Trilobites and intercontinental tie points in the Upper Cambrian of Scandinavia

AHLBERG, P.

The Upper Cambrian of Scandinavia is highly condensed and largely represented by dark grey or black, finely laminated mudstones and shales with lenses and beds of dark grey limestones (stinkstones or "orsten"). The mudstones and shales are referred to as alum shales, and they are notably enriched in organic matter (up to 28%), pyrite, phosphate and trace elements. The deposits were formed in fairly shallow waters under poorly oxidised (dysoxic to anoxic) and extremely stable tectonic conditions. The lithological homogeneity and the large areal extent of the alum shale facies point to a fairly uniform depositional environment in a broad epicontinental sea, prone to stagnation. To the east, the alum shale facies grades into coarser clastic deposits. The stratigraphically most complete successions are in Scania, southern Sweden, and in the Oslo Region of Norway. In these areas the Upper Cambrian attains a thickness of 55-57 m. In most other areas the Upper Cambrian are considerably thinner and there are several local gaps in the sequence.

The Upper Cambrian alum shale successions are generally richly fossiliferous. The faunas are taxonomically restricted and dominated by arthropods, especially trilobites. Brachiopods and conodonts may also be common in certain intervals with stinkstones. The alum shales have a long history of palaeontological research, extending well back into the eighteenth century. The succession of trilobites in the Upper Cambrian of Scandinavia has been studied since the second half of the nineteenth century, the most comprehensive study being that by Westergård (1922), who subdivided the Upper Cambrian into six biozones. As species turnover rate is high, the zonation was subsequently refined by Westergård (1947), subdividing the six biozones into 24 subzones. An even more refined zonation was introduced by Henningsmoen (1957), who monographed the olenid trilobites and subdivided the Upper Cambrian of Scandinavia into eight zones and 32 subzones. Three of Henningsmoen´s subzones have recently been abandoned (Nielsen and Schovsbo 1999) and currently 29 subzones are recognised. The trilobite faunas are generally dominated by olenid trilobites, except in the lowermost part of the series where agnostids frequently occur in abundance. The olenids are widely used for intraregional correlations and they provide a firm basis for the biostratigraphic classification. They tend, however, to be provincial and facies controlled, and hence of limited value for long-distance correlations.

Agnostids are the most precise tools available for intercontinental correlation of Cambrian strata. Some twenty species of agnostids are known from the Upper Cambrian of Scandinavia. Most of these occur in the lower part of the Upper Cambrian. Higher in the sequence agnostids become very rare; and only five species have been recorded from the upper part (Westergård 1947; Ahlberg and Ahlgren 1996). The lowest zone of the Upper Cambrian, the *Agnostus* pisiformis Zone, is dominated almost entirely by the zonal index. Other agnostids are here very rare and include specimens of *Linguagnostus reconditus* Poletaeva and Romanenko, 1970. This species provides additional corroboration for correlations within the A. pisiformis Zone in the North Atlantic region. It also provides evidence for correlation of the A. pisiformis Zone with the lower part of the Youshuian Stage (L. *reconditus* Zone) in South China.

Because of their nearly worldwide distribution, Gliptagnostus stolidotus and G. reticulatus are extremely valuable for intercontinental correlations of lower Upper Cambrian deposits. In Scandinavia, G. reticulatus occurs in the lowest two subzones of the *Olenusl* Agnostus (Homagnostus) *obesus* Zone, indicating that this part of the Scandinavian succession can be correlated with the G. reticulatus Zone and equivalent beds in Australia, South China, Korea, Kazakhstan, Laurentia, and elsewhere in the world. The recent discovery of Aspidagnostus stictus 0pik, 1967 in the *Olenus gibbosus* Subzone provides additional evidence for a precise correlation of the G. reticulatus Zone (lower Idamean Stage) of Australia with the lowermost part of the *Olenusl* A. (H.) *obesus* Zone of Scandinavia. G. stolidotus is not known from Scandinavia. However, cephala morphologically intetmedíate between those of G . "stolidótús and those of G. reticulatus have recently been collected from alum shales slightly above G. reticulatus-bearing beds at Andrarum in Scania, southern Sweden (see Clarkson *et* al. 1998, Fig.3D). This is puzzling because in other parts of the world G. stolidotus precedes G. reticulatus.

Agnostids are generally rare in beds above the *Olenusl* A. (H.) *obesus* Zone, and precise correlation of the Scandinavian medial and upper Upper Cambrian cannot yet be satisfactorily determined. However, the presence of *Pseudagnostus* cyclopyge (Tullberg, 1880) in the upper Steptoean Stage of Laurentia (Pratt 1992) indicates a general correlation with the Parabolina .spinuloza Zone of Scandinavia. Lotagnosstus trisectus (Salter, 1864) is in peed of revision, but appears to have a fairly wide geographic distribution. In Sweden and England it occurs in the Peltura minor and P. scarabaeoide,r Zones. Closely related or conspecific forms are known from, e.g., eastern Canada and Argentina, and their occurrences suggest a broad correlation with the Peltura Zones of Scandinavia.

Conodonts show promise for long-range correlations in the upper half of the Upper Cambrian. Studies during the last two decades have revealed that conodonts are abundant and taxonomically diverse in the Scandinavian Upper Cambrian, and recently Szaniawski and Bengtson (1998) proposed an euconodont-based correlation of the uppermost Cambrian of Baltoscandia with Laurentia. Further investigations, particularly in the Acerocare Zone, are desirable.

References

Ahlberg, P. and Ahlgren, J.,199G. Agnostids from the Upper Cambrian of Vastergotiand, Sweden. *GFF* 118,129-140.

Clarkson, E.N.K., Ahlberg, P. and Taylor, C.M., 1998. Faunal dynamics and microevolutionary investigations in the Upper Cambrian *Olenu*s Zone at Andrarum, Skáne, Sweden. *GFF 120,* 257-267.

Henningsmoen, G., 1957. The trilobite family Olenidae with description of Norwegian material and remarles on the Olenid and Tremadocian Series. *Skr. Nor. Vidensk. Alkad. Oslo, I. Mat.Naturvidensk.* Kl. 1957(1),1-303.

Nielsen, A.T, and Schovsbo, N.H.,1999. The *Leptoplartus* Zone (Upper Cambrian) at Slemmestad, Norway. In: Eriksson, M. (Ed.), Lundadagarna i Historisk Geologi och Paleontologi VI, Abstracts. *Lund Publ. Geol.* 144, p. 22.

Pratt, B.R.,1992. Trilobites of the Marjuman and Steptoean stages (Upper Cambrian), Rabbitkettle Formation, southern Mackenzie Mountains, nortwest Canada. *Palaeontogr. Can.* 9, 1-179.

Szaniawski, H., Bengtson, S.,1998. Late Cambrian euconodonts from Sweden. In: Szaniawski, H. (Ed.), Proceedings of the Sixth European Conodont Symposium (ECOS VI). *Palaeontol.* Pol. 58, pp. 7-29.

Westergård, A.H.,1922. Sveriges olenidskiffer. Sver. Geol. Underr. Ca 18,1-205.

Westergård, A.H., 1947. Supplementary notes on the Upper Cambrian trilobites of Sweden. Sver. Geol. Unders. C 489,1-34.