

## **‘*Nodibeyrichia jurassica*’ and associated beyrichiacean ostracode species and their significance for the correlation of late Silurian strata in the Baltic and Britain**

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**ABSTRACT** - Taxonomic revision reveals that the beyrichiacean ostracode ‘*Nodibeyrichia jurassica*’ can no longer be regarded as an index species for the uppermost (late Přídolí) ostracode ‘zone’ of the Silurian of the Baltic region embracing Estonia, Latvia and Baltic-floor derived erratic boulders. The taxon *Nodibeyrichia jurassica* Sarv, 1968 (*non* Gailite 1967) is regarded as a junior subjective synonym of *Beyrichia protuberans* Boll, 1862. Moreover, the material hitherto assigned to ‘*Nodibeyrichia jurassica*’ is herein considered to belong to two species: *Nodibeyrichia protuberans* (Boll, 1862) and *Nodibeyrichia verrucosa* Shaw, 1969. *N. verrucosa* occurs in England and Estonia, in the basal part and upper part of the Přídolí Series respectively. *N. protuberans*, as herein restricted, can be used to recognize the late Přídolí, uppermost ostracode assemblage level (*N. jurassica* Zone of previous literature) of the Silurian only in the central East Baltic (Latvia) and in erratic boulder material found in southern Baltic areas. *J. Micropalaeontol.* 13(2): 81–91, December 1994.

### **OSTRACODE BIOSTRATIGRAPHY IN THE SILURIAN**

Study of palynomorphs, conodonts, ostracodes and other microfossil groups has resulted in the establishment of many biostratigraphical schemes to complement and challenge macrofossils as dating tools in the Silurian (see papers in Holland & Bassett, 1990). Over the last 25 years in particular, ostracodes have proved useful in refining stratigraphic resolution in the several Silurian ostracode biogeographical faunal regions now recognized (see Siveter, 1989).

No global ostracode biozonal scheme exists for the Silurian. Intra- and intercontinental correlations are attempted with respect to the ‘European’ (essentially Baltic–British), Appalachian, North American mid-continent, Cordilleran and Bohemian ostracode faunal regions (Siveter, 1989). Moreover, though some authors have identified so-called zones for their particular ‘local’ Silurian ostracode sequences, such schemes have not been formally defined in terms of range or other types of zones. Silurian ostracode biostratigraphy in these various regions is best demonstrated as a series of distinctive ostracode species associations within vertically successive ostracode faunas (Martinsson, 1967). Such biostratigraphical schemes have been best tested in the ‘European’ ostracode faunal region, which offers good interprovincial and intercontinental correlation in the region between Podolia in the Ukraine and New England, USA/Nova Scotia, Canada (for summary see Siveter, 1989; Hansch, 1993, *in press*). This ostracode faunal province embraces both the Baltic area and, sited in Britain, the stratotype areas for the three oldest of the four Series of the Silurian.

### **THE ‘*N. JURASSICA*’ ZONE – THE NATURE OF THE PROBLEM**

The ‘*Nodibeyrichia jurassica* Zone’ has been used for the last 25 years to denote the youngest of the ostracode associations in the Silurian of the northern (Estonia), central (Latvia) and contiguous areas in the East Baltic (e.g. Gailite, 1965, 1967, 1978, 1986; Sarv, 1977, 1982; Meidla & Sarv, 1990; see also Hansch, 1985). It has been exclusively used by, for example, Gailite, Sarv, and also Abushik (1986) as a correlative of the later part of the Přídolí, the youngest Series of the Silurian. In the Baltic area much of the Silurian rocks of latest Ludlow Series and Přídolí age occur as submarine ‘exposures’ (e.g. see Martinsson, 1963a, b, 1965b), from which are derived the suites of ‘Beyrichienkalk’ erratic boulders, including some recorded as containing ‘*N. jurassica*’ and associates, ubiquitously found along the southern Baltic and adjacent areas.

The term ‘Beyrichienkalk’ is sometimes used in a broad sense (e.g. see Hansch, 1985, 1993): for all the upper Silurian erratic boulders, characterized by several successive ostracode associations, which according to current correlations would span the late Ludlow to late Přídolí. Used in its more restricted sense, ‘Beyrichienkalk *s.s.*’ erratics are those of middle to late Přídolí age, between the early Přídolí *Frostiella groenvalliana* ostracode fauna and the assumed level of the Siluro-Devonian boundary. The taxonomy, faunal subdivision, occurrence and correlation of the Beyrichienkalk *s.s.* has been thoroughly treated by Martinsson (e.g. see 1963a, b, 1964, 1965a, b, 1967, 1977a, b; also Siveter, 1989; Hansch, 1985, 1986a, b, 1993, *in press*).

It was apparent from our studies on British and Baltic Silurian ostracode faunas that the taxonomic definition of

the 'species' *N. jurassica* required revision and its value as an index species for the recognition and correlation of the late Přídolí needed to be re-evaluated. The aim of this paper is to address both of these points. In doing so we also resolve the primary and complicated nomenclatorial problem of the availability, authorship and date of publication of the binomen *Beyrichia jurassica* Gailite, 1965 (*nomen nudum*).

We herein show that the valid binomen, authorship and date for the species in question is *Nodibeyrichia jurassica* Sarv, 1968, which we consider to be a junior subjective synonym of *Nodibeyrichia protuberans* (Boll, 1862). We also conclude that the late Přídolí Estonian ostracodes previously assigned (e.g. by Sarv, 1968) to '*Nodibeyrichia jurassica*' are conspecific with the early Přídolí British species *Nodibeyrichia verrucosa* Shaw, 1969. The hitherto so-called *Nodibeyrichia jurassica* (= *Nodibeyrichia protuberans*) Zone is now restricted to only the late Přídolí of the central (Latvia) and southern ('Beyrichienkalk' s.s. erratic boulders) parts of the Baltic. The 'Zone' cannot be used, as hitherto, to also embrace the late Přídolí strata in Estonia.

## SYSTEMATIC PALAEONTOLOGY

Subclass **Ostracoda** Latreille, 1802

Order **Palaeocopa** Henningsmoen, 1953

Superfamily **Beyrichiacea** Matthew, 1886

Family **Beyrichiidae** Matthew, 1886

Subfamily **Beyrichiinae** Matthew, 1886

Genus ***Nodibeyrichia*** Henningsmoen, 1954

**Type-species.** *Beyrichia pustulosa* Hall, 1860, p. 157, text-fig. 19; subjective synonym of *Beyrichia tuberculata* Boll var. *Gedanensis* Kiesow, 1884 and *Beyrichia Bronni* Reuter, 1885. The latter was designated type-species of *Beyrichia* (*Nodibeyrichia*) by Henningsmoen, 1954, p. 26. *B. pustulosa* is from the Stonehouse Formation of Arisaig, Nova Scotia, Canada.

**Other species.** *N. bifida* Sarv, 1968; *N. protuberans* (Boll, 1862); *N. tuberculata* (Klöden, 1834); *N. verrucosa* Shaw, 1969; ? *N. torosa* Abushik, 1971.

**Diagnosis.** (Modified from Martinsson, 1965a: 122). Beyrichiinae in which the anterior lobe is generally well set off from other lobal elements and is divided into a cuspidal lobule and a usually prominent, rounded,

anteroventral lobule. All kinds of lobular spines absent. Crumina with a tuberculate marginoventral field. Syllodium with usually one blunt cusp.

**Discussion.** The genera *Neobeyrichia* and *Nodibeyrichia* are closely related (Martinsson, 1965a). *Nodibeyrichia* differs from *Neobeyrichia* mainly by its tuberculate subcruminal ornament and by its rounded anteroventral lobule. The velar ridge is sometimes spinose in *Neobeyrichia* and often somewhat thicker, sparsely tuberculate and well set off from the lobes in *Nodibeyrichia*. Furthermore, *Neobeyrichia* often has a postcruminal velar process and a granulose ground ornament not common in typical *Nodibeyrichia* species such as *N. tuberculata* or *N. pustulosa*. Both *Neobeyrichia* and *Nodibeyrichia* have, in contrast to *Beyrichia*, an anterior lobe which is typically mostly, or entirely, isolated from other lobal elements and is characteristically differentiated into dorsal and anteroventral lobules; *Neobeyrichia* and *Nodibeyrichia* also lack prominent individual lobal spines. Such spines, together with the occurrence of a ventral ridge on the crumina, are important distinguishing characteristics of *Calcaribeyrichia*.

**Occurrence.** In Britain *Nodibeyrichia* is known only from the Přídolí Series (Siveter, 1978, 1989). The genus occurs extensively in Přídolí deposits in the Baltic area in general (for example, see Martinsson, 1965a, 1967, 1977a, b; Gailite, 1967, 1978, 1986; Witwicka, 1967; Sarv, 1968, 1970, 1971, 1977, 1982; Zbikowska, 1973, 1974; Tomczykowa & Witwicka, 1972, 1974; Hansch, 1985, 1986a, b, 1993, *in press*; Sidaraviciene, 1986; Siveter, 1989). It is also known from Přídolí correlatives in the western USA and western Canada (Copeland, 1960, 1964; Martinsson, 1967, 1970, 1977b; Copeland & Berdan, 1977; Berdan, 1983, 1990) and possibly in Podolia (Abushik, 1971).

### *Nodibeyrichia protuberans* (Boll, 1862)

(Pl. 1, figs 1–11)

1862 *Beyrichia protuberans* Boll (1862), Boll: 122, 123, pl. 1, fig. 3.

1877 *B. protuberans*; Krause: 31, 33, 36.

1886 *Beyrichia protuberans* Boll; Jones & Holl: 343.

non 1888 *Beyrichia Klödeni* var. *protuberans* Boll; Kiesow: 10, 11, pl. 2, figs 4a–c, 5 (=

## Explanation of Plate 1

Figs 1–10: *Nodibeyrichia protuberans* (Boll, 1862). **Figs 1, 2, 4.** Neotype, female left valve, SGWG 80/1: fig. 1, lateral view (stereo-pair),  $\times 25$ ; fig. 2, detail of ornament of crumina (stereo-pair),  $\times 200$ ; fig. 4, ventral view, (stereo-pair),  $\times 25$ . From erratic boulder, Boll collection no. BO1, from Neubrandenburg; stored in the Müritz Museum, Waren; 'Beyrichienkalk' s.l., Přídolí Series. **Fig. 3.** Male left valve, lateral view (stereo-pair), SGWG 80/2,  $\times 25$ . From same erratic boulder as Neotype. **Figs 5, 9.** Female right valve, SGWG 78/11: fig. 5, lateral view (stereo-pair),  $\times 25$ ; fig. 9, ventral view,  $\times 25$ . From erratic boulder, SGWG no. Bey. F4, from Jarosławiec, Poland; 'Beyrichienkalk', Přídolí Series. **Fig. 6.** Male right valve, lateral view (stereo-pair), MB.O 27,  $\times 25$ . Original of *Beyrichia borussica* Kiesow, 1892, pl. 24, fig. 10. From erratic boulder from Łęgowo, near Gdansk, Poland; 'Beyrichienkalk' s.l., Přídolí Series. **Figs 7, 8.** Female right valve, MB.O 30. Original of *Beyrichia borussica* Kiesow, 1892, pl. 24, probably fig. 14 (not fig. 13, *errore* in Hansch, 1986: 22): fig. 7, lateral view (stereo-pair),  $\times 25$ ; fig. 8, ventral view (stereo-pair),  $\times 25$ . From erratic boulder from Łęgowo, near Gdansk, Poland; 'Beyrichienkalk' s.l., Přídolí Series. **Fig. 10.** Small tecomorphic right valve, lateral view, SGWG, 92/1,  $\times 25$ . From erratic boulder, SGWG no. Bey. F4, from Jarosławiec, Poland; 'Beyrichienkalk', Přídolí Series. **Fig. 11.** Small tecomorphic left valve, lateral view, SGWG, 80/3,  $\times 25$ . From same erratic boulder as Neotype.

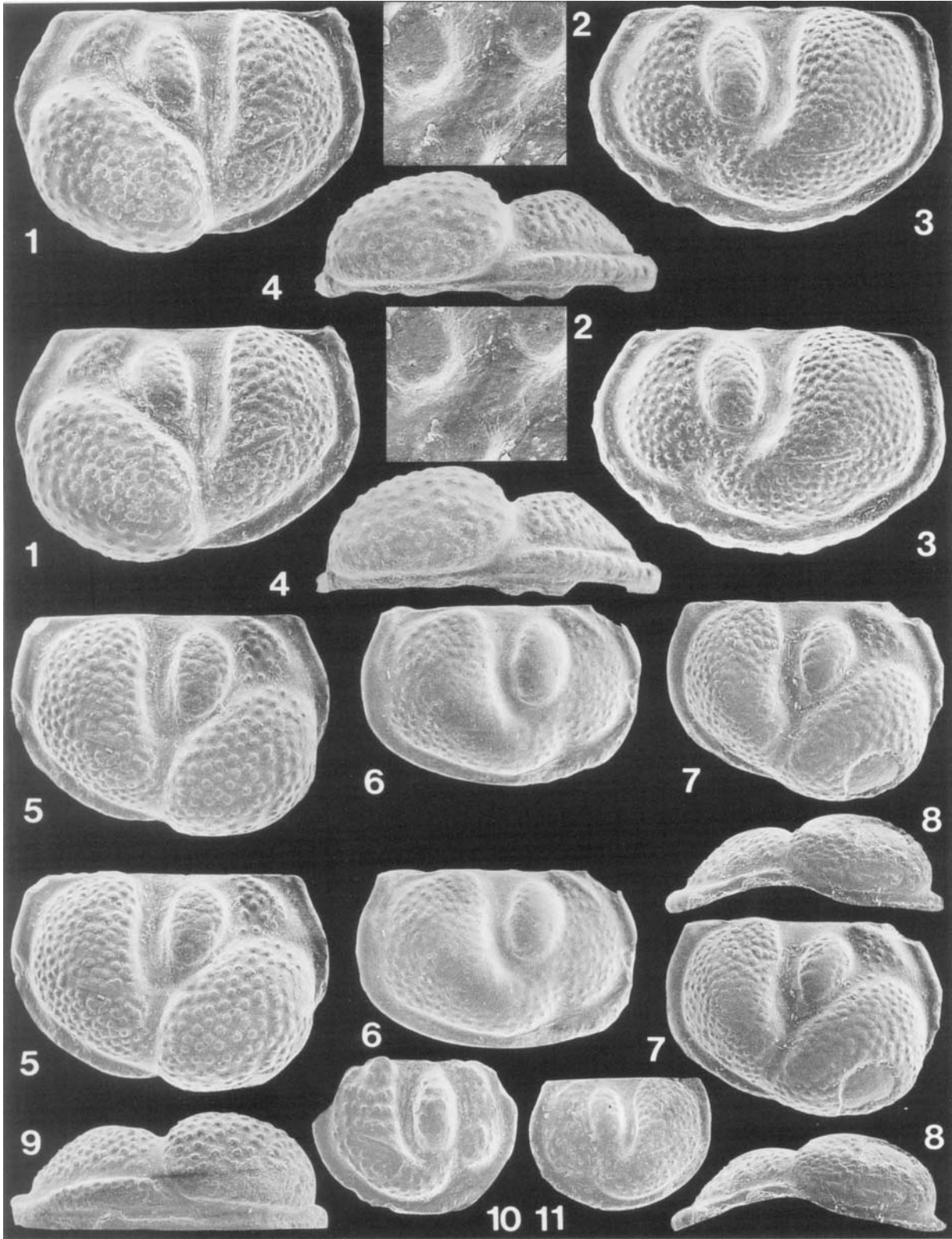


Plate 1

- Neobeyrichia ctenophora* & *Beyrichia (Simplicibeyrichia) globifera*, both Martinsson, 1962, respectively).
- 1891a *Beyrichia protuberans* Boll; Krause: 516.
- 1891b *Beyrichia protuberans* Boll; Krause: 12.
- 1892 *Beyrichia borussica* nov. sp., Kiesow: 101, 102, pl. 24, figs 10b, 11b, 12b, 12c, 13b, 14b.
- ?1896 *Beyrichia protuberans* Boll; Gürich: 390 (cited in Bassler & Kellett, 1934).
- 1897 *B. protuberans* Boll; Grönwall: 52.
- ?1908 *Beyrichia kloedeni protuberans*; Ulrich & Bassler: 285 (cited in Bassler & Kellett, 1934).
- 1909 *B. borussica*; Moberg & Grönwall: 61.
- 1910 *Beyrichia protuberans* Boll; Bonnema: 140.
- 1913 *Beyrichia protuberans* Boll; Bonnema: 72, fig. 4.
- 1914 *Beyrichia protuberans* Boll; Bonnema: 1106, 1109.
- 1924 *Beyrichia borussica* Kies.; Kummerow: 431.
- 1930 *Beyrichia protuberans* Boll; Bonnema: 116, 118, 120, fig. 13.
- 1934 *Beyrichia borussica* Kiesow; Bassler & Kellett: 187.
- 1934 *Beyrichia protuberans* Boll; Bassler & Kellett: 204.
- non 1941 *Beyrichia protuberans klödeni* Boll; Triebel: 304, pl. 3, figs. 29a–b (= *Neobeyrichia ctenophora*).
- 1962 *N. protuberans*; Martinsson: 19, 326.
- 1964 *Beyrichia (Simplicibeyrichia)* sp. n., Gailite: 66, 69.
- 1965 *Simplicibeyrichia jurassica*; sp. n., Gailite: 68, 70 (*nomen nudum*; = Piltene borehole). (Gailite's summary, in English, implies that she regarded *Simplicibeyrichia* as a subgenus of *Beyrichia*.)
- 1967 *Simplicibeyrichia jurassica*; Martinsson: 378.
- 1967 *Beyrichia (Beyrichia) ? protuberans* (Boll), 1862; Gailite: 130, 131, pl. 9, figs 6a–c (=Piltene 1 borehole).
- 1968 *Nodibeyrichia jurassica* (Gailite); Sarv: 47 (*partim*, reference to holotype and Latvian material only), non pl. 17, figs 5–9 (= *Nodibeyrichia verrucosa*).
- non 1970 *N. jurassica* (Gailite); Sarv: 159, tab. 18, 169 (=Estonian material).
- non 1971 *Nodibeyrichia jurassica* (Gailite); Sarv: 353, 355, fig. 3 (=Ohesaare borehole, Estonia).
- 1972 *N. jurassica* Gailite; Gailite: 353 (=Kolka 4 borehole).
- 1977 *Nodibeyrichia jurassica*; Sarv: 164, fig. 2 (=Piltene 1 borehole), possibly also 161, text-fig. 1 (=Kolka 54 borehole), 173–176 (*partim*).
- 1978 *Nodibeyrichia jurassica*; Gailite: 16, 17, 20, 21, tabs 1 (Latvia only), 2 (Piltene 1 borehole; possibly also Piltene 31, 32, Kolka 4, 54 boreholes, e.g. text-fig. 5).
- 1982 *Nodibeyrichia jurassica*; Sarv: 75, 76 (table), fig. 1 (all *partim* e.g. Piltene 1 borehole).
- 1985 *Nodibeyrichia protuberans* (Boll); Hansch: 274, 275, 279, fig. 2E, fig. 3 (*partim*), tab. 1.
- 1986 *Nodibeyrichia jurassica*; Gailite: 111, 114.
- 1986a *Nodibeyrichia protuberans* (Boll, 1862); Hansch: 15, 16, pl. 1, figs 1–6.
- 1987 *Nodibeyrichia protuberans* (Boll, 1862); Schallreuter & Schäfer: 58.
- ?1989 *Nodibeyrichia jurassica*; Bassett, Kaljo & Teller: 167, fig. 123 (Ventspils borehole).
- non 1990 *Nodibeyrichia protuberans*; Meidla & Sarv: tab. 11, pl. 9, figs 1, 2 (= *Nodibeyrichia verrucosa*).
- non 1990 *Nodibeyrichia protuberans*; Nestor: 176, fig. 53 (= *Nodibeyrichia verrucosa*).
- Neotype.** SGWG 80/1, a female left valve, designated Hansch, 1986a, pl. 1, figs 1, 4; herein Pl. 1, figs 1, 2, 4. Boll's original is lost, probably during the last war. Erratic boulder, Boll, stored in the Müritz Museum, Waren, collection no. BO1, from Neubrandenburg; 'Beyrichienkalk', Přídolí Series.
- Material.** Consists of calcareous shells.
- Diagnosis.** Species of *Nodibeyrichia* with callus on broad, undissected and non-cuspidate syllobium. Anterior lobe also lacks a cusp above the hinge line and is not differentiated into any lobules. Preadductorial node almost vertical.
- Description.** Syllobium broad, dorsally is gently curved to the hinge line, without cusps. Low, obliquely trending callus on syllobium; syllobial groove not discernable. Preadductorial node almost vertical in tecnomorphs, slightly more inclined forwards in females. Anterior lobe broad, gently crescentic, lacks lobules, has no cusp above hinge line. Anteroventral depression indistinct, below a narrow, shallow prenodal sulcus. Syllobium has only weak lobal connections with preadductorial node and anterior lobe. Small tecnomorphs (Pl. 1, figs 10, 11) show faint hint of a rounded anteroventral lobule.
- Velum present between cardinal corners, is narrow, sparsely tuberculate. Crumina well developed, elongate along an anterodorsal–posteroventral axis. All lobes and lobal connections and crumina have dense covering of somewhat subdued tubercles.
- Measurements.** Hinge length–height of females, from the Beyrichienkalk, figured herein: 1850–1420  $\mu\text{m}$  (SGWG 80/1), 1700–1300  $\mu\text{m}$  (SGWG 78/11), 1580–1180  $\mu\text{m}$  (MBO.30).
- Synonymy.** *Beyrichia borussica* Kiesow, 1892 is considered to be a junior synonym of *Beyrichia protuberans* Boll, 1862; both are from the upper Silurian 'Beyrichienkalk' of the Baltic. This synonymy is supported by reference to Kiesow's original description and illustrations and by the fact that, according to Kiesow (1892), '*B. borussica* occurs 'stets in Begleitung einer kleinen Form der *Beyrichia Wilckensiana*' (= *Kloedenia perfecta* Hansch, 1986a). Moreover, Krause (1891b: 12) also thought that these two species were synonymous.
- In 1967 Gailite (pl. 9, figs 6a–c) described some beyrichiine material from the upper part of the Přídolí

Series of the Piltene Borehole, Latvia, under the name *Beyrichia* (*Beyrichia*) ? *protuberans* (Boll). She had previously assigned (Gailite, 1964, 1965), without description or illustration, this Latvian material to the binomen *Simplicibeyrichia jurassica* sp. n. (= *nomen nudum*; in the English summary to her paper she implied that she regarded *Simplicibeyrichia* as a subgenus of *Beyrichia*). Later, Sarv (1968) figured beyrichiines from Estonia under the binomen '*Nodibeyrichia jurassica* (Gailite)' and, in doing so, selected a holotype for this taxon from amongst Gailite's, 1967 (pl. 9, figs 6b, c) Latvian specimens. It follows that the authorship of the species *Nodibeyrichia jurassica* should be Sarv, 1968 (not Gailite, 1965), the publication in which the name first became 'available' (P. Tubbs & A. Gentry, International Commission on Zoological Nomenclature, London, pers. comm.). Based on its holotype and sympatric material the Latvian species *Nodibeyrichia jurassica* Sarv, 1968 is herein considered (see also Hansch, 1986a) a junior synonym of the beyrichiine *Nodibeyrichia protuberans* (Boll, 1862). Furthermore, the Estonian material, from the upper Pridoli Ohesaare 'Stage', which Sarv (e.g. 1968, pl. 17, figs 5–9; Meidla & Sarv, 1990, pl. 9, figs 1, 2; herein Pl. 2, figs 1–6) included within *N. jurassica* and *N. protuberans* respectively is herein assigned to *Nodibeyrichia verrucosa* Shaw, 1969, a species originally described from British strata of lower Pridoli age.

Of the borehole records from Latvia, it is possible to recognize *N. protuberans* or its synonyms with confidence only from the Piltene 1 borehole, the only locality for which there is figured material (Gailite, 1967). Other records, from similar horizons in Latvia (boreholes Piltene 31, 32, Kolka 4, 54 and Ventpils), probably represent conspecific material though it is not possible to be as confident in such cases; accordingly, this qualification is reflected in the comments in both the synonymy above and 'Occurrence' below.

**Discussion.** Morphological features characteristic of *Nodibeyrichia* are less evident in *N. protuberans* than in other congeneric species. Its syllobium is entire and its anterior lobe is not completely isolated from its other lobes nor, except in small tecnomorphs (Pl. 1, figs 10, 11), does that lobe show any sign of an anteroventral lobule. In many respects *N. protuberans* shows affinity with the beyrichiines *Beyrichia* (*Beyrichia*) and *Beyrichia* (*Simplicibeyrichia*). However, in that *N. protuberans* differs from such taxa by having a tuberculate rather than striate subcruminal field, a lack of lobular spines and its albeit faint recall of an anteroventral lobule the species is best considered as a morphologically simple end member of *Nodibeyrichia*.

Like *N. protuberans*, the typical Baltoscandian Beyrichienkalk s.s. *Nodibeyrichia* species *N. tuberculata* in some specimens also shows a tendency to develop a callus on its lobular syllobium (e.g. see Martinsson, 1965a, fig. 11). In the case of *N. tuberculata* this development may be an ecophenotypic response, as such specimens always seem to occur together with the beyrichiacean ostracodes *Frostiella cornuta* Martinsson, 1965a and especially *Kloedenia leptosoma* Martinsson, 1963a. Interestingly, females of such *N. tuberculata* specimens also in some cases show a slight

paracruminal swelling (Hansch unpublished information), a feature hitherto recorded only from the type-species of *Nodibeyrichia*, *N. pustulosa* (see Martinsson, 1965a).

**Occurrence.** Upper part of the Pridoli Series, upper Silurian; Baltic area. Beyrichienkalk s.s. erratic boulders (Beyrichienkalk ostracode association D of Hansch, 1985). Borehole Piltene 1 and possibly (recorded without illustrations) boreholes Piltene 31 and 32 (cf. Sarv, 1977, fig. 3 with Gailite, 1978, tab. 2), Kolka 4 and 54 and Ventpils (Gailite, 1967, 1978; Sarv, 1968, 1977, 1982; Bassett *et al.*, 1989), Latvia; Jura Formation.

#### *Nodibeyrichia verrucosa* Shaw, 1969

(Pl. 2, figs 1–9)

1968 *Nodibeyrichia jurassica* (Gailite); Sarv: 47 [*partim, non* 'holotype' and Latvian material = *Nodibeyrichia protuberans* (Boll, 1862)], pl. 17, figs 5–9.

1969 *Nodibeyrichia verrucosa* n. sp. Shaw: 63, figs 7a–c.

1970 *N. jurassica* (Gailite); Sarv: 159, tab. 18, 169.

1971 *Nodibeyrichia jurassica* (Gailite); Sarv: 353, 355, fig. 3.

1978 *Nodibeyrichia verrucosa* Shaw, 1969; Siveter: 68, 86, pl. 9, figs 9, 10, tab. 2.

1982 *Nodibeyrichia verrucosa*; Bassett *et al.*: 8, 15, fig. 6.

1988 *Nodibeyrichia verrucosa*; Siveter: 35, text-fig. 7.

1989 *Nodibeyrichia verrucosa*; Siveter: 258, fig. 167.

1989 *Nodibeyrichia verrucosa*; Siveter *et al.*: 45, fig. 38.

1990 *Nodibeyrichia protuberans*; Meidla & Sarv: 71, tab. 11, pl. 9, figs 1, 2.

1990 *Nodibeyrichia protuberans* Nestor: 176, fig. 53.

**Holotype.** GSM 103262, tecnomorphic left valve external mould; figured Shaw, 1969, figs 7a, b. From 1ft 9in. (53.5 cm) above the Ludlow Bone Bed, Platyschisma Shale Member of Downton Castle Sandstone Formation; Forge Bridge, near Downton, Hereford & Worcester, England.

**Material.** British material consists of mostly incomplete, internal and external moulds. Estonian material is preserved as calcareous shells.

**Diagnosis.** Species of *Nodibeyrichia* with a callus and two subequal cusps on the undissected syllobium. Ventral part of anterior lobe differentiated as a weakly elevated, rounded lobule; dorsal part flatter, with a small cusp just above the hinge line. Preadductorial node slopes forward.

**Description.** Syllobium broadest at about mid-height, has two subequal-sized cusps above hinge line in adults and a diagonal callus above a faint syllobial groove. Preadductorial node elongate, sloping forward, terminates just below hinge line. Anterior lobe has weakly elevated, rounded anteroventral lobule differentiated from dorsal, cuspidal part. Anteroventral depression moderately well developed but not discretely defined. Lobal connection from syllobium to preadductorial node and anterior lobe is poorly developed.

Velum present between cardinal corners, is narrow and inconsistently finely tuberculate. Crumina well developed, elongate along anterodorsal–posteroventral axis. All lobes, lobal connections and crumina have small tubercles.

**Measurements.** Hinge length–height of female valves from the Ludlow Bone Bed Member, Downton Castle Sandstone Formation, England: 1950–1400  $\mu\text{m}$  (OS 6604),

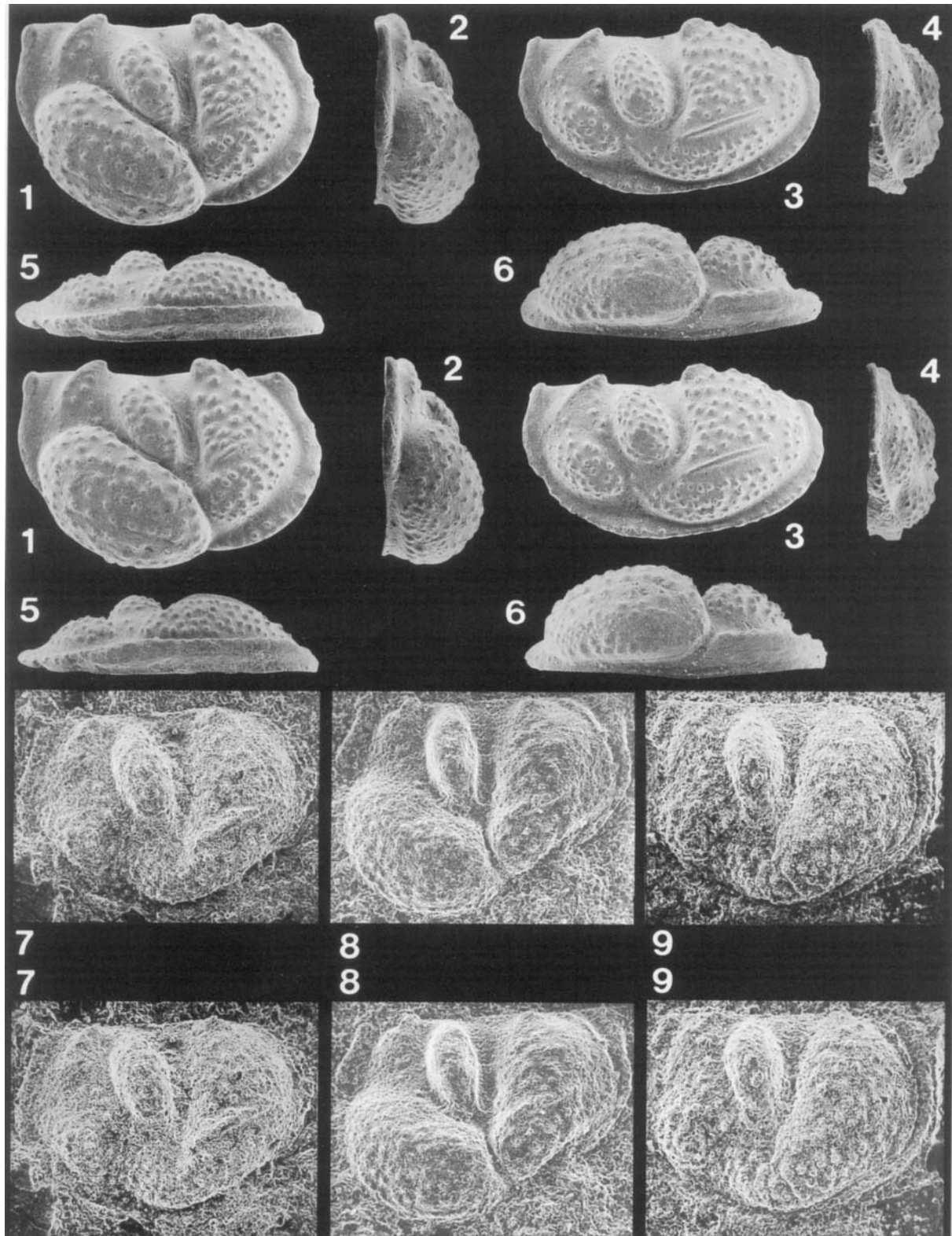


Plate 2



1875–1350  $\mu\text{m}$  (OS 6605), 1760–1310  $\mu\text{m}$  (OS 14095). Hinge length–height of valves from the Ohesaare 'Stage', Estonia: 2250–1650  $\mu\text{m}$  (female left valve, OS 5378), 2200–1425  $\mu\text{m}$  (tecnomorphic left valve, OS 5379).

**Synonymy.** The beyrichiine valves from the upper Přídolí of Estonia, which Sarv (1968) and Meidla & Sarv (1990) figured under *Nodibeyrichia jurassica* (Gailite) and *Nodibeyrichia protuberans* (Boll) respectively, have been examined (Pl. 2, figs 1–6). They are considered conspecific with the type and newly collected material (Pl. 2, figs 7–9) of *N. verrucosa* Shaw, 1969 occurring in the early Přídolí of Britain. It is probable, though not certain (no illustrations given), that all the Estonian material previously cited as *N. jurassica* (e.g. in Sarv, 1970, 1971; Nestor, 1990) belongs to *N. verrucosa*.

**Discussion.** Although the mould nature of the material has not yet allowed confirmation of the female subcruminal morphology in the British specimens, in the Estonian valves studied it is tuberculate and, thus, typical of the genus. The undissected nature of the syllobium and the relatively incipient development of the anteroventral lobule places this, the oldest *Nodibeyrichia* species, as a morphologically simple member of the genus.

*N. verrucosa* differs from the upper Přídolí *N. protuberans* (as restricted herein) chiefly by its bicuspidate syllobium and the presence on its anterior lobe of a ventral lobule and dorsal cusp. In addition, *N. verrucosa* tends to have a more forwardly inclined preadductorial node. The British material of *N. verrucosa* occurs in sandstones and siltstones (e.g. The Whitcliffe road sections; see Siveter *et al.*, 1989); *N. protuberans*, as restricted herein, is known from dolomitic marl and limestone strata from the Baltic (Piltene 1 borehole, Gailite, 1967; Kolka 4 borehole, Gailite, 1972; Ventpils borehole, Bassett *et al.*, 1989; Beyrichienkalk ostracode association D of Hansch, 1985: 281). Thus, as both this particular British and Baltic material occur in intertidal to shallow subtidal marine to possibly marine influenced/brackish, regressive sequences, along with concomitant faunas of a broadly similar aspect (relatively impoverished, but containing non-palaeocope ostracodes and fish), it seems less likely that their morphological differences represent merely ecophenotypic, intraspecific variation. Indeed, the Estonian material herein also assigned to *N. verrucosa* comes from sparitic limestones of a high-energy shoal belt and from biomicritic limestones of a faunally rich and diverse, open marine shelf (Ohesaare cliff

section; Nestor, 1990: 177, fig. 53) thus representing quite different environments to that of the presumed conspecific British material.

**Occurrence.** Přídolí Series, upper Silurian; Welsh Borderland and Estonia. In the Welsh Borderland from the Ludlow (D.J.S. collections, see Siveter, 1978; Bassett *et al.*, 1982) and Downton (Shaw, 1969) areas, Shropshire, and the Long Mountain region (Shaw, 1969) to the west. Collected by D.J.S. from the Ludlow Bone Bed Member (locs 69a, 69b of Siveter, 1980; = *not* 'Topmost Whitcliffe Beds' cf. Siveter, 1980: 8, *in errore*), Downton Castle Sandstone Formation (see Bassett *et al.*, 1982). Shaw's (1969) Downton area material is from the Platyschisma Shale Member, Downton Castle Sandstone Formation. The Estonian material is from the upper Přídolí Ohesaare 'Stage', Isle of Saaremaa (Sarv, 1968, 1970, 1971; Meidla & Sarv, 1990; Nestor, 1990), where it has also been collected from the Ohesaare cliff section by the present authors.

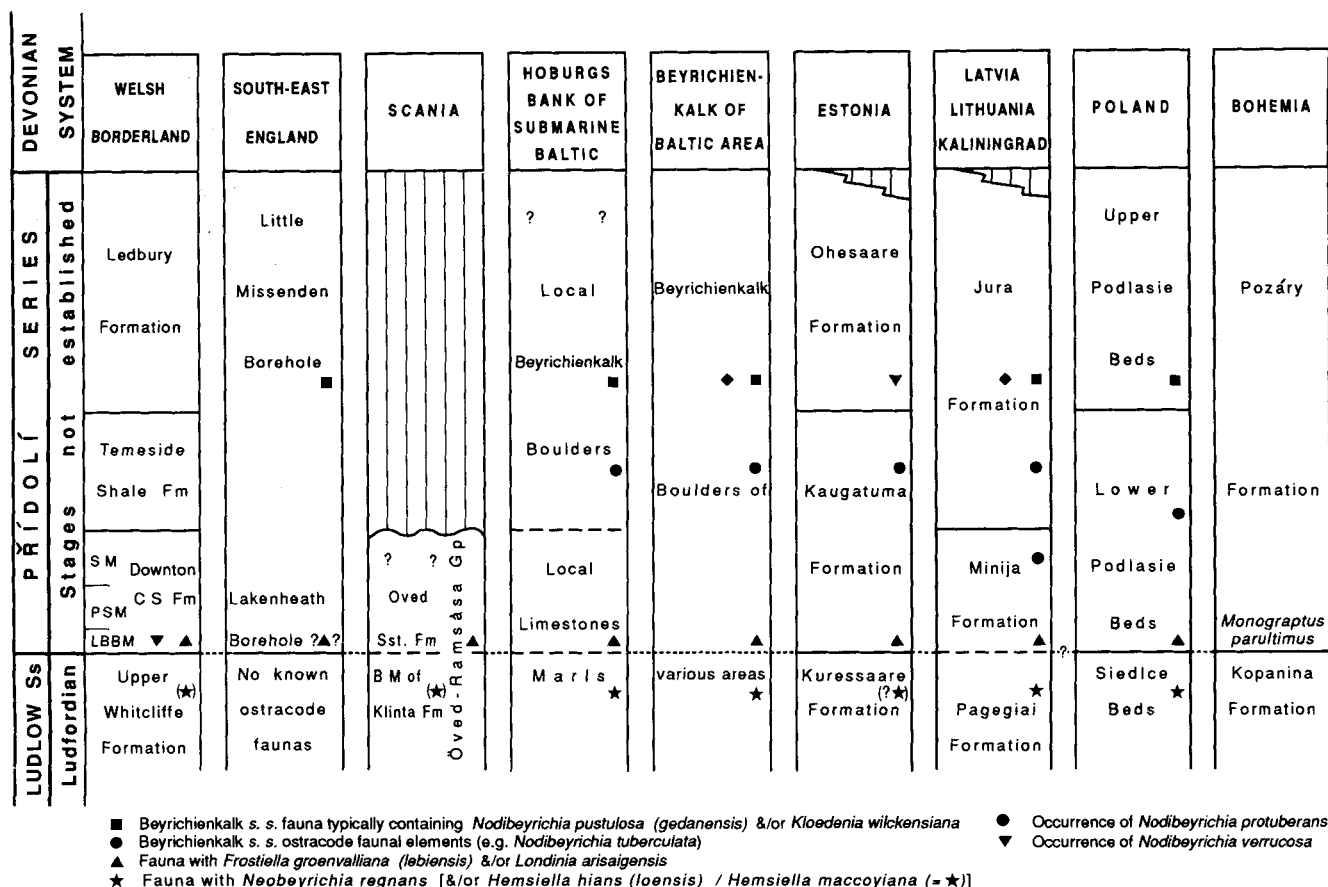
## BIOSTRATIGRAPHICAL SIGNIFICANCE OF TAXONOMIC REVISION

These new taxonomic opinions regarding *N. protuberans* ('*N. jurassica*') and *N. verrucosa* necessitate a revision of part of the informal ostracode 'zonal' scheme which has long been applied to the Upper Silurian of the East Baltic area and associated Beyrichienkalk drift boulder sequences. Fig. 1 outlines such a revised scheme for the various parts of Baltoscandia and the faunally associated area of Britain.

In the Baltoscandian area in general the oldest and most widespread ostracode assemblage of the basal part of the Přídolí Series is the *Frostiella groenvalliana* association, which can be traced into correlatives in Britain and eastern North America (Fig. 1; see Siveter, 1989 and Hansch *et al.*, 1990 for a summary of its distribution). The *F. groenvalliana* association is succeeded by a number of ostracode faunas which encompass the Beyrichienkalk *s.s.* faunas of traditional literature. Of the latter, the most widespread ostracode associations in the literature are the successive faunas characterized by *Nodibeyrichia tuberculata* and, in the late Přídolí, either *Nodibeyrichia pustulosa* (*gedanensis*) or '*N. jurassica*' depending on the area of Baltoscandia in question (for example, see Martinsson, 1967, Siveter, 1978, 1989, Hansch, 1985, 1993, *in press*). The two faunas with *F. groenvalliana* and *N. pustulosa* respectively are both recognized from Britain, the former from outcrops of

## Explanation of Plate 2

Figs 1–9: *Nodibeyrichia verrucosa* Shaw, 1969. **Figs 1, 2, 6.** Female left valve, OS 5378. Original of Sarv, 1968, pl. 17, fig. 5: fig. 1, lateral view (stereo-pair),  $\times 19$ ; fig. 2, anterior view (stereo-pair),  $\times 19$ ; fig. 6, ventral view (stereo-pair),  $\times 19$ . From Ohesaare Cliff, Saaremaa, Estonia; Ohesaare Formation, Přídolí Series. Collected L. Sarv, 1959. **Figs 3, 4, 5.** Male left valve, OS 5379. Original of Sarv, 1968, pl. 17, fig. 6: fig. 3, lateral view (stereo-pair),  $\times 19$ ; fig. 4, anterior view (stereo-pair),  $\times 19$ ; fig. 5, ventral view (stereo-pair),  $\times 19$ . Locality and horizon as for fig. 1. **Fig. 7.** Silicone rubber cast of external mould of male left valve, lateral view (stereo-pair), OS 6606,  $\times 23$ . From Ludford Lane, Ludlow, Shropshire (collected D.J.S.); Ludlow Bone Bed Member (loc. 69a of Siveter, 1980; = *not* 'Topmost Whitcliffe Beds' cf. Siveter, 1980, p. 8, *in errore*), Downton Castle Sandstone Formation, Přídolí Series. **Fig. 8.** Silicone rubber cast of external mould of female left valve, lateral view (stereo-pair), OS 6604,  $\times 20$ . Locality and horizon as for fig. 7. **Fig. 9.** Silicone rubber cast of external mould of male left valve, lateral view (stereo-pair), OS 6608,  $\times 23$ . Locality and horizon as for fig. 7.



**Fig. 1.** Correlation of latest Ludlow-Prídolí ostracode faunas of Baltoscandia, Britain and Czechoslovakia (modified from Siveter, 1989, fig. 164; see also Hansch, 1985, fig. 3, 1993, *in press*). Symbols denote the presence (mostly only the *earliest* occurrence) of a fauna within a stratigraphical unit, not their exact positions. Vertical columns not to scale. The only firm time line is the Ludlow/Prídolí boundary. Correlation agrees with Martinsson (1967) and Bassett *et al.*, (1982, 1989). The Scanian succession (from Jeppsson & Laufeld, 1987) and the base of the Prídolí with respect to the Minija Formation follows Bassett *et al.* (1989).

*Monograptus parultimus*, the basal Prídolí graptolite in the Bohemian stratotype, is not recorded from Polish sequences; that level is coeval with the base of the Lower Podlasie Beds (Bassett *et al.*, 1989). The last occurrence of the conodont *O. crispus* in Bohemia is immediately below the first occurrence of *Monograptus parultimus*. The inference (Viira, 1982, see also Schönlaub, 1986) that *O. crispus* ('*Spathognathodus*' aff. *snajdri* complex) ranges into the lowermost Kaugatuma Formation in Estonia - northern Latvia, thus suggesting that the Ludlow/Prídolí boundary occurs in the lowermost part of the Kaugatuma Formation, is denied by the now confirmed, exclusively Upper Paadla Formation occurrence of *O. crispus* in Estonia (Männik & Viira, 1990); the Kaugatuma/Kuressaare formational boundary therefore is given as a solid line. Based on Baltic ostracodes and conodonts from Beyrichienkalk boulders and the Prídolí stratotype area (Jeppsson, 1981, 1988) there is no resolvable hiatus between the *Nodibeyrichia pustulosa* (*gedanensis*)/*Kloedonia wilckensiana* ostracode fauna of the Beyrichienkalk and the Silurian-Devonian boundary (Hansch, 1993, *in press*).

*Neobeyrichia regnans* in the upper Ludlow Siedlce beds of Poland (cf. Tomczykowa & Witwicka, 1974) is based on Zbikowska (1973) and Martinsson (1964, 1967). Plots of the fauna with *Hemsiella hians* (*loensis*) &/or *Hemsiella maccoyiana* (alongside that containing *Neobeyrichia regnans*) are additional to data of Siveter, 1989: *Hemsiella maccoyiana* from the upper Ludlow of Scania (Moberg & Grönwall, 1909: 'Ramsåsa lag 3 & 4', 'Klinta lag 1 & 3', 'Bjarsjölagård lag 1 & 3'), Estonia (*H. cf. maccoyiana* of Sarv, 1968: Kuressaare and Kaugatuma strata) and the Ludlow (Upper Whitcliffe Formation; Siveter, 1980: 49) and Kerry areas (Cefn Einion Formation; G. Miller, Leicester University, pers. comm.) of the Welsh Borderland; *Hemsiella hians* (*loensis*) from the upper Ludlow of Estonia (Sarv, 1968: Paadla and ? Kuressaare strata).

**Abbreviations:** B M of Klinta Fm - Bjarsjölagård Member of Klinta Formation; Downton CS Fm - Downton Castle Sandstone Formation; LBBM - Ludlow Bone Bed Member; Öved-Ramsåsa Gp - Öved-Ramsåsa Group; Öved Sst. Fm - Öved Sandstone Formation; PSM - Platyschisma Shale Member; SM - Sandstone Member.

possible 'quasi-marine' deposits in an overall regressive sequence and the latter from fully marine deposits in a borehole.

During the last 25 years, the '*Nodibeyrichia jurassica* Zone' has been used, with various degrees of refinement, to denote the youngest of the ostracode faunal associations in

the Silurian of the northern and central East Baltic (Estonia and Latvia respectively; land outcrop and boreholes) and contiguous areas (Baltic submarine exposures and Beyrichienkalk s.s. boulders). The 'Zone' has been uniformly used to identify horizons equivalent to the Ohesaare Regional 'Stage' (i.e. the Ohesaare Formation in Estonia



and the upper part of the Jura Formation in parts of Latvia; e.g. Sarv, 1977: 178) which, it is commonly agreed, correlates with the upper part of the Põldol Series. The stratigraphical interval in question was first identified as the [*Beyrichia*] *Simplicibeyrichia* sp. nov. Zone and later, from the Piltene 1 borehole in Latvia, as the [*Beyrichia*] *Simplicibeyrichia jurassica* Zone (Gailite, 1964, 1965). Though nomenclatorial opinions changed, the same interval was subsequently identified again in West Latvian boreholes (*Beyrichia* ?*protuberans* Zone of Gailite, 1967; *Nodibeyrichia jurassica* Zone of Sarv, 1977, 1982; Gailite, 1978, 1986), in a borehole and Cliff Section on Saaremaa Island, Estonia (*Nodibeyrichia jurassica* Zone of Sarv, 1968, 1971, 1977; *Nodibeyrichia protuberans* Zone of Meidla & Sarv, 1990) and from the Beyrichienkalk erratic boulder sequence (*Nodibeyrichia protuberans* fauna of Hansch, 1985, 1986a).

The taxonomic revisions herein have the following consequences for the Upper Silurian ostracode biostratigraphy in the Baltic-British ostracode faunal region:

1. The '*Nodibeyrichia jurassica* Zone' should be termed the *Nodibeyrichia protuberans* Zone.
2. *Nodibeyrichia protuberans*, and therefore its 'Zone', can still be identified from the central East Baltic (Latvia) and from the submarine floor of the Baltic (Beyrichienkalk s.s. erratic boulder sequence).
3. *Nodibeyrichia protuberans*, and therefore its 'Zone', can no longer be identified from the Silurian of the northern East Baltic (Estonian) sequence.
4. *Nodibeyrichia verrucosa* is no longer confined to the lower Põldol Downton Castle Sandstone Formation of the Welsh Borderland. Conspecific material also characterizes the late Põldol Ohesaare Formation (Ohesaare Regional 'Stage') of Estonia.
5. Considering the ostracode faunal succession of the East Baltic area in general, it is possible to recognize three, broadly defined, successive faunas which are relatively widespread: characterized by the beyrichiaceans *F. groenvalliana*, *N. tuberculata* and *N. pustulosa* respectively (Fig. 1 herein; see also Hansch, 1993, *in press* for a summary). The oldest and youngest of these three associations are also present in Britain (Siveter, 1978, 1989).

## REPOSITORIES

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