-up of pygidium (G) views. Scale bar is 5 mm.

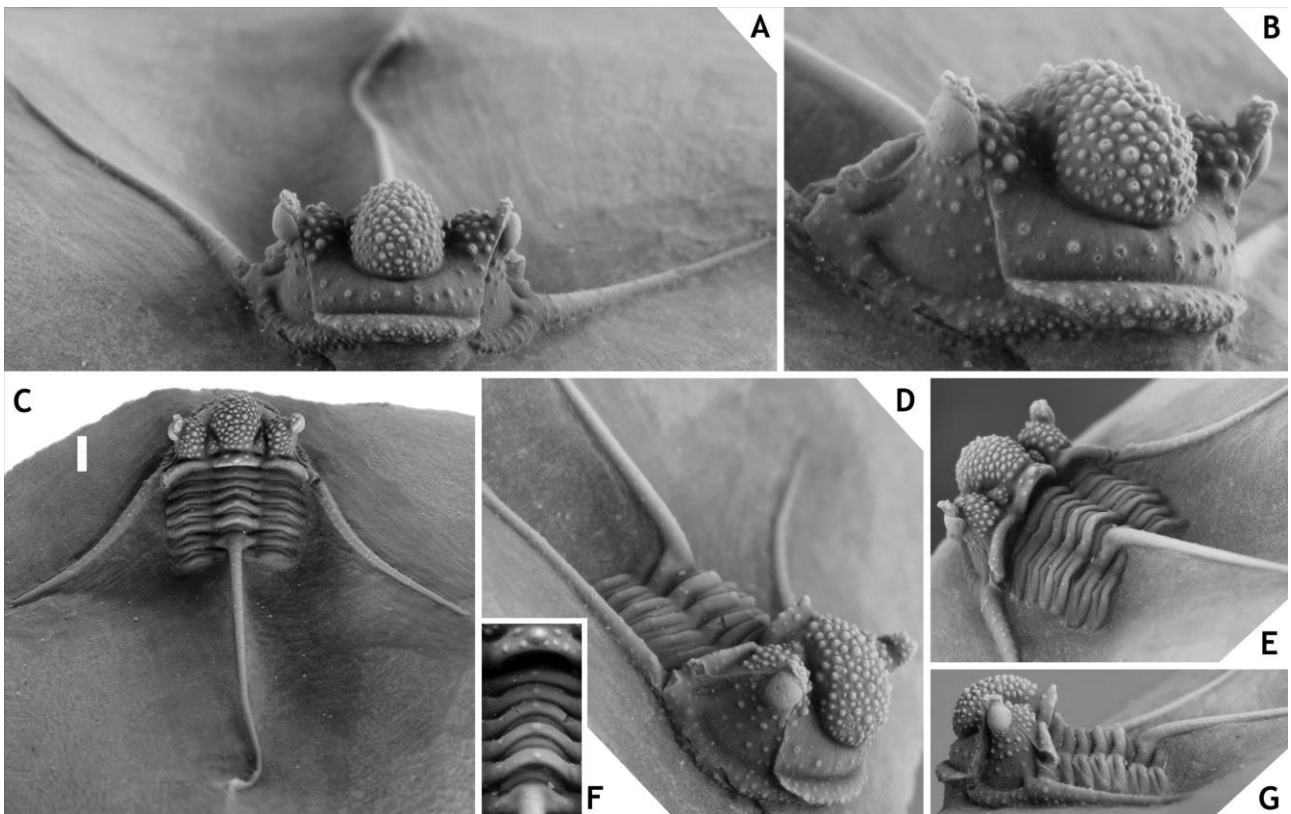


Figure 22. *Cyphaspis agayuara* Chatterton et al., 2006 from interval between the “*Gerastos* and *Hollandops* couches”, Amerboh Group at Talawarite, upper Emsian, Morocco. Cephalon with seven tergites attached IRSNB a13005, in anterior (A), anterolateral (B), dorsal (C), oblique anterolateral (D), oblique posterolateral (E), close-up of occipital ring and anterior six thoracic axial rings (F), lateral (G) views. Scale bar is 2 mm.

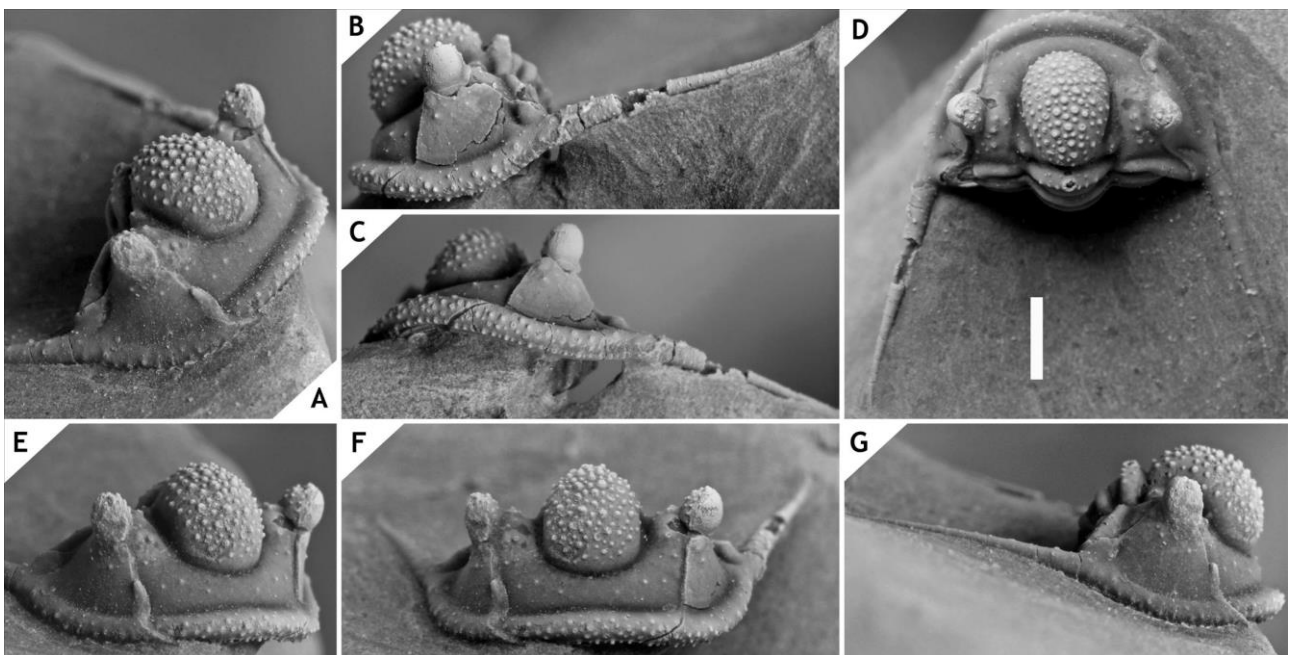


Figure 23. *Cyphaspis cf. eberhardiei* Chatterton et al., 2006 from ZGEE3, Timrhanrhart Formation, at Fom Zguid, lower Eifelian, Morocco. Enrolled specimen IRSNB a13001, in oblique anterolateral (A), left lateral (B), ventral close-up of cephalic border (C), oblique dorsal (D), anterolateral (E), anterior (F), right lateral (G) views. Scale bar is 2 mm.

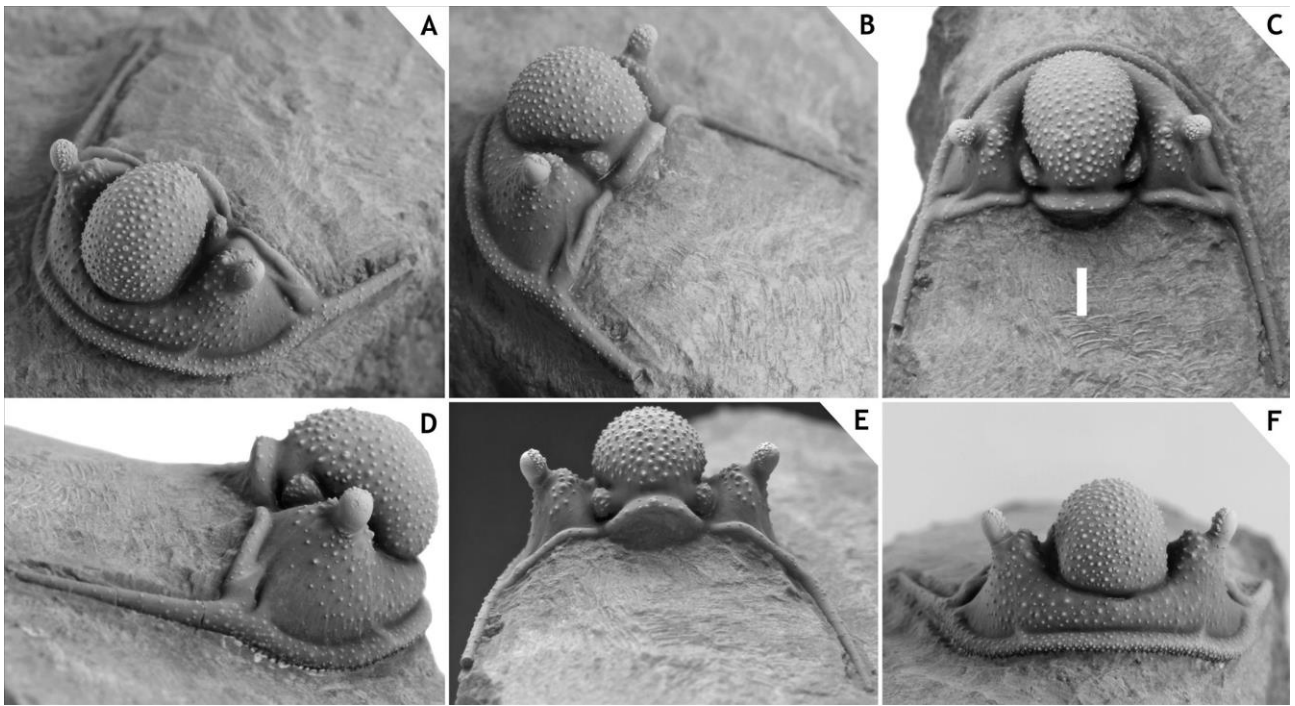


Figure 24. *Cyphaspis khraidensis* sp. nov. from ZGEE2, Timrhanrhart Formation, at Khraid, upper Emsian, Morocco. Holotype cephalon IRSNB a13004, in oblique anterolateral (A), oblique posterolateral (B), dorsal (C), lateral (D), posterior (E), anterior (F) views. Scale bar is 2 mm.

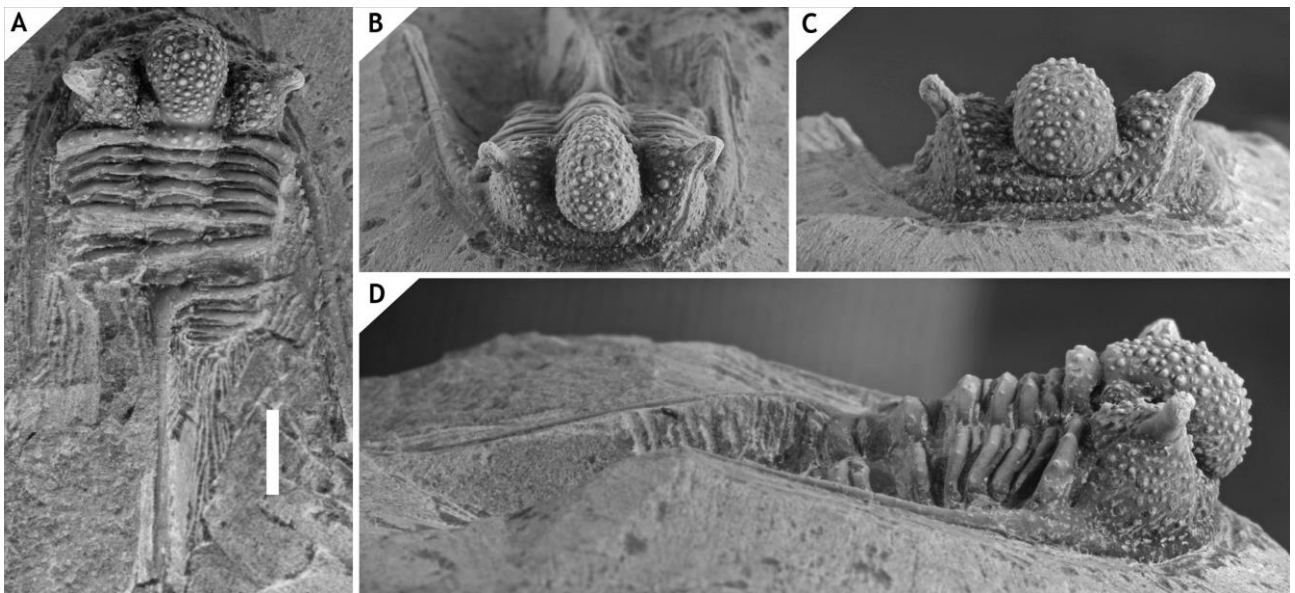


Figure 25. *Cyphaspis* cf. *khraidensis* sp. nov., presumably from the Emsian at Issoumour1, Morocco. Complete specimen IRSNB a13006, in oblique dorsal (A), oblique anterior (B), anterior (C), lateral (D) views. Scale bar is 5 mm.

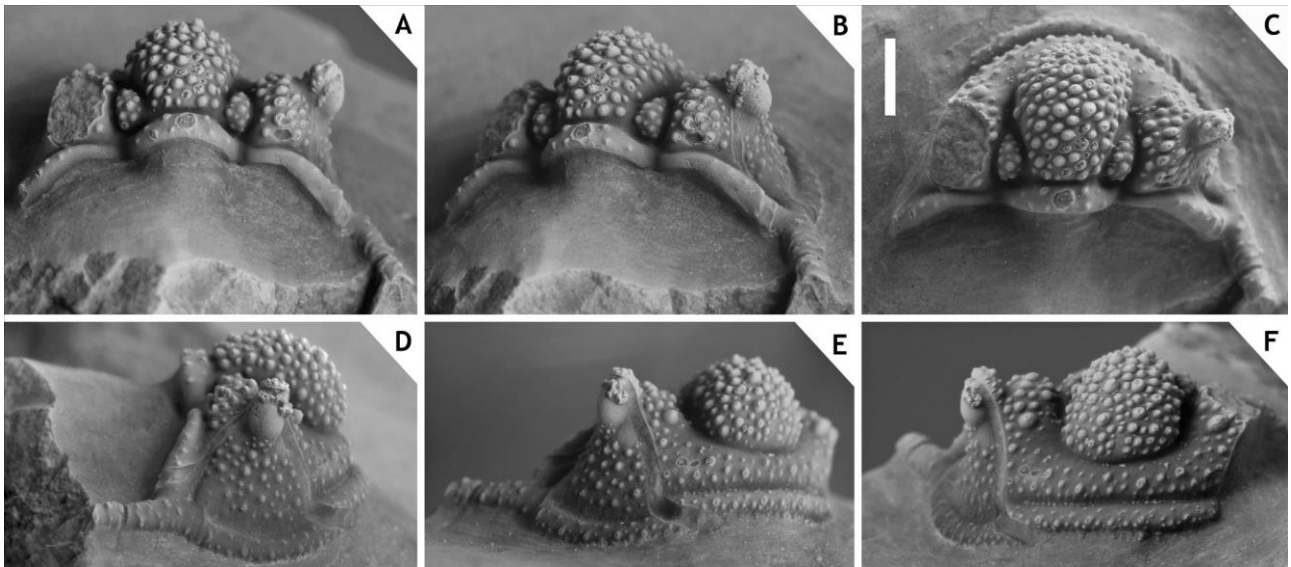


Figure 26. *Cyphaspis tadachachtensis* sp. nov. from the Khebchia Formation, at Tadachacht, upper Emsian, Morocco. Holotype incomplete cephalon IRSNB a13002, in posterior (A), oblique posterior (B), dorsal (C), lateral (D), anterolateral (E), anterior (F) views. Scale bar is 2 mm.

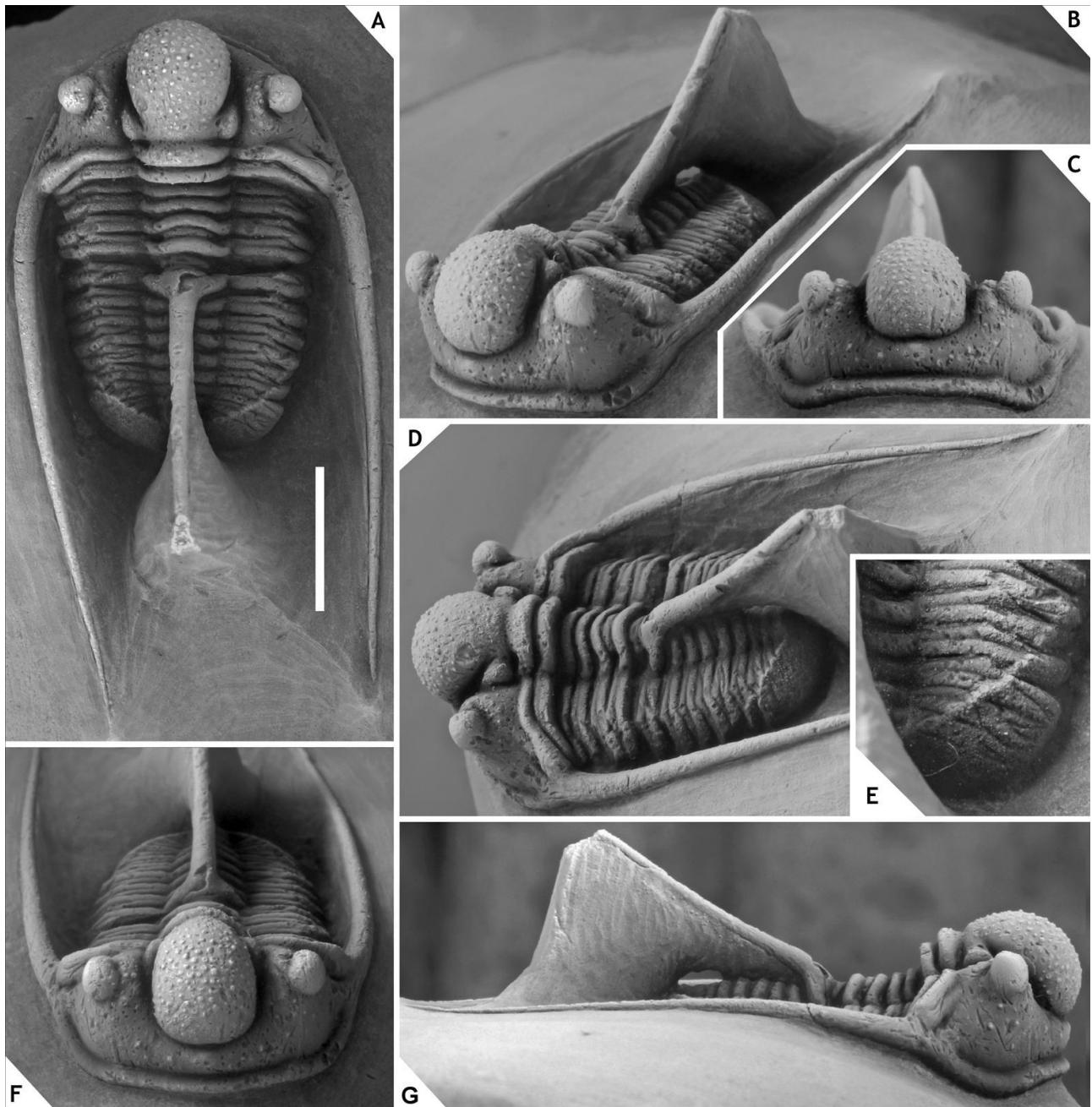


Figure 27. *Cyphaspis ihmadii* sp. nov. from the lower “*Radiaspis couche*”, Bou Dîb Formation, at Issoumour2, Givetian, Morocco. Holotype complete specimen IRSNB a13021, in dorsal (A), oblique anterolateral (B), anterior (C), oblique lateral (D), close-up of pygidium (E), oblique anterior (F), lateral (G) views. Scale bar is 5 mm.