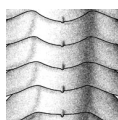


A new arthropod from the lower Cambrian Sirius Passet Fossil-Lagerstätte of North Greenland

JOHN S. PEEL & MARTIN STEIN



Aaveqaspis inesoni gen. et sp. nov., is described from the lower Cambrian Sirius Passet Fossil-Lagerstätte of Peary Land, North Greenland. It has a semicircular head shield and a thorax with 5 tergites. The tail shield carries 2 pairs of spines, the most anterior of which is enormous and dominates the trunk. *A. inesoni* lacks any preserved trace of eyes, as is also the case with several other Sirius Passet arthropods, suggesting that the fossils accumulated in deeper water than the contemporaneous Chengjiang Fossil-Lagerstätte of China or the middle Cambrian Burgess Shale assemblages of British Columbia. • Key words: Cambrian, arthropod, Sirius Passet, Lagerstätte, Greenland.

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Black laminated mudstones and siltstones juxtaposed against the prominent buried escarpment of an eroded carbonate platform in Peary Land, North Greenland (Fig. 1), yield the rich fossil assemblage comprising the Sirius Passet Fossil-Lagerstätte (Conway Morris *et al.* 1987, Conway Morris 1998, Babcock & Peel 2007). The geological setting is similar to that of the middle Cambrian Burgess Shale of British Columbia (see summary by Hagadorn 2002). The North Greenland fossils, however, are of early Cambrian age (Cambrian Series 2, Stage 3), and thus some 10 my older than the Burgess Shale. As such, the Sirius Passet biota is the oldest major Fossil-Lagerstätte from the Cambrian of Laurentia and equivalent in age to the Chengjiang Fossil-Lagerstätte of southern China (Chen 2004, Hou *et al.* 2004). The Sirius Passet Fossil-Lagerstätte occurs within the Buen Formation which overlies the carbonate platform dolomites of the Portfjeld Formation throughout central North Greenland (Fig. 1B; Peel & Sønderholm 1991, Ineson & Peel 1997).

The Sirius Passet biota is dominated by arthropods with unmineralized cuticle, some of which have been described in publications by Budd (1993, 1995, 1997, 1998, 1999a, b), Budd & Peel (1998), Williams *et al.* (1996), Taylor (2002), Stein (in press), Stein *et al.* (in press) and Lagebro *et al.* (2009). Other finds include sponges (Rigby 1986), the earliest annelids (Conway Morris & Peel 2008), palaeoscolecids and articulated halkieriids (Conway Morris & Peel 1990, 1995; Vinther & Nielsen 2005). The most conspicuous taxon

with biomineralized hard parts is the trilobite *Buenellus* Blaker, 1988 which, although restricted to this locality (Blaker & Peel 1997), indicates the *Nevadella* Zone of the early Cambrian of North American usage, equivalent to Series 2 (Stage 3) of the developing chronostratigraphic scale for the Cambrian (Babcock *et al.* 2005, Zhu *et al.* 2006).

In this paper we describe a new arthropod species, *Aaveqaspis inesoni* gen. et sp. nov., from the Sirius Passet Fossil-Lagerstätte that is characterised by a pair of exceptionally large spines on the tail shield, comprising more than 40% of the total body length. While not preserving limbs or traces of the digestive tract known from some members of the biota, *A. inesoni* is similar to several other co-occurring arthropods in lacking evidence of eyes. Ivantsov *et al.* (2005) speculated that the absence of the frondose algae which are conspicuous in the Burgess Shale and Chengjiang Fossil-Lagerstätten suggested that the Sirius Passet biota lived in deeper water. The lack of preserved evidence for visual organs in the majority of benthic elements of the arthropod fauna is in line with that hypothesis, although eyes were developed in the trilobite *Buenellus higginsi* Blaker, 1988 (Blaker & Peel 1997, Babcock & Peel 2007). A putative eye is reported from the presumed pelagic *Isoxys volucris* Williams, Siveter & Peel, 1996 (Stein *et al.* in press).

The tergites in all 3 known specimens of *Aaveqaspis inesoni*, as preserved, are imbricated such that low angle light in the illustrations (Figs 2A, 3A, B) strikes the raised

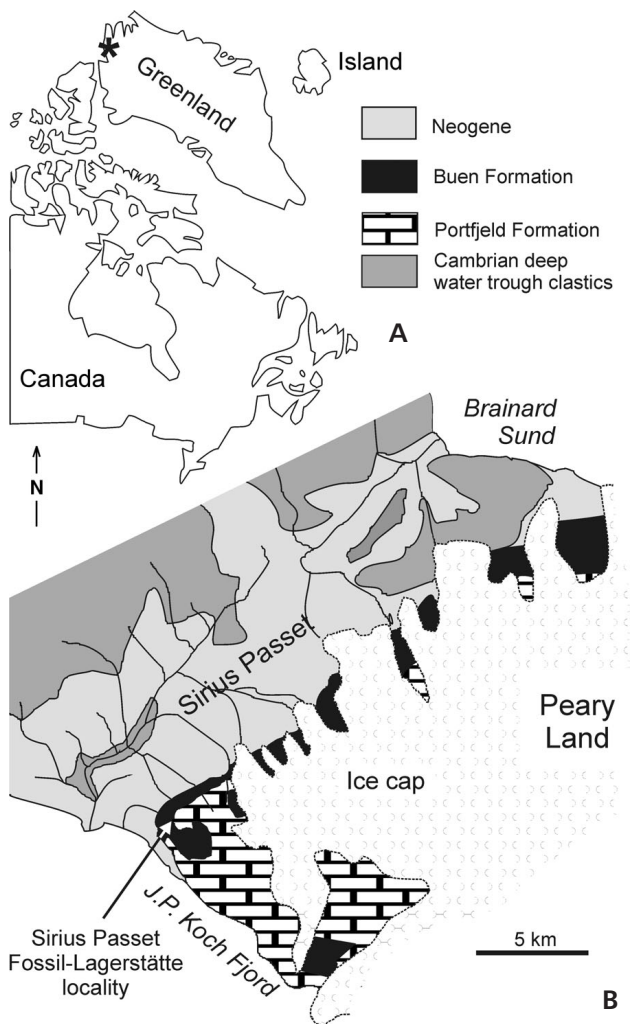


Figure 1. Location of the Sirius Passet Fossil-Lagerstätte in North Greenland (A) with geological map of the area around the locality (B).

anterior margin of each following tergite as it overlies the preceding one. In life, in dorsal view, the anterior margin of each tergite is overlain by the posterior margin of the preceding tergite. Thus, all three specimens are interpreted as external moulds of the tergites, although similar imbrication would result in a view of the interior of the exoskeleton.

The paratypes are more affected by lateral compression than the holotype. This compaction results in a more parabolic outline of the head shield and also affects the splay of the large pygidial spines which accounts for variation of the maximum width in the specimens between 10.5 mm and 14.8 mm. In both paratypes (Fig. 3), lateral compaction has resulted in shortening of one side with the axis appearing as a broad fold; the axial nodes are impressed in the apex of this fold. This skewing of the tergites indicates considerable convexity in life. The large splay between the free tergoleural extremities and the large tergal overlap in the axis were likely adaptations for dorsoventral flexure necessitated by the large convexity.

The surface of paratype C (Fig. 3B) is crossed by a series of narrow burrows, about 0.1 mm wide. Preservation of fine burrows within the area of individual fossils is a common phenomenon in the Sirius Passet Fossil-Lagerstätte and has been noticed by several authors (e.g., Babcock & Peel 2007). Frequently, the burrows can be traced for a short distance beyond the margin of the fossil indicating that their three dimensional preservation is probably a diagenetic effect representing early mineralization within the area of sediment affected by the decaying carcass. The burrows cross the compactional fold without deflection, which may indicate that they were formed after compaction of the carcass.

The similarity in size between the 3 specimens is noteworthy; the occurrence of several specimens of *Kleptothule rasmusseni* Budd, 1995 on the same slabs as 2 of the specimens of *A. inesoni* may suggest derivation from the same stratum, although all 3 specimens were collected from talus.

Material. – Figured specimens are deposited in the type collection of the Geological Museum (Natural History Museum of Denmark), Copenhagen, Denmark (MGUH prefix).

Systematic palaeontology

Arthropoda von Siebold & Stannius, 1845

Genus *Aaveqaspis* gen. nov.

Type species. – *Aaveqaspis inesoni* gen. et sp. nov., early Cambrian (*Nevadella* Zone of Laurentian usage); Cambrian Series 2, Stage 3, Sirius Passet Fossil-Lagerstätte, Peary Land, North Greenland.

Etymology. – From *Aaveq* (Greenlandic, walrus), reflecting the fancied resemblance of the tail spines to the prominent tusks of the arctic mammal, and *aspis* (Greek, shield).

Diagnosis. – Body narrowly oval, with a weakly defined axis; dominated by a pair of broad, elongate spines, which form most of the tail shield. Head shield semicircular without dorsal eyes, with stubby genal spines; thorax parallel-sided, with 5 free overlapping tergites, strongly curved in dorsal view and drawn out laterally into robust spines; tail with two pairs of broad spines, of which the first pair is macropleural, extending far to the posterior of the inner pair.

Description. – As for type species, below.

Discussion. – As for type species, below.

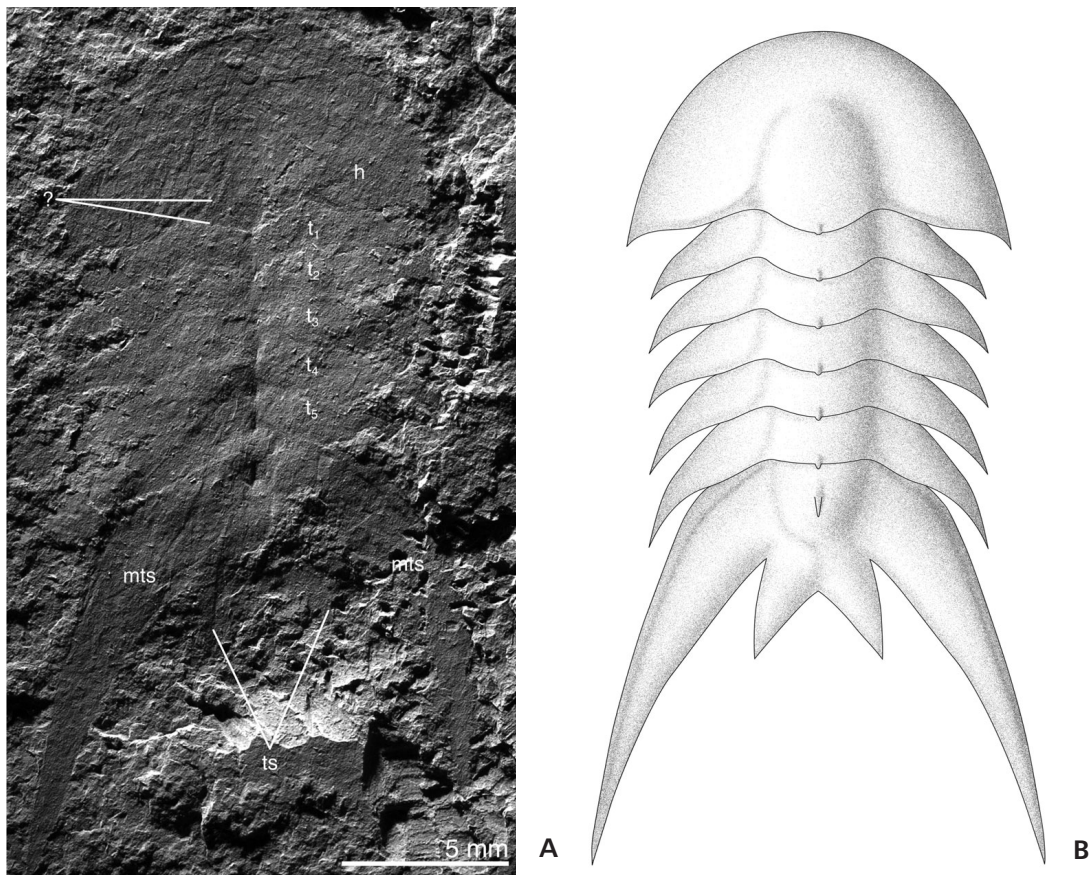


Figure 2. *Aaveqaspis insoni* gen. et sp. nov., Sirius Passet Fossil-Lagerstätte, Buen Formation (early Cambrian), Sirius Passet, Peary Land, North Greenland, holotype, MUGH 29,130. • A – view of external mould with lighting from upper left. • B – interpretive drawing; h – head shield, t₁–t₅ – tergites, mts – macropleural tail spine, ts – tail spine.

***Aaveqaspis insoni* sp. nov.**

Figures 2, 3

Holotype. – MGUH 29,130 from the Buen Formation, Sirius Passet Fossil-Lagerstätte, Peary Land, North Greenland, (latitude 82°47' 6" N, longitude 42°13' 7" W), on the south side of the broad valley known as Sirius Passet at its junction with J.P. Koch Fjord (Fig. 1).

Paratypes. – MGUH 29,131 and 29,132 from the same locality and horizon as the holotype.

Etymology. – For Jon R. Ineson, in appreciation of his studies of the Cambrian of North Greenland.

Diagnosis. – As for genus, above.

Description – The total length is about 26 mm. The head shield is semicircular, weakly trilobate; the axis is only marked by a slight change in relief and an extension of the posterior margin, an axial furrow is not developed. Axis roughly cylindrical, about one fifth of the total width of the head shield; it tapers slightly towards the anterior, and ex-

tends about two thirds of the distance towards the anterior margin. The posterolateral corners of the head shield form acute but short genal spines. The posterior extension of the axial margin of the head shield overlaps the axis of the first tergite; it carries a median node.

The trunk consists of 5 free tergites, each about 1.6 mm long (sag.) and a tail shield. The tergites have a weakly defined axis, occupying about one third of the tergal width, projecting posteriorly in a process overhanging the posteriorly adjacent tergite by about a quarter of the tergal length. As in the head shield, the process carries an antero-posteriorly elongate median node; the size of the nodes increases in the more posterior tergites. No axial furrow is developed. The tergopleurae are extended into acute pleural spines with gently arched anterior margins. The posterior margins are shallowly concave, producing a considerable splay between successive spines.

The tail shield is dominated by a pair of large segmental marginal spines, reminiscent of macropleural spines in the thorax and pygidial spines of certain trilobites. The axis of the tail shield is weakly defined; it carries one node which is larger and more sharply defined than the nodes on the tergites. The anterior border of the tail shield is convex and

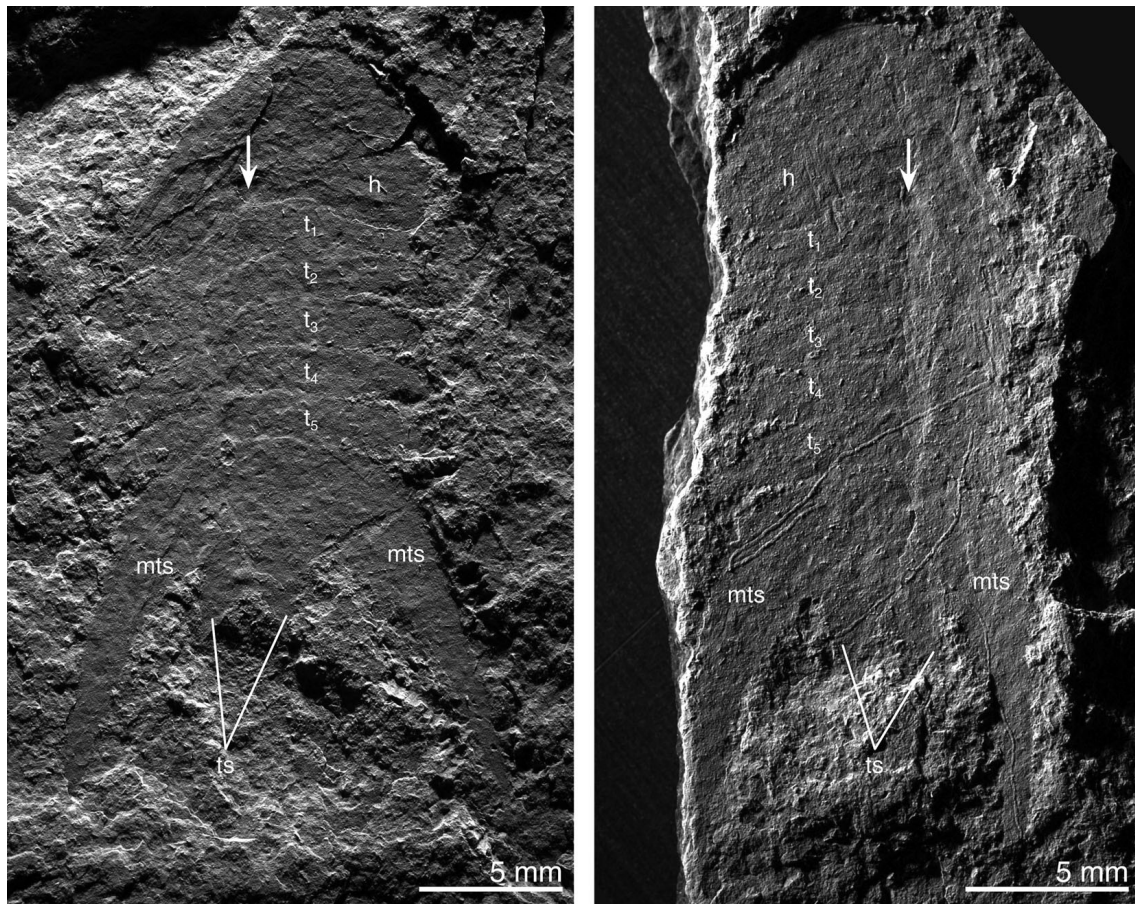


Figure 3. *Aaveqaspis insoni* gen. et sp. nov., Sirius Passet Fossil-Lagerstätte, Buen Formation (early Cambrian), Sirius Passet, Peary Land, North Greenland. • A – paratype, MGUH 29,131, view of external mould with slight deformation of left side of specimen due to compaction, lighting from anterior. • B – paratype, MGUH 29,132, view of external mould with slight deformation of left side of specimen due to compaction, lighting from upper left. Note fine burrows differentially preserved within the area of the fossil. Arrows indicate the median axis in the compacted and distorted specimens; for explanation see Fig. 2.

curves laterally into the large spines which extend postero-laterally, constituting half the total body length. An oblique ridge extends from the axis concentric with the anterolateral margin of the large spines to the tips. The posterior margin of the spines is concave and merges into a second pair of short, broad, triangular spines located one on each side of a median embayment; a terminal spine is not present. The ventral morphology is unknown.

Discussion

Aaveqaspis insoni, the type species, from the Sirius Passet Fossil-Lagerstätte is the only species currently assigned to the genus. The huge spines arising from the anterior of the tail shield serve to distinguish *A. insoni* from other described Cambrian arthropod species with unmineralized cuticle (cf. Størmer 1959, Simonetta & Delle Cave 1991, Chlupáč 1995, Hou & Bergström 1997), although spines of similar size are not infrequently developed in various ceratopygid, cheirurid,

crepicephalid damesellid and zacantheid trilobites (Harrington *et al.* 1959). Interpretation of the large marginal spines of the tail shield of *A. insoni* as segmental is supported by the presence of an axial node, analogous to the nodes on the free tergites of the trunk. There is no indication of a functional joint between the segment with the macropleural spines and the remainder of the tail shield. *Buenaspis forteyi* Budd, 1999 from the Sirius Passet fauna is most similar in general body form to *A. insoni* (Budd 1999a), although the tail shield lacks marginal spines. *Buenaspis forteyi* is isopygous, with 6 thoracic tergites instead of the 5 of *A. insoni*.

Among species from the Chengjiang Fossil-Lagerstätte, *Acanthomeridion serratum* Hou, Chen & Lu, 1989 is similar in displaying large spines in the posterior region of the trunk and a deep median embayment of the most posterior sclerite, although the posterolateral extremities of that sclerite are rounded rather than pointed like the smaller triangular spines of *A. insoni*. Importantly, the large spines in *Acanthomeridion serratum* arise from a free tergite, and there is another tergite between this spine bearing tergite

and the terminal tergites, whereas all spines in *Aaveqaspis insoni* are part of one ankylosed plate. A terminal spine is present in *Acanthomeridion serratum* but not in *A. insoni*. Also, *Acanthomeridion serratum* has a more parabolic head shield, with dorsal sutures, a considerably wider thoracic axis and tightly spaced tergopleural spines.

Aaveqaspis insoni shows some similarity to *Sinoburius lunaris* Hou, Ramsköld & Bergström, 1991 from the Chengjiang Fossil-Lagerstätte. Both have a semicircular head shield with a weakly defined axis and an obliquely sinuous posterior border. The genal spines of *S. lunaris* are relatively longer, but their form is similar. The most distinguishing feature in the head shield of *S. lunaris* is the presence of bulges to accommodate lateral eyes (Edgecombe & Ramsköld 1999) but there is no evidence of eyes in *A. insoni*. The thoracic tergites in both taxa show similar, distinct, imbrication and similarly-shaped pleural extremities (*cf.* Hou & Bergström 1997, fig. 77C, D), but the first trunk tergite in *A. insoni* has almost the same width as the following tergites. In contrast, the first trunk tergite in *S. lunaris* is considerably narrower than the following tergites, a feature which has been given some weight in the discussion of affinities of *S. lunaris* (Edgecombe & Ramsköld 1999). Furthermore, there is no evidence of a ridge across the pleural field to the tip in *A. insoni*. The pygidia of the two taxa are similar in having segmental marginal spines, but there is no evidence of a broad based median spine in *A. insoni*. It is unclear if the nodes on the posterior tergites of *A. insoni* were the base of a median axial spine (*cf.* Edgecombe & Ramsköld 1999, character 23), but their occurrence on multiple tergites renders such an interpretation unlikely. The status of the marginal spines on the tail of *S. lunaris* is unclear. Two pairs of tail spines of roughly equal size are reported, which is consistent with a specimen figured by Luo *et al.* (1997, pl. II, fig. 4), but a specimen figured by Edgecombe & Ramsköld (1999, fig. 1.2) carries a pair of considerably larger lateral spines that are more similar to, albeit still smaller than, those in *A. insoni*.

Sinoburius lunaris is commonly recognized as sister taxon to the Xandarellida Chen, Ramsköld, Edgecombe & Zhou in Chen *et al.* 1996 (Hou & Bergström 1997, Edgecombe & Ramsköld 1999, Cotton & Braddy 2004), together constituting the Petalopleura Hou & Bergström, 1997. Synapomorphies for Petalopleura proposed by Edgecombe & Ramsköld (1999) include a head incorporating antennular and four postantennular limb-bearing segments, the presence of eye slits, a head shield covering an anteriorly tapering trunk, or rather accommodating the narrow anterior trunk tergite in an posteromedian embayment (Hou & Bergström 1997), and an axial spine on the posterior tergite. It may be added here that tergites of *Xandarella spectaculum* Hou, Ramsköld & Bergström, 1991 carry a pleural ridge (Hou & Bergström 1997, figs 68D, E, 69A, B), as described from *S. lunaris*, although the status of that structure is unclear in *Cindarella eucalla* Chen,

Ramsköld, Edgecombe & Zhou in Chen *et al.* 1996. As no limbs are preserved in *A. insoni*, the number of limb bearing segments in the head cannot be established. Neither is there evidence of eye slits in *A. insoni*. The presence of an axial spine in *A. insoni* is also unclear. A raised ridge on the tergopleurae is present in the large marginal spines of the tail shield, but can not be traced in the trunk tergites. Given this, it seems tenuous to include *A. insoni* in Petalopleura or even to regard it as forming a sister group. The lack of traceable synapomorphies in *A. insoni* demonstrates that the similarities are superficial; better preserved material is needed to resolve its affinities.

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