

Note

Llandovery and Wenlock miospores and spore-like microfossils from the Ringerike district, Norway

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Five species of spores and spore tetrads assignable to the genera *Ambitisporites*, *Nodospora*, *Tetrahetraletes* and *tetraletes* are recorded from the Llandovery and Wenlock succession of the Ringerike district, together with two undescribed species of spore tetrads. The earliest incoming of spore Tetrads is recorded from the top Vik Formation (lower to middle Telychian). Trilete spores have so far only been recorded from Steinsfjorden Formation (Sheinwoodian).

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Although the Lower Paleozoic succession of the Oslo Region has been a center of intensive paleontological research for more than a hundred years, very few palynological data have been published. Investigations on the Silurian palynoflora of the Oslo Region were initiated by Dr. S. B. Manum (University of Oslo) and others several years ago, but no data were published from these earlier studies. The only published work on the Silurian was carried out by Dorning & Aldridge (1982), who examined five samples from the early Silurian of the Ringerike district. Dorning & Aldridge (1982) concluded that there is a good potential for recovering acritarch assemblages through the early Silurian sequence in Ringerike and probably elsewhere in the Oslo Region. In my own studies I have recorded the stratigraphic distribution of fifty-eight species of acritarchs and prasinophycean algae through the Llandovery (Sælabonn, Rytteråker, Vik and Bruflat Formations) and lowermost Wenlock (lowermost unit of the Braksøya Formation) succession of the Ringerike area (Smelror 1987).

Most of the Wenlock strata have not been investigated palynologically, and this report includes records of the microflora from a few spot samples from the Steinsfjorden Formation in addition to the Llandovery data.

The purpose of this preliminary report is to provide additional information on the growing record of trilete plant spores and spore tetrads from pre-Devonian strata. The trilete spores and

spore tetrads from the Ringerike district are not the oldest known (see Gray et al. 1982), and although no new species are formally described, the present description and illustration of the precisely dated Ringerike palynoflora are presented here for their potential stratigraphic value.

Geology

The Ringerike district (Fig. 1) is located at the northwestern margin of the Oslo Region graben structure. Within the Oslo Region, Silurian sediments have a composite thickness of approximately 1950 m and represent a continuous depositional sequence from the early Llandovery until the Pridoli (Worsley 1982). The Llandovery and Wenlock consist of marine deposits with both clastic and carbonate facies, and a transition to red bed facies occurs a little below the Wenlock/Ludlow boundary. A brief account of the geology of the Ringerike district is given by Whitaker (1977). Worsley et al. (1983) presented a lithostratigraphical scheme for the entire marine succession of the Oslo Region, including descriptions of depositional environments and syntheses of key biostratigraphical elements found throughout the sequence. Lithostratigraphical units and biostratigraphical correlations of the Ringerike district are shown in Fig. 3. Fig. 2 shows the locations of the samples from which miospores and spore-like microfossils are recorded in this present study.

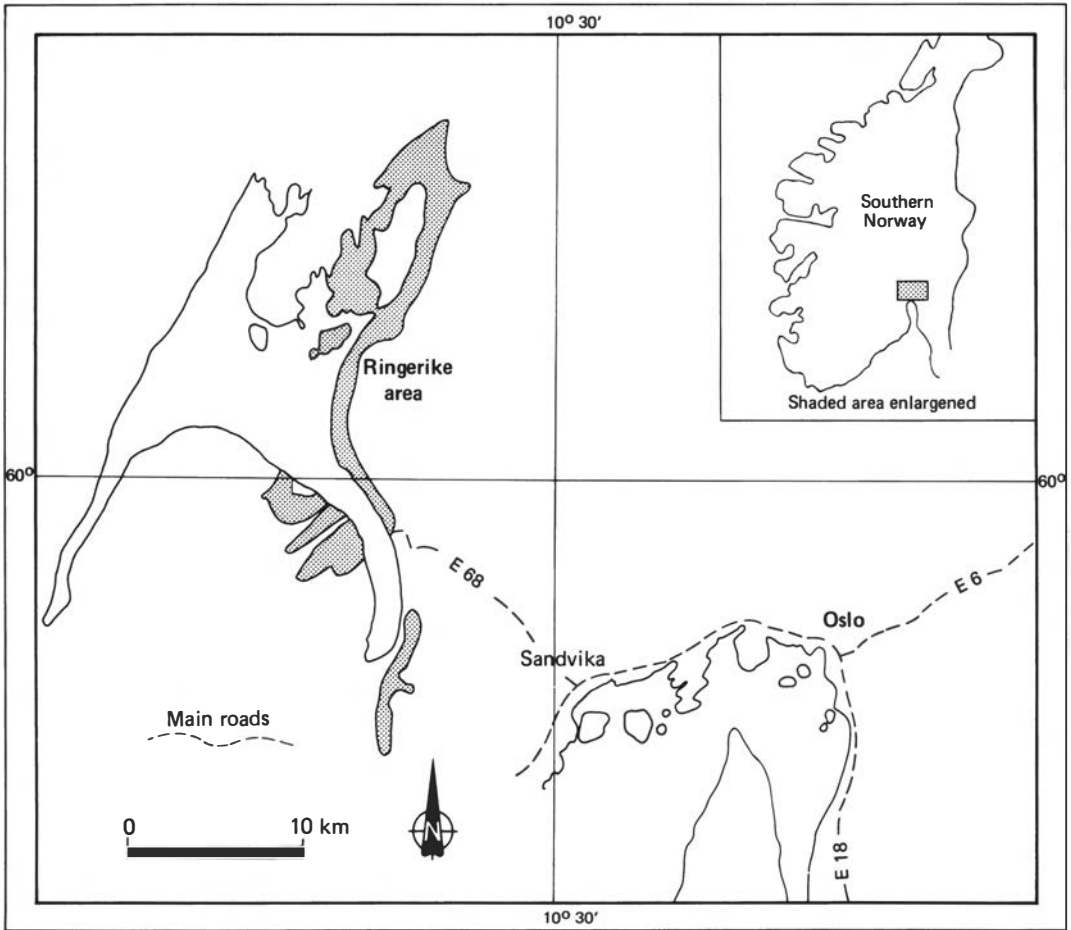


Fig. 1. Location map of the Ringerike area. Shaded areas indicate distribution of Silurian outcrops around the Lake Tyrifjorden (data from Kier 1908).

Discussion

No spore-like microfossils have so far been recorded from the Rhuddanian and Aeronian strata of Ringerike. Spore-tetrads appear from the top-Vik Formation. These (here informally named Tetrad type A) are tetrads of inaperturate spores or spore-like palynomorphs, with smooth walls, arranged in a cross configuration. Spore-tetrads comparable with those showing their earliest appearance in the top of the Vik Formation are previously reported from strata as old as Ashgill (Gray et al. 1982). According to Gray (1985a), in both the North Atlantic Region and the Malvinokaffric Realm from the middle Ordovician onwards, land-plant spores are a common component of shallow-water, near-shore marine

rocks. Dorning & Aldridge (1982) also recorded the miospore *Nodospora burnhamensis* Strother & Traverse 1979 from the top of the Vik Formation. The conodont and brachiopod faunas indicate a lower to middle Telychian age for the Vik Formation (Worsley et al. 1983). Another type of spore-tetrads, with rugose walls (Tetrad type B, Fig. 4B), occur from the lower part of the Bruflat Formation to the lowermost unit of the Braksøya Formation. The spore tetrads occurring in the Telychian strata of Ringerike are rare, and the palynomorph assemblages are dominated by abundant acritarchs and prasinophycean algae.

No trilete spores have so far been recorded from the Llandovery strata of Ringerike, but the samples from the Wenlock Steinsfjorden For-

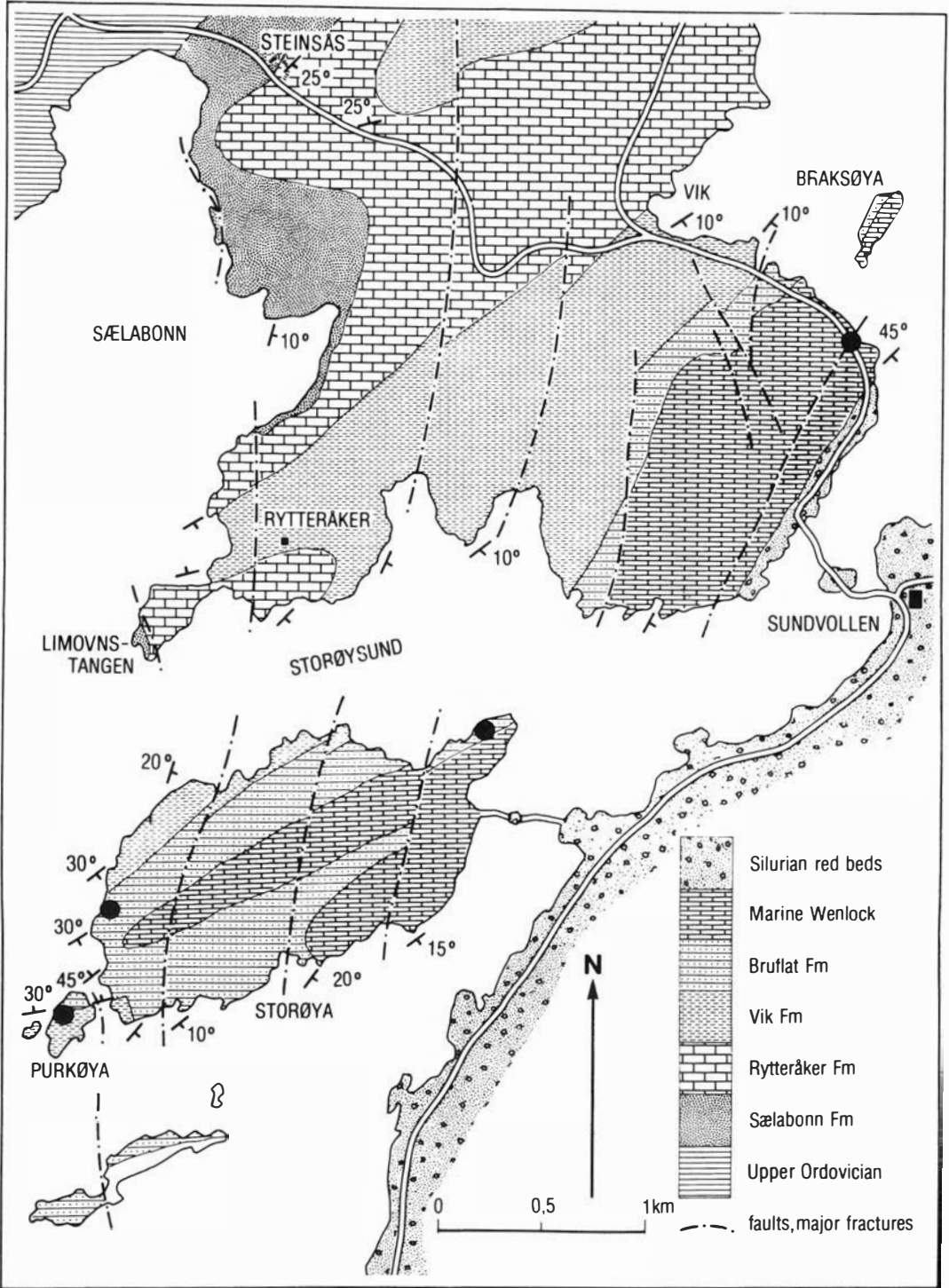


Fig. 2. Geological map of northeastern Tyrifjorden, Ringerike, showing the locations from which miospores and spore-like palynomorphs are recorded.

mation show a moderate abundance of *Ambitisporites*. Specimens assignable to both *A. avitus* Hoffmeister 1959 and *A. dilutus* (Hoffmeister) Richardson & Lister 1969 are present. In England *A. dilutus* is known to range from Upper Aeronian to Upper Homerian (Aldridge et al. 1979).

Within the upper part of the Steinsfjorden Formation *Ambitisporites* occur together with spore tetrads as *Nodospora burnhamensis* Strother & Traverse 1979, *Tetraedraletes medinensis* Strother & Traverse 1979, and *Tetraletes variabilis* Cramer 1966. It should be noted that Gray (pers. com.) and Duffield (1985) suggested that *Nodospora* and *Tetraedraletes* are the same forms seen in different orientations. However, with the limited material recorded from this study specimens are assigned to these two genera separately. Representatives of the *Nodospora-Tetraedraletes* complex are known from several localities within both the Malvinokaffric and North Silurian Realms. *Nodospora burnhamensis* is earlier recorded from USA (Gray & Boucot 1971; Strother & Traverse 1979; Miller & Eames 1982; Johnson 1985), Libya (Hill et al. 1985) and Canada (Duffield 1985). *Tetraedraletes medinensis* is previously known from USA (Gray & Boucot 1971; Strother & Traverse 1979; Miller & Eames 1982; Johnson 1985), Libya (Hill et al. 1985) and Brazil (Gray et al. 1985).

The miospores and spore-tetrads of the Steinsfjorden Formation comprise approximately 40% of the palynomorph assemblages, but the total microflora is not so rich in specimens. Prasinophycean algae are most common, while acritarchs and chitinozoans are relatively rare.

Trilete spores are more common than spore tetrads in these Sheinwoodian assemblages. Cuticle fragments (Fig. 4E) and tracheid-like tubes (Fig. 4I) are also relatively common. The assemblages from the Steinsfjorden Formation can be correlated with the Assemblage Zone II of Gray (1985). According to Gray (1985), Zone II assemblages are characteristic for the post-middle Llandovery to ?late Wenlock, and are found in the Appalachian region, western Europe and North Africa.

Evidence from well-dated sections of the Welsh Borderlands indicates that the first *Ambitisporites* appeared within the upper Aeronian (Aldridge et al. 1979). Representatives of the genus *Ambitisporites* are previously reported from Silurian strata in England (Richardson & Lister 1969),

Ireland (Smith 1979), East-Greenland (Armstrong & Dorning 1984), Spain (Cramer 1966, Rodrigues 1978), Libya (Hoffmeister 1959, Richardson & Ioannides 1973, Hill et al. 1985) and USA, i.e. Indiana (Wood 1978) and Pennsylvania (Strother & Traverse 1979; Johnson 1985). Hoffmeister's original record of *Ambitisporites* from a Libyan borehole was dated to near the lower-middle Llandovery boundary, and Gray et al. (1982) reported trilete spores from strata just above the C₂/C₃ boundary (upper Aeronian) in Libya. Gray et al. (1982) suggested that the morphologic change from tetrahedral tetrads assemblages to trilete-spore dominated assemblages is a major evolutionary event that occurs over a wide geographic area within the upper Aeronian. The absence of trilete spores in the Aeronian and Telychian strata of Ringerike is therefore noteworthy, since it is clear that the Ringerike area through the Llandovery represented nearshore depositional environments (Johnson & Worsley 1982). Neither have any tracheid-like tubes or sheet of cuticle-like cells been recorded from these Llandoveryan settings; they first occur in association with *Ambitisporites* in the samples from the Wenlocky Steinsfjorden Formation.

Gray (pers. comm.) recorded smooth-walled trilete spores in ?upper Wenlock/lower Ludlow samples from Rudstangen at Ringerike. However, the palynological data from the investigated area are still very scanty, and at present no samples have been examined from the important Wenlock interval between the base of the Braksøya Formation and the middle to upper part of the Steinsfjorden Formation.

Descriptions

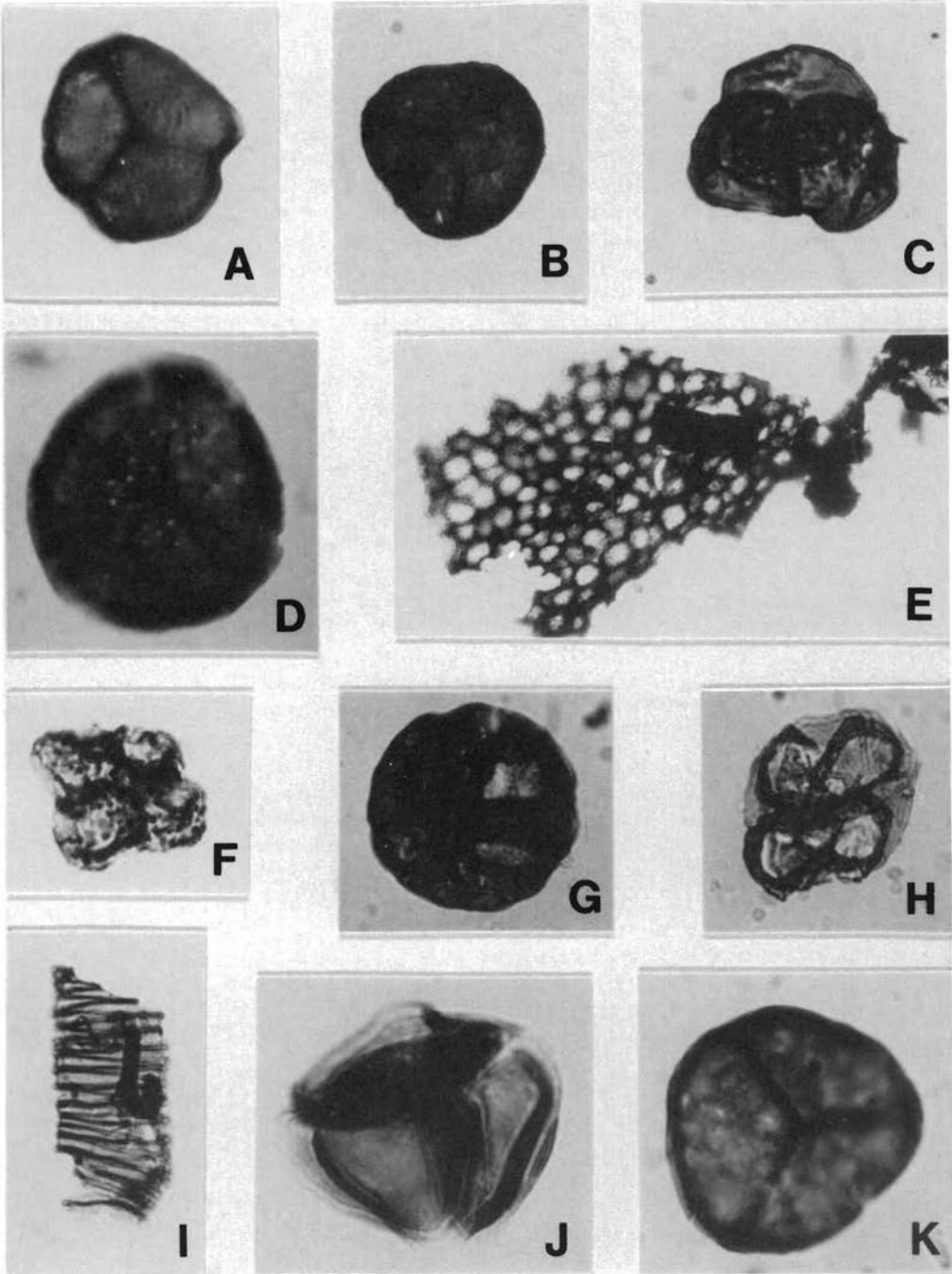
Tetrad type A

Fig. 4H

Description: Tetrads of inaperturate spores or spore-like palynomorphs, with smooth walls, spherical to subspherical in outline, arranged in a cross configuration. The tetrads are without envelopes. There is a marked tendency for the individual 'spores' of this cross tetrad to separate.

Dimensions. 25–52 µm in overall diameter (8 specimens measured).

Occurrence. Upper part of the Vik Formation and throughout the Brufvatn Formation (Telychian).



Remarks. The tendency for the individual spore bodies of this cross tetrad to separate exclude this species from the genera *Nodospora* Strother & Traverse 1979 and *Tetraedraletes* Strother & Traverse 1979. Tetrad type A is comparable with the spore tetrads illustrated by Strother & Traverse (1979, pl. 3, fig. 8) from the Wenlock ?Clinton Group; Pennsylvania, U.S.A. Tetrad type A seems also to show close relations to the tetrads illustrated by Gray et al. (1982, figs. 2B, 8, 9, 10B) from the Ashgill Elkhorn Formation, Kentucky, from the Djefarn Formation (Northern Tripolitania) and Tanezzuft Formation (Northern Murzuk Basin) in Libya, and from the Ludlow Burgsvik Formation of Gotland, Sweden.

Tetrad type B

Fig. 4G

Description. As per tetrad type A, but with rugose walls.

Dimensions. 44–53 µm in overall diameter (4 specimens measured).

Occurrence. Lower part of the Bruflat Formation to the lowermost unit of the Braksøya Formation (Telychian—Lower Sheinwoodian).

Remarks. Tetrad type B may appear somewhat comparable to *Nodospora rugosa* Strother & Traverse 1979, but differs in showing partly separated individual spore bodies.

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Fig. 4. Llandovery and Wenlock miospores, spore-tetrads and land plant remains from the Ringerike district. All Figs. ×700.

A: *Ambitisporites avitus* Hoffmeister 1959. PA 4373: R. 39/1. Steinsfjorden Formation.

B: *Ambitisporites avitus* Hoffmeister 1959. PA 4371: U. 34/0. Steinsfjorden Formation.

C: Spore tetrad. PA 4371: Q. 48/3. Steinsfjorden Formation.

D: *Ambitisporites dilutus* (Hoffmeister) Richardson & Lister 1969. PA 4371a: C. 36/4. Steinsfjorden Formation.

E: Cuticle-like fragment. PA 4371: N. 29/0. Steinsfjorden Formation.

F: *Tetraletes variabilis* Cramer 1966. PA 4372: L. 31/4. Steinsfjorden Formation.

G: Tetrad type B. PA 4281: C. 39/1. Bruflat Formation.

H: Tetrad type A. PA 4134: K. 34/0. Vik Formation.

I: Tubular structure. PA 4373: D. 34/1. Steinsfjorden Formation.

J: *Tetraedraletes medinensis* Strother & Traverse 1979. PA 4373: O. 27/3.

K: *Ambitisporites* cf. *dilutus* (Hoffmeister) Richardson & Lister 1969. PA 4371a: N. 29/0. Steinsfjorden Formation.

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