Tectonic framework, stratigraphy, sedimentation and volcanism of the Late Precambrian Hedmark Group, Østerdalen, south Norway

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The Hedmark Group in the Imsdalen - Bjørånes - Atna - Øvre Rendal area belongs to the Osen-Røa Nappe Complex, and crops out northwest of the late-Caledonian central Østerdalen structural depression. The Brøttum Formation and the Imsdalen Conglomerate occur on the southwestern side of the Imsdalen fault (IMF), which is a synthrust high angle reverse fault. The pre-Varanger Brøttum Formation (turbidites, deltaic, fluvial) is correlated with the fluvial Rendalen Formation NE of IMF. Basin evolution prior to the Varanger glaciation also includes carbonate sedimentation, black mud deposition in stagnant secondary basins, and block faulting accompanied by basalt volcanism and coarse-clastic, subaqueous resedimentation. The glacial Moelv Tillite rests unconformably on various units and was succeeded by post-glacial deltaic and fluvial sedimentation and early Cambrian deposition of shallow-marine quartz sands. New formations are defined: the Imsdalen Conglomerate and the Svartt}Ørnkampen Basalt.

The Atna Quartzite is given the rank of formation, and the B}Ørånes Shale Member is referred to the Biri Formation. Parts of the Sollia Formation are correlated with well-established formations in the Hedmark Group.

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The Late Precambrian (Upper Proterozoic) Hedmark Group consists of sandstones, conglomerates, tillite, shales, carbonate rocks as well as a basalt in an area extending from the river Imsa and northwards to Bjørånes, Atna and Øvre Rendal (Figs. 1 & 2). The stratigraphical relations within the sequence are of importance for the interpretation of facies variations within the Hedmark Group and for the Late Precambrian to Early Cambrian palaeogeography in southern Scandinavia. Acritarchs sampled from the type area at Mjøsa indicate Vendian to Early Cambrian age for the Hedmark Group; the lowermost part may be of Late Riphean age (Vidal 1980, p. 41).

Stratigraphical and structural problems in the central part of the Østerdalen area have been dealt with by Törnebohm (1986), Bjørlykke (1905), Werenskiold (1911), Oftedahl (1943, 1954), in Oftedahl & G. Holmsen 1952, in P. Holmsen & Øftedahl 1956), Bjørlykke (1965, 1969), Prost (1975), Kjølberg (1980) and Nystuen & Ilebekk (1981). The discussions have particularly concerned the litho- and tectonostratigraphical positions of the area's 'light and dark sparagmites'. These old lithological terms denote arkoses and feldspathic sandstones which we can now refer to formations in the Hedmark Group and the Kvitvola Nappe. The magnitude of horizontal displacements during the Caledonian orogeny has been another main problem of controversy.

The purpose of the present study has been to elucidate the stratigraphical relations within the Hedmark Group and to define the tectonic structures in which the sequence occurs. The main part of the field work was carried out in the years 1977–1979, with supplementary investigations in 1980 by J. P. Nystuen in the Imsdalen area (valley district along the river Imsa and the lakes northern and southern Imssjøen).

Tectonostratigraphy

Oftedahl (1943, in Oftedahl & G. Holmsen 1952) considered the Hedmark Group in the area to be allochthonous, thrust from northwest of the Attnsjøen window (Fig. 1). Later, Øftedahl (1954) and P. Holmsen and Oftedahl (1956) suggested that the Hedmark Group rocks occurred in two tectonostratigraphical units. The sequence in the
Sparagmite Region
southern Norway
J.P. Nystuen 1980
Bjørånes area was considered parautochthonous and belonging to the upper part of the Hedmark Group (Ring Formation and younger). These strata were interpreted to outcrop within a 'Bjørånes window', overthrust by older formations within a 'Sparagmite nappe'. This latter tectonic unit was thought to comprise a giant fold nappe within the central, southern part of the Sparagmite Region (P. Holmsen & Oftedahl 1956, p. 18). The hypothesis of a 'Bjørånes window' was further evolved by Bjørllykke (1965, 1969), who interpreted the Bjørånes shale, Moelv Tillite and Ekre Shale in the Bjørånes area as parautochthonous, being exposed within an antiform. This sequence was suggested to be overlain by an imbricated thrust unit consisting mainly of the Vangsås Formation, which, in turn, was overthrust by the Kvitvola Nappe. Prost (1975, p. 545) interpreted the lower part of the sequence in the Imsdalen – Atna – Sollia area as autochthonous and a higher part (his 'Atna Unit' and 'Sollia Formation') as an allochthonous equivalent to the Osen Nappe at the southern front of the Sparagmite Region.

An allochthonous position for the Hedmark Group is demonstrated by its thrust contact along the boundary of the Atnsjøen and Spekedalen windows. Older units of the group lie here tectonically above a thin and discontinuous sequence of younger strata which also include Cambrian phyllites. The lower sequence has sedimentary contact to the Precambrian crystalline basement within the windows (Oftedahl 1943, Oftedahl in Oftedahl & G. Holmsen 1952, Nystuen 1978, Siedlecka 1979, Nystuen & Ilebekk 1981).

The 3000–4000 m thick allochthonous sedimentary sequence in the northern part of the Sparagmite Region belongs to the Røa Nappe which extends eastwards into Hjardéalen in Sweden (Tórnebohm 1896, Nystuen 1975a). In Sweden, this tectonostratigraphical unit was named the Hede Nappe by Røshoff (1978). According to Nystuen (1981), the Røa Nappe rocks can be followed into the Osen Nappe at the southern nappe front of the Sparagmite Region in southern Norway; the complete thrust unit was called the Osen-Røa Nappe Complex.

The Røa Nappe consists of three thrust sheets in the area between the Atnsjøen window and the Rendalen fault (Nystuen & Ilebekk 1981). The basal thrust of the upper thrust sheet is very prominent in the area at Langtjörna, northwest of Øvre Rendal (Kjølberg 1980). The thrust has been mapped westwards to Hanestad, but its further continuation is uncertain; it probably joins the sole thrust of the Røa Nappe along the southern boundary of the Atnsjøen window. The upper thrust sheet comprises the Hedmark Group sequence which can be followed from Øvre Rendal in the northeast through the Bjørånes area to the mountains Famphøgdene and Piggvola in the southwest (Fig. 2). The sequence is here cut by the Imsdalen fault (IMF); the structural significance of the fault is discussed below.

The Kvitvola Nappe, which is thrust upon the Røa Nappe, consists of Upper Proterozoic metasediments (the Engerdalen Group, Nystuen 1980) and sheets of Precambrian crystalline basement rocks.

**The Øvre Rendal – Piggvola folds**

The Osen-Røa Nappe Complex forms a duplex (Elliott & Johnson 1980, McClay 1981) between its gently dipping sole thrust and the weakly undulating basal thrust of the Kvitvola Nappe; folds and steeply dipping secondary thrusts in the Osen-Røa Nappe unit are cut by the overlying Kvitvola thrust (Nystuen 1981). The interface between these two nappe units is deformed into a structural depression in the central Østerdalen – Storsjøen area (Fig. 1). This *central Østerdalen depression* (CØD, Fig. 1) is formed by the interference between two major synforms. The *Storsjøen – Øvre Rendal synform*...
 Geological map of the Imsdalen-Bjørånes-Atna-Øvre Rendal area
Sparagmite Region, southern Norway
T. Sæther & J.P. Nystuen 1980

- Kvitvola Nappe
- Sollia Fm.
- Vangsås Fm.
- Ekre Shale
- Moelv Tillite
- Limestone & dolomite
- Black shale
- Turbidite sst.
- Håkenstad cgl.
- Svarttjørnkampen Basalt
- Atna Quartzite
- Rendalen Fm.
- Storskarven Sst.
- Granite
- NE of IMF
- SW of IMF (Imsdalen fault)
- Thrust plane in general
- Røa Nappe thrust plane
- Fault
- Bedding plane (normal, inverted) 360°

Fig. 2. Geological map of the Imsdalen-Bjørånes-Atna-Øvre Rendal area. A-A', B-B', C-C', D-D' and E-E' are section lines of profiles shown in Fig. 3. Abbreviations: Atna st. = Atna railway station, Gr. h. = Gråhammaren, s.Kj.b. = søndre Kjølsjøberget, Sv.k. = Svarttjørnkampen, Gardb. = Gardbekken, Langtj. = Langtjørsna.

runs NNW-SSE in the area between Glomma and Storsjøen – Rendalen, and the Imsa-Kvitåsen synform can be traced from Imsdalen in the southwest to the mountain Kvitåsen in the east (Fig. 1). The axis of the latter synform is arcuate, being orientated WNW-ESE in the west and...
NE-SW in the east. The central Østerdalen depression is cut by the post-Caledonian Rendalen fault, with subsidence on the western side. The structural depression has probably been formed contemporaneously with the late-Caledonian antiform farther north, along which windows are preserved, exposing the Precambrian basement.

The Hedmark Group crops out in a series of subordinate anticlines and synclines along the northwestern boundary of the central Østerdalen depression, from Øvre Rendal in the northeast to Piggvola in the southwest (Fig. 2). These folds predate the formation of the central Østerdalen depression, but their orientation is affected by the late-Caledonian large-scale deformation.

The thick Rendalen Formation, consisting of sandstones, is folded into broad, open folds in the area north of Atna, but farther south this unit is broken up in imbricated sheets which dip to the north-west and north (Fig. 2). The formation occurs in a major anticline which is overturned to the south in the Famphgøndene–Gardbekken–Bjørånes area and at Øvre Rendal (Figs. 2 & 3). This anticline is cut by high angle thrusts within the imbricated Rendalen Formation and at Øvre Rendal (Figs. 2 & 3). This anticline is cut by high angle thrusts along which the Rendalen Formation has been locally displaced above younger units, as recorded in the area from Harrsjøen to Kivfjell and also in the area between Famphgøndene and Gråhammaren (Figs. 2 & 3). The units which lie above the Rendalen Formation are in part tightly folded and cut by thrusts, as seen in southern side of Famphgøndene and Piggvola and in southern Kjølsjøberget and Svarttjømkampen.

Sediments younger than the Rendalen Formation also occur in the Hira–Granåsen–Løvåsen area (Fig. 2). This is the eastern limb of a synclinorium which extends westwards to the northernmost part of Imsdalen (Fig. 1).

The Øvre Rendal–Piggvola folds display an arcuate trend in the Bjørånes–Piggvola area (Fig. 2). Steeply inclined thrusts within the imbricated Rendalen Formation are also curved in the horizontal section; the convex sides face southwards, in the direction of the nappe’s movement. A similar structural style has been formed also in other parts of the Osen-Røa Nappe Complex. Nystuen (1981) explained this arcuate fold and imbrication pattern as the result of one single phase of deformation, produced within a décollement nappe driven by gravity forces.

Post-Caledonian normal faults cut the folds along the river Kiva and in the area east of Atna railway station. The NNW-SSE running Kiva fault is characterized by a red-coloured fault breccia which is very similar to rupture breccias along Permian faults in the Oslo Region.

**Imsdalen fault**

The Imsdalen fault (IMF, Fig. 2) cuts the Øvre Rendal-Piggvola folds in the area southwest of Famphgøndene and Piggvola. The Imsdalen fault forms the northeastern limit of the extensive Brøttum Formation area, within the Sparagmite Region (Fig. 1). The fault does not appear to cut the Kvitvola Nappe in the southeast. It dips nearly vertically in the area southeast of Famphgøndene, but the dip decreases towards the northwest and is about 50° to the SW in the area north of northern Imssjøen. The fault has not been investigated in detail outside the map area of Fig. 2. Reconnaissance studies indicate that it continues for at least ten kilometres farther to the NNW, following the eastern side of Imsdalen (Fig. 1).

The axial planes of the folds on the northeastern side of the fault are cut by the fault at an acute angle, but bedding planes in the Brøttum Formation on the southwestern side strike parallel with the fault line. The Imsdalen Conglomerate forms a marker horizon in the sequence southwest of the fault. The folds here include an anticline which is slightly overturned to the northeast and cut by the Imsdalen fault (profile B-B’, Fig. 3). The Brøttum Formation and the Imsdalen Conglomerate dip 30°-60° to the SW in the area northwest of northern Imssjøen, and the strata here are probably stacked into imbricated sheets.

The Brøttum sandstones in the hanging wall are strongly sheared along the fault, being altered to quartz-sericite phyllonites in a 10–20 m thick zone. The rocks in the footwall, on the other hand, are much lesser deformed along the fault. In general, there is no difference in degree of tectonic deformation and metamorphism between the rocks southwest and northeast of the fault. In both areas severe tectonic deformation with growth of light mica and quartz is mostly limited to zones which have suffered high strain.

As pointed out in a later chapter, the Brøttum and Rendalen Formations are interpreted as lithostratigraphical equivalents; the Rendalen Formation consists of fluvial sandstones, whereas the Brøttum Formation in the Imsdalen area includes turbidites, shallow-marine sediments as
well as fluvial sandstones similar to those in the Rendalen Formation.

The Imsdalen fault is of syn-Caledonian origin and predates the emplacement of the Kvitvola Nappe. It is a high angle reverse fault, and it may have been formed contemporaneously with the folding along the axial plane of a tightly compressed syncline (Fig. 3). A high degree of concordance in fold axis orientations, deformational style and metamorphism between the sequences separated by the fault is in favour of this interpretation. On the other hand, the thick phyllonite zone at the base of the hanging wall is very similar to the strongly deformed arkosic sandstones which occur at the sole of several major thrust sheets in the Sparagmite Region. The northeastern tectonic boundary of the Brøttum Formation can be explained by an inclined sole thrust of a separate nappe unit, lying above the Røa Nappe. The Imsdalen fault could thus be interpreted as a folded ramp structure, i.e. a thrust which cuts up stratigraphically from a
bedding plane thrust (McClay 1981). This hypothesis has to be tested by detail studies of the Imsdalen fault farther to the north.

At the present stage of our investigations in this area, we prefer to consider the Imsdalen fault as a high angle reverse fault which was formed in consequence of folding within the upper thrust sheet of the Røa Nappe. The fault’s particular location between the Brøttum and Rendalen Formations could be due to synde­mentary faults or flexures in the transitional zone between a fluvial basin in the northeast (Rendalen Formation) and a turbidite basin in the southwest (Brøttum Formation).

**Lithostratigraphy and depositional environment**

**Brøttum Formation**

The Brøttum Formation crops out in a large area in the central and southern part of the Sparagate Region. Our investigations have revealed that the formation extends far to the north in the area west of the Imsdalen fault (Fig. 1). The stratigraphical and structural features of the formation are still uncertain in the area south of Sol­lia (Fig. 1) (see the section below on the Sol­lia Formation).

Neither base nor top of the formation is known from the studied area (Fig. 2). However, correla­tion between the Imsdalen Conglomerate (see below) and the Biskopås Conglomerate at Mjøsa (Fig. 4) suggests that the Brøttum Formation in the area (Fig. 2) represents the upper part of the unit. The minimum thickness in the area is at least 1500 m.

The sediments are dominated by medium- to coarse-grained, grey to light-grey and red feld­­spatic sandstones and arkoses. Four major facies associations have been distinguished.

In the southeasternmost part of Imsdalen (Fig. 1), grey, feldsparic sandstones and arkoses. Four major facies associations have been distinguished.

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The Brøttum Formation at Mjøsa (Bjørlykke et al. 1976) and in Gudbrandsdalen (Englund 1972). The turbidites here in the easternmost part of Imsdalen are probably located within an anti­form and probably represent a deep, strati­graphical level of the formation. The facies asso­ciation probably represents channels (sand­stones), levees (sandstone and shale) and inter­channel areas (shale) in a mid fan position of a turbidite fan (see Rupke 1978, p. 408).

In the area south of southern Imssjøen, and stratigraphically below the Imsdalen Conglomer­ate, there are very thick (5-30 m) sedimentary units of coarse-grained and conglomeratic arkoses. The units have erosional lower contacts with 1-2 m deep channels. Remnants of shale beds are preserved at the base of some sand­stones. Scattered, irregular shale flakes occur in the lower part of the units. Individual units are composite, consisting of massive, graded and ungraded sequences with transitional lower and upper contacts. This facies is associated with dark grey feldsparic sandstones which occur in 50 cm to 4 m thick graded beds. The facies association is considered to be of turbiditic origin, deposited within the channels of an upper turbidite fan in front of a steep, submarine slope.

A third facies association occurs west of northern Imssjøen and stratigraphically above the Imsdalen Conglomerate. It comprises a series of 50 cm to 3.5 m thick beds of well­sorted, coarse- to medium-grained light grey feldsparic sandstones. The beds reveal parallel and undulatory stratification and tabular cross­bedding. They are usually ungraded. The sand­stone units are separated by thin, grey mudstone beds, and together these facies comprise a c. 200 m thick fining- to coarsening-upward sequence. This sequence is terminated by a multistorey 15 m thick conglomeratic red arkose which occurs within a channel, at least 50 m broad. The facies association is suggested to represent shallow­marine or deltaic sediments overlain by a fluvial, distributary channel sandstone.

The fourth facies association has been re­corded from the hillside east of southern Imssjøen. The sediments here are dominated by 1-4 m thick graded units of red, coarse-grained to medium-grained arkoses. The lower contacts are erosional, and in the lower part the sand­stones display large-scale (20-70 cm) through cross­bedding, succeeded by small-scale (5-20 cm) trough cross­bedding and parallel stratifica­tion at the top. The arkoses are interpreted to be
of fluvial origin, deposited by low-sinuosity streams on a delta plain. This facies is very similar to the fluvial arkoses which occur in the Rendalen Formation northeast of the Imsdalen fault. The fluvial Brøttum sandstones occur within the core of a tight syncline which is overturned to the NE; this indicates a stratigraphical position above the Imsdalen Conglomerate (Fig. 3.)

Bjørlykke et al. (1976, p. 239) suggested that the conglomeratic arkose facies of the Brøttum Formation in Østerdalen south of Imsa was deposited as turbidites on the submarine slope of a large fan delta. The results of the present study fit well into this interpretation, suggesting that the facies associations in the Imsdalen area comprise environments including middle to upper turbidite fan, shallow-marine to deltaic and fluvial delta plain. Similar facies transitions from turbidites to continental facies have been described from the Tertiary in California by Kamp et al. (1974, pp. 562–563).

**Imsdalen Conglomerate**

This conglomerate occurs as a marker horizon and a mappable unit in the Imsdalen area (Fig. 2) and is below defined as a formation in the Hedmark Group.

**Name.** – The name is taken from Imsdalen, the valley of the river Imsa, in which the conglomerate crops out at several places (Fig. 2).

**Historical background.** – The conglomerate was called the ‘Biri Conglomerate’ by Oftedahl (in P. Holmsen & Oftedahl 1956, p. 70), because of correlation with the Biskopås Conglomerate (previously referred to as the Biri Conglomerate, see Bjørlykke et al. 1967) at Mjøsa. Prost (1975, p. 198) presented a section through the conglomerate from the southern side of Imsdalen. However, he did not recognize the Kvitvola thrust above the conglomerate and thus misinterpreted the carbonate rocks at the base of the Kvitvola Nappe as the Biri Formation in the Hedmark Group. The Brøttum sandstones pass upwards into the matrix of the conglomerate. The boundary of the formation is here defined to the base of the lowermost conglomerate bed. Erosional contacts with 1–2 m deep channels cut into the underlying sandstones are present north of Imsa (Stor-Elvdal 1918 III, NP 937 237) and SSE of southern Imssjøen (Imsdalen 1818 II, NP 897 238).

**Type locality.** – The river section at Imsa (map sheet Stor-Elvdal 1918 III, NP 928 227) is selected as the type locality.

**Thickness.** – The conglomerate unit is about 200 m thick in the northeast (Fig. 2). The thickness varies westwards, but is generally decreasing; it is about 50 m at the type locality, 5–10 m SSE of southern Imssjøen, 15–50 m SW of the same lake and 30–100 m west of northern Imssjøen.

**Lower boundary.** – This is either gradational or erosional. Gradational contacts have been observed in two localities, one in the eastern part of the area (Stor-Elvdal 1918 III, NP 921 239) and the other in the southwest (map sheet Imsdalen 1818 II, NP 859 236). In these localities the Brøttum sandstones pass upwards into the matrix of the conglomerate. The boundary of the formation is here defined to the base of the lowermost conglomerate bed. Erosional contacts with 1–2 m deep channels cut into the underlying sandstones are present north of Imsa (Stor-Elvdal 1918 III, NP 937 237) and SSE of southern Imssjøen (Imsdalen 1818 II, NP 897 238).

**Upper boundary.** – The conglomerate grades upwards into overlying sandstones of the Brøttum Formation. This type of contact is exposed north of Imsa (Stor-Elvdal 1918 III, NP 933 232) and SSE of southern Imssjøen (Imsdalen 1818 II, NP 897 238).

**Description.** – The formation is in the type section at the river Imsa developed as a massive, unstratified and disorganized conglomerate in
the lower part. In the upper part there are inversely graded, clast-supported beds about 1 m in thickness. A matrix-supported texture dominates in the lower part of the conglomerate which here contains several irregular slabs of black shale. The largest shale clast measures, in the vertical section, 4 m × 30 cm. The clasts are confined to one particular level in the conglomerate and are obviously the remains of a ruptured shale bed. Several of the rounded extrabasinal stones are partly covered by thin shale envelopes. This feature demonstrates that the black shale beds have been only weakly consolidated when they were torn up and mixed with the extrabasinal material. Impure limestone (maximum clast diameter of 80 cm) is another intrabasinal clast type at the Imsa locality.

In other localities the conglomerate consists of either one single massive, disorganized unit, or of several beds, 70 cm to 5 m thick, which are either graded or ungraded. In the southwesternmost locality (Fig. 2), the graded units display lower erosional contacts and commence with conglomerates which grade upwards into dark-grey feldspathic sandstones, eventually with black shale on the top. In this locality there are also thin beds (30 cm) of black, pebbly mudstone.

The clast size varies considerably within one single outcrop and from the east towards the west. In the east the maximum diameter of extrabasinal clasts is 80 cm and in the west 15 cm.

The clast assemblage is composed of grey quartzite (25–70%), red quartzite (8–20%), granite (3–12%), aplite and felsite (5–50%), porphyry (1–6%), vein quartz (2–10%) and gneiss, basalt, black and grey shale and limestone, each of the last four types in amounts of less than about 5%. Quartzite, granite, aplite, felsite, porphyry and quartz clasts are usually rounded, whereas those of intrabasinal origin, shale, limestone and also basalt are angular to subangular.

In general, the conglomerate is only slightly deformed tectonically. Imbrications along high angle thrusts have taken place in the conglomerate beneath the Kvivola thrust in the southwesternmost area. In parts of the conglomerate west of northern Imsjøen, the quartz and quartzite clasts have been elongated in the NNW-SSE direction. The deformation of the conglomerate increases towards the NNW.

**Depositional environment.** The Imsdalen Conglomerate has been formed by the mixing of long-transported, rounded extrabasinal stones and angular short-transported clasts derived from intrabasinal sources. The association of graded feldspathic sandstones, black shale, pebbly mudstone, graded and massive conglomerate beds with ruptured shale layers suggests a subaqueous origin by gravity flow processes. The types of internal structures in the Imsdalen Conglomerate have all been described from deep-water conglomerates associated with turbidites (Walker 1975, 1979). The depositional site has probably been braided, distributary channels on the upper part of a coarse-clastic subaqueous fan in front of the steep slopes of a gravel delta.

**Rendalen Formation**

The Rendalen Formation is the dominating bedrock in the Sparagmite Region in the area northeast of the Imsdalen fault (Fig. 1). It rests with sedimentary contact on the Storskarven Sandstone in the area just east of the Atnsjøen window (Figs. 1 & 2). The Storskarven Sandstone was defined as a formation by Nystuen & Hebekk (1981, p. 21), and this unit is dominated by well-sorted, fine-to-medium-grained feldspathic sandstones and has a thickness of at least 2000 m. In all other areas in the eastern and northeastern part of the Sparagmite Region, the Rendalen Formation has been recorded as the lowermost unit in the Hedmark Group. The formation is preserved with sedimentary contacts on Precambrian granite within thrust sheets in the Røa Nappe at Femunden (Nystuen 1978, 1979 a), but is elsewhere cut by the Røa Nappe sole thrust (Fig. 1).

The Rendalen Formation consists of coarse-grained to conglomeratic red and light arkoses and feldspathic sandstones. 1–8 m thick units are usually graded, and reveal structures such as trough, tabular and low-angle cross-bedding, parallel stratification and scour-and-fills. Thin beds or laminae of red mudstone are locally preserved between the sandstone units. The sandstones are obviously of fluvial origin and have probably been deposited by braided flood streams on a wide alluvial plain.

The stratigraphical position of the Rendalen Formation within the map area of Fig. 2 has been a matter of some controversy. The unit, previously called 'red' or 'light sparagmite', was correlated with pre-Moelv Tillite sandstones at Mjøsa by Oftedahl (1943, in Oftedahl & G. *Late Precambrian Hedmark Group* 201
Holmsen 1952, in P. Holmsen & Oftedahl 1956), but was later correlated with the Vangsås Formation by Bjørlykke (1965, 1969), Prost (1975) and partly also Kjølberg (1980). Within the map area of Fig. 2 the stratigraphical position of the formation beneath the Atna Quartzite (see below), the Moelv Tillite and the Biri Formation is shown at Famphøgdene, northern Bjøråa, southern Kjølsjøberget, Svarttjørnkampen, Øvre Rendal and Langtjørna (Figs. 2-4), and at some other localities farther to the north (Nystuen & Ilebekk 1981). The boundary relations at the northern Bjøråa and Øvre Rendal are of particular significance.

In the river section and road cuts (highway No. 3, previously No. 30) at northern Bjøråa (Stor-Elvdal 1918 III, NP 997387), the red, coarse-grained arkose of the Rendalen Formation is overturned; it passes stratigraphically upwards into a 5-8 m thick dark grey arkose which is, in turn, conformably overlain by dark mudstone of the Bjørånes Shale Member in the Biri Formation. The inverted relationships are shown by trough cross-bedding in the arkoses and by ripple-lamination and load casts in sandstone lenticles in the mudstone.

A similar inverted contact between the Rendalen Formation and the stratigraphically overlying Biri Formation is exposed at Øvre Rendal (map sheet Hanestad 1918 IV, PP 087 644), see Fig. 5. The basal beds of the Biri Formation are here represented by grey siltstone, black shale and the Håkenstad conglomerate (see below).

On recently compiled maps of the Sparagmite Region (Prost 1975, Prost et al. 1977, Bjørlykke et al. 1976, Bjørlykke 1978), the Rendalen Formation (named Ring Formation) has been considered to exist only on the eastern side of the Rendalen fault line. In most earlier palaeogeographical reconstructions of the sedimentary basin of the Hedmark Group, it has been suggested that the area east of the Rendalen fault line was a separate ‘eastern basin’ which evolved later than the ‘western basin’ (Englund 1972, 1973, Nystuen 1976a, Bjørlykke 1978). The identification of the Rendalen Formation in the area west of the Rendalen fault line is important to discussions about the sedimentary evolution of the Hedmark Group.

Atna Quartzite

The name of this formation was originally introduced by Prost (1970). Later the unit was re-named the ‘Hira Quartzite Formation’, and the name ‘Atna’ was applied to a supposed nappe unit (Prost 1975, 1977). Nystuen & Ilebekk (1981, p. 23) defined the Atna Quartzite Member as the uppermost member of the Rendalen Formation. The quartzite is an important mappable unit in the area south of the Atnsjøen window (Fig. 1) and attains here a thickness of c. 200 m (Siedlecka 1979). The fluvial arkoses of the Rendalen Formation thin out towards the west in this area, and the Atna Quartzite comprises the basal unit in the Røa Nappe (Fig. 1). We have considered these features of the Atna unit and found them to be substantial reasons (see Hedberg 1976, p. 32) to change its stratigraphical rank to formation.

The Atna Quartzite has a gradational lower contact to the Rendalen Formation (Nystuen & Ilebekk 1981). Within the map area (Fig. 2), it is overlain by the Svarttjørnkampen Basalt, the Biri Formation and the Moelv Tillite (Fig. 4). The thickness varies considerably within the area (Fig. 2): absent at Øvre Rendal, 30 m at southern Kjølsjøberget, 10 m at Famphøgdene and 100–150 m at Granåsen.

The Atna Quartzite is a light grey, fine- to medium-grained feldspathic quartzite. It is well-sorted and occurs in 10–80 cm thick beds. The beds are parallel-stratified, and wave-ripples are observed on bedding planes. In the northern part of the Insdalen area, there are greyish-green shale beds within the quartzite. A 10–15 m thick clast-supported conglomerate occurs locally at the base of the Atna Quartzite at Gråhammaren and at Kivfjell. The clasts are up to 10–15 cm in diameter, are rounded and dominated by quartzite.

The Atna Quartzite is suggested to be of fluvial to shallow-marine origin (Nystuen & Ilebekk 1981).

Svarttjørnkampen Basalt

The unit is here defined as a formation within the Hedmark Group.

Name. – The name is taken from the mountain Svarttjørnkampen, which is located east of Glomma between the Atna and Hanestad railway stations (Hanestad 1918 IV, NP 980 492).

Historical background. – Werenskiold’s (1911, p. 64) ‘diabase dyke’ in the southern side of Fampåshøgden must have been the basalt here. Oftedahl (in P. Holmsen & Oftedahl 1956, p. 116–117) interpreted the basalt in northern and
southern Kjølsjøberget as a sediment with lava fragments and the basalt at Kivfjell as gabbro belonging to the 'Lower Jotun Nappe'. Bjørlykke (1969, p. 316) was the first to identify the 'basalt and greenstone' in Famphøgdene and Kjølsjøberget as a volcanic rock on which the Moelv Tillite was resting with depositional contact. However, he interpreted the basalt as a sheet of the Precambrian crystalline basement, separated from the sequence beneath by a thrust plane. Prost (1975, p. 206-207) considered the dark crystalline rock in Famphøgdene to be an altered dolerite and part of an autochthonous Precambrian basement which had been folded together with its sedimentary cover.

**Geographical extent.** – The Svarttjørnkampen Basalt occurs in the southern side of Famphøgdene, at Gråhammaren, southern Kjølsjøberget-Svarttjørnkampen and at Kivfjell. The unit is continuous for about 5 kilometres in the area northeast of the Atna railway station and for about 2 kilometres at Famphøgdene (Fig. 2).

**Type locality** – The mountain Svarttjørnkampen is chosen as type locality. The basalt is well exposed at all sides of the top (870 m a.s.l.).

**Thickness.** – The basalt has a lenticular geometry in all outcrops, and the maximum thickness varies between 5m and 30 m. The thickness is greatest in the Svarttjørnkampen area and least at Famphøgdene.

**Lower boundary.** – The formation rests on the Atna Quartzite. There is a distinct, lithological contact between the two rock types. Within the folded sequence at Svarttjørnkampen the contact is slightly disturbed due to differential tecto-
nic movements along the boundary. The strata are also folded and cut by minor thrusts at Famphågdene, but the primary features of the contact are preserved locally (Imsdal 1818 II, NP 902 294). The interface here between quartzite and basalt is uneven and irregular, suggesting that the quartzite was un lithified when the lava flowed over it.

Upper boundary. - The basalt is overlain by the Moelv Tillite. The contact appears undisturbed at Svatthjørnkan mpen. The tillite is in its basal part enriched in fine-clastic detritus and larger clasts derived from the basalt. Thus the contact is of erosional origin.

Description. - Tectonic deformation and alteration of the basalt vary. In shear zones, it is penetrated by a fracture cleavage and all primary textures are destroyed. A porphyritic texture and undeformed calcite-filled amygdules are well preserved in some exposures at Svatthjørnkan mpen, southern Kjølsjøberget and Famphågdene. The plagioclase phenocrysts are thin (up to 1 mm) plates up to 1 cm long. They have numerous inclusions of sericite, and the very finely crystalline groundmass consists of chlorite, epidote, sericite and iron ore minerals. Pyroxene is preserved at Famphågdene. The alteration is probably in part of synvolcanic origin. Preliminary analyses on the major elements show the rock to be an alkali basalt; further studies on its geochemistry are in progress.

Origin. - The Svatthjørnkan mpen Basalt is the first volcanic rock encountered from the Upper Proterozoic Hedmark Group. It is probably the result of fissure eruptions along intrabasinal fault zones. A diabase dyke in the Storskarven Sandstone north of Hanestad (Nystuen & Ilebekk 1981, p. 22) may have been one of several feeders.

Correlations. - Basaltic rocks which may be stratigraphically equivalent to the Svatthjørnkan mpen Basalt have been recorded from two other areas. In 1970, a 8 m thick basalt was identified in two drill cores from the area between the river Rena and the lake Ossjøen (J. P. Nystuen, unpublished technical report). The basalt here occurs within a quartzite unit similar to the Atna Quartzite and displays primary lower and upper contacts towards its host. The quartzite is overlain by black shales and limestones of the Biri Formation. The other occurrence is located east of the lake Storsjøen (Sæther 1979). The rock is a greenstone which is strongly deformed and is associated with a limestone of the Biri Formation.

Clasts of greenstone, lithologically very similar to the Svatthjørnkan mpen Basalt, occur in the Biskopås Conglomerate at Mjøsa (Bjørlykke et al. 1976) and are present in the Imsdal Conglomerate and the Håkenstad conglomerate (see below) in the area of the present study. These fragments have been derived from pre-Moelv Tillite basalts which could have been lateral equivalents to the Svatthjørnkan mpen Basalt, or separate, local lava flows of approximately same age (for further discussion, see the last section).

Biri Formation

The Biri Formation rests with sedimentary contact on the Rendalen Formation and the Atna Quartzite and is unconformably overlain by the Moelv Tillite (Figs. 2-5). The maximum thickness (at Øvre Rendal and Bjørånes) can be estimated to 150-200 m.

The formation is dominated by (1) black and grey shale and mudstone and (2) carbonate rocks. Within the former facies there occur at Øvre Rendal the (3) Håkenstad conglomerate and (4) a sandstone unit.

Bjørlykke (1965) introduced the ‘Bjørånes shale’ as a formation name for the black and dark grey, alumina-rich shale which occurs in the area east of Famphågdene and continues northwards to Gråhammaren (Fig. 2). It is proposed here to change the rank of the unit to the Bjørånes Shale Member of the Biri Formation and to include the black and grey shale at Øvre Rendal in this member (Fig. 4).

The Bjørånes Member at Øvre Rendal is a black, organic-rich and pyritic shale in its lower part but grades upwards into a more silty, grey shale. This, in turn, passes gradually into an overlying grey and pink dolomitic limestone. The limestone is rich in shaly laminae. It thins out towards the southwest at Harrsjøen and also towards the southeast, as shown in the tunnel to the Rendalen hydroelectric power plant (Kjølberg 1980). The dolomite at Langtjørna displays a transitional contact to the underlying Atna Quartzite. A similar dolomite rests on the Atna Quartzite in the area west of Glomma (Fig. 1). However, in the area between the river Atna and Løvåsen (Fig. 2), there are also dolomitic limestones associated with black and green shale and...
Late Precambrian Hedmark Group

Håkenstad conglomerate

The Håkenstad conglomerate is the informal name of a conglomerate which occurs at the base of the Biri Formation west of the farm Håkenstad at Øvre Rendal (Hanestad 1918 IV, PP 087 644). The conglomerate is interstratified with dark grey shales and siltstones which belong to the Bjørånes Shale Member (Fig. 5). The grey, graded and massive feldspathic sandstones, which occur stratigraphically beneath the conglomerate-shale sequence and above the Rendalen Formation, have also been referred to the Biri Formation. The conglomerate is about 50 m thick at the easternmost locality and thins out westwards over a distance of c. 2 km and is here laterally replaced by the Bjørånes Shale Member. This shale unit also lies stratigraphically above the conglomerate.

The Håkenstad conglomerate consists of 1–2 m thick graded units which have erosional lower contacts. The units commence with matrix-supported conglomerate in which clast size and clast frequency decrease upwards; the conglomerate facies passes into dark grey, massive and medium- to fine-grained feldspathic sandstone (Fig. 5). Rounded clasts of grey quartzite, porphyry and granite (few) are the extrabasinal stones, whereas irregular fragments of shale, mudstone, calcareous sandstone, limestone and basalt (up to 25 cm) are considered to be of intrabasinal origin. Shale fragments are very abundant in the upper part of the Håkenstad conglomerate. The clast size decreases westwards, and the conglomerate is clast-supported in the westernmost exposure.

The Håkenstad conglomerate reveals structural and petrographical similarities with the Imsdalen Conglomerate, and a corresponding mode of deposition is suggested. The conglomerate probably represents a small subaqueous gravel fan in the black shale basin of the Bjørånes Member. It has been formed by resedimentation of rounded, fluvial extrabasinal debris mixed with short-transported intrabasinal clasts. The geometry of the conglomerate body and the decrease of clast diameters towards the west favour a sediment transport in this direction.

Another body of coarse-clastic sediments occurs higher up in the black shale member at Øvre Rendal (Fig. 4). The up to 15 m thick unit is composed of coarse-grained, grey feldspathic sandstone. The unit comprises 3–4 beds which are massive and partly graded, partly ungraded. The lithofacies of this sandstone unit is similar to the coarse-grained turbidites in the Brøttum Formation. It marks an isolated event with coarse-clastic influx by turbidity currents in the black shale basin.

The Biri Formation is absent from the area between the mountains southern Kjølsjøberget and Kivfjell, and it thins out towards Famphøgdene (Fig. 2). The present outcrop pattern along the Øvre Rendal-Piggyola folds may reflect original topographic highs and depressions within the major sedimentary basin. The sedimentation has taken place between emerged areas on shallow marine carbonate flats and in deeper, secon-
dary stagnant basins where organic-rich mud settled. These basins received intermittently coarse-clastic detritus, deposited by turbidity currents and other sediment gravity flows.

Moelv Tillite

The Moelv Tillite was formed during the Varanger Ice Age about 650 Ma ago (Bjørlykke & Nystuen 1981). The formation forms the most significant unit within the area, for stratigraphical correlations (Figs. 2–4). It rests with erosional unconformity on the Svarttjørnkampen Basalt and the Bir i Formation; farther north it also rests on the Rendalen Formation and the Atna Quartzite (Nystuen & Hebekk 1981).

Bjørlykke (1965, 1969) thought the Moelv Tillite was present along the western boundary of the Børånes Shale Member, in the streams northem Bjøråa and Gardbekken (Fig. 2). The small scattered clasts, reported by Bjørlykke (1965), in the mudstone here are probably irregularly outlined secondary aggregates of calcite and quartz.

The Moelv Tillite is a 2–20 m thick diamictite, which normally is massive but locally reveals a faint, discontinuous stratification. Angular to rounded clasts consist of red and grey quartzite, granite, porphyry, felsite, gneiss, greenstone (basalt), shale and carbonate rocks. The largest observed block is 1 m in diameter (granite). The poorly sorted matrix is dominated by the silt and sand fractions.

The diamictite has been formed as a basal till from grounded glacier ice (Bjørlykke et al. 1976, Nystuen 1976a, Bjørlykke & Nystuen 1981). The glacier ice moved across a basin floor which consisted of sandstones, shales, carbonate rocks and basalt. Debris derived from these intrabasinal source rocks were incorporated in the sole of the basal till. This intrabasinal glacial erosion accounts for the present local variations in composition of matrix and abundance of various intrabasinal clasts in the tillite of the area. These relationships have also been found for the Moelv Tillite in the area east of the Rendalen fault (Nystuen & Sæther 1979).

The boundary with the Ekre Shale is exposed at Øvre Rendal. It is transitional through an uppermost laminated zone (20–100 cm thick) in which the clast frequency decreases. This transitional zone has been interpreted as a glaciomarine facies with ice-dropped clasts (Bjørlykke et al. 1976, Nystuen 1976a, Bjørlykke & Nystuen 1981).

The Ekre Shale at Famphøgdene was the westernmost locality in the Imsdalen area where Prost (1975) identified this formation. We have mapped the tillite with 'classical' diamictite facies, normal thickness (10–15 m) and with overlying Ekre Shale and Vangsås Formation to a stream (Kvernbekken) northwest of Piggvola (Fig. 2). The sequence obviously continues from here farther to the north along the eastern side of the Imsdalen fault. In September 1980 we identified the Moelv Tillite at Skjerdingfjell, 13 km NNW of Piggvola. The diamictite includes clasts of porphries, granite, quartzite, carbonate rocks and greenstone. It is associated with greenish-grey shale and phyllite, quartz pebble conglomerates and feldspathic sandstones. The sequence is complicatedly folded and rests at this locality with thrust contact on the light dolomite of the Bir i Formation. Prost (1975) included all rock types at these outcrops in his Sollia Formation (see below).

Ekre Shale

The Ekre Shale is a laminated grey, green and red silt-rich shale with thin sandstone beds and laminae. The sand content increases towards the top of the unit. In the area east of Gråhammaren a fine-grained sandstone with calcareous matrix occurs in the border zone to the overlying Vangsås Formation. The Ekre Shale is about 5–50 m thick. The lower part of the unit may have been formed in response to a post-glacial rise of sea level as pro-delta sediments (Nystuen 1976a). A general low boron content of the Ekre Shale has been interpreted to indicate low water-salinity in the depositional basin (Bjørlykke & Englund 1979).

Vangsås Formation

This formation consists of the lower Vardal Sandstone Member and the upper Ringsaker Quartzite Member, as in the Mjøsa area (Bjørlykke et al. 1967).

The Vardal Sandstone Member has a transitional lower contact to the Ekre Shale. The contact is seen at Øvre Rendal and northwest of Piggvola. At Øvre Rendal the member is a greyish-green, fine-grained sandstone with silty interbeds in the lower part. The grain size increases upwards, and this part of the unit is a medium- to coarse-grained, dark grey feldspathic sandstone.
The facies is characterized by 50–200 cm thick beds which are massive and graded and locally interbedded with thin, dark shales. The facies here is probably of turbiditic origin.

In the area southwest of Harrsjøen and southwards to Bjørånes, the Vardal Member includes lithologies such as grey, greenish-grey or red feldspathic sandstones with interbeds of greenish-grey siltstone and shale. This facies association reflects fluvial to deltaic sediments.

In the Famphøgdene – Piggvola area, the Vardal Sandstone Member is developed as a coarse-grained feldspathic sandstone with trough cross-bedding and horizontal stratification. This facies is suggested to be of fluvial origin.

The Ringsaker Quartzite Member is a dark, bluish-grey to light and nearly white orthoquartzite which appears to be massive. The thickness is up to 50 m, but the unit is absent or very thin at Øvre Rendal. In the area east of Glomma, primary features are disturbed by imbrications beneath the Kvitvola Nappe.

The Ringsaker Quartzite Member has a wide regional development within the Hedmark Group and also occurs autochthonously, deposited on the Precambrian crystalline basement beneath the Osen-Røa Nappe Complex (Nystuen 1981). The quartzite has generally been considered as a shallow-marine deposit; its high mineralogical maturity is a response to a reduced relief on the Baltoscandian craton (see Bjørlykke et al. 1976).

**Sollia Formation**

Prost (1970, p. 761) introduced this formation name for folded, imbricated and in part strongly deformed rocks beneath the Kvitvola Nappe in the area south of the Atnsjoen window.

Prost (1975) included into the Sollia Formation a number of different sedimentary rocktypes, comprising the following facies assemblages above the Atna Quartzite: (1) dolomite, limestone and associated black and green shales, and phyllites and pebbly mudstone and (2) diamicrite, greenish-grey shale and phyllites, quartz-pebble conglomerates, greenish-grey and red, medium- to coarse-grained feldspathic sandstones and ‘greywackes’. In the Imsdalen area, west of the Imsdalen fault, the Sollia Formation comprised (3) thick-bedded, grey feldspathic sandstones, ‘greywackes’, shales (and phyllites) and conglomerates. The ‘greywackes’ correspond to feldspathic sandstones, rich in phyllosilicates (Prost 1975, p. 379).

The first facies assemblage (1) has been correlated with the Biri Formation in this paper (see above). Our investigations have proved that the second facies assemblage (2) consists of the Moelv Tillite, Ekre Shale and the Vangsås Formation (Vardal Sandstone Member) in the area east of the Imsdalen fault, northwest of Piggvola. The sediments here were also included in the Sollia Formation (Prost 1975, Fig. 90, p. 531). The identification of the Moelv Tillite within this second facies assemblage at Skjerdingfjell (see above) suggests that the Moelv, Ekre and Vangsås Formations are present also in that northern area of the Sollia Formation.

The third facies assemblage (3), in the area west of the Imsdalen fault, has been found to consist of the Brøttum Formation and the Imsdalen Conglomerate (see chapters above on these formations). Prost (1975, Fig. 90, p. 531) suggested that the Sollia and Brøttum Formations were separated by a regional, post-Caledonian fault in the area NW of northern Imssjøen. The mapping in this area (J.P.N.) has not given any evidence for the inferred fault.

The ‘Sollia Formation’ has been applied on our maps (Figs. 1 & 2) for sequences of unknown stratigraphical position which occur in the tectonostratigraphical interval between the Atna Quartzite and the Kvitvola Nappe.

**Tectonic framework and basin evolution; summary and conclusions**

The Hedmark Group rocks in the Imsdalen – Bjørånes – Atna – Øvre Rendal area belongs to the Røa Nappe and were deposited in a basin northwest of the Atnsjøen window. The tectonic framework of the sequence consists of a series of syn- and anticlines which in part are cut by northward dipping high angle thrusts. From Øvre Rendal to Piggvola in Imsdalen the trend of folds and associated thrusts changes from NE-SW to SE-NW. This arcuate pattern was produced during the phase of deformation when the decollement nappe moved towards the SE.

These Øvre Rendal – Piggvola folds are cut by the Imsdalen fault in the SW; the fault is a high angle reverse fault, dipping to the SW and form-
ing the northeastern boundary of the Brøttum Formation. The fault is suggested to have been formed at a late stage during the origin of the Øvre Rendal – Piggvola fold structure. However, we leave the possibility open to interpret the fault as an inclined major thrust beneath a separate nappe, lying above the Røa tectonic unit.

The Røa Nappe structures are discordantly cut by the Kvitvola Nappe sole thrust. The Røa and Kvitvola Nappe were folded during a late-Caledonian deformation phase which produced the wide and open central Østerdalen structural depression, in which the Kvitvola Nappe has been preserved as the highest tectonic unit.

The stratigraphical columns from the studied area are correlated with the type stratigraphy from Mjøsa and with the stratigraphy in the district east of the Rendalen fault line (Fig. 4).

The Brøttum and Rendalen Formations occur in corresponding stratigraphical levels beneath the Moelv Tillite and the Birr Formation. The presence of deltaic to shallow-marine and fluvial sediments, besides turbidites, in the Brøttum Formation in the Imsdalen area suggests that there has been a transition from fluvial plains in the east (Rendalen Formation) to a large turbidite basin in the west (Brøttum Formation). Arkoses and feldspathic sandstones are dominant lithologies in both units in Østerdalen, and lithoclasts (porphyries, felsite, granite, quartzite) in associated conglomerates indicate a source area lying to the east (Nystuen & Sæther 1979).

A phase of submergence commenced with deposition of well-sorted sands on distal fluvial plains and adjacent shallow marine areas; the event is marked by the Atna Quartzite. In shallow seas and embayments, where the terrigenous influx became restricted, carbonate sedimentation succeeded the ‘Atna sands’, and the early dolomite, limestone and calcareous sandstones of the Birr Formation were formed.

The early submergence (the ‘Birr transgression’) was probably initiated by a regional, moderate downwarping of the basin floor. The presence of the Svartjørnkampen Basalt above the Atna Quartzite probably reflects the onset of a phase with high tectonic activity. The basalt eruptions must have been of the fissure type, restricted to fault zones. The presence of similar basalt in other parts of the Sparagmite Region, and as fragments in the Imsdalen, Håkenstad and Biskopås conglomerate beds, suggests that there must have been several local lava flows.

As the results of tectonic movements (faults, flexures), secondary stagnant basins with deposition of organic-rich, black mud were formed; the Bjørånes Shale Member characterizes the ‘Øvre Rendal sub-basin’ and the ‘Bjørånes sub-basin’. Other parts of the basin area arose tectonically and suffered erosion. Clasts of intrabasinal origin became intermingled with long-transported, fluvial gravel derived from extrabasinal source rocks. The detritus of mixed origin was ultimately laid down by gravity sediment flows as subaqueous fans (Imsdalen and Håkenstad conglomerate beds). During a single event, the mud sedimentation in the ‘Øvre Rendal sub-basin’ was interrupted by the influx of coarse-grained sands, deposited from turbidity currents. A shallowing of the ‘Øvre Rendal sub-basin’ gave rise to carbonate sedimentation at the top of the Bjørånes Shale Member. The grey, silt-rich shale, into which the limestone passes laterally, has probably been deposited in lagoonal areas at the flanks of a carbonate mound.

The Imsdalen Conglomerate and the upper part of the Brøttum Formation can be correlated with the Biskopås Conglomerate in the Mjøsa type sections. Like the Imsdalen Conglomerate, the Biskopås Conglomerate also contains clasts derived from the early transgressive carbonate rocks of the Birr Formation. The latter conglomerate wedges into the Birr shales (Bjørlykke et al. 1976, Bjørlykke 1978) in a way similar to that of the Håkenstad conglomerate.

The Biskopås Conglomerate, occurring in several bodies in the central Sparagmite Region (Fig. 1), has been ascribed to various physical factors: tectonic subsidence and rise along marginal faults (Skjeseth 1963, p. 29, Løberg 1970, p. 181, Englund 1973, p. 9), regression due to epeirogenic lowering of sea level (Bjørlykke 1966, p. 13, Spjeldnæs 1967, p. 56) and glaciofluvial transport (Oftedahl 1945, p. 291, Bjørlykke et al. 1976, p. 243). In our opinion, the ‘conglomerate phase’ in the evolutionary history of the Hedmark Group’s basin is associated with faulting, local basaltic fissure eruptions, formation of secondary basins and erosion within emerged intrabasinal areas as well as in areas adjacent to the basin.

A hiatus is represented by the erosional unconformity beneath the Moelv Tillite. The unit was deposited during the Varanger Ice Age when glacier ice moved from the east towards the west, crossing the basin floor. Nystuen (1976, p.
38) and Nystuen & Sæther (1979, p. 250) suggested that there was an open bay during glacial maximum in that part of the basin which is represented by the sequence in the studied area. However, the diamictite of basal till facies here proves that also this part of the basin was covered by grounded glacier ice. The Varanger glaciation in southern Norway has been reviewed recently by Bjørlykke & Nystuen (1981).

The Ekre Shale and Vangsså Formation have great lateral extent in the Sparagmite Region (Fig. 1); their general depositional history has been described by Bjørlykke et al. (1976). In the present area, both units display their maximum thickness at Øvre Rendal. This may imply a recurrent subsidence of the ‘Øvre Rendal sub-basin’; the turbidite facies here in the Vardal Sandstone Member was probably formed in front of a steep delta slope. Delta progradation and fluvial sedimentation (Ekre Shale and Vardal Member) were succeeded by the early Cambrian transgression and deposition of quartz sands, forming the shallow-marine Ringsaker Quartzite Member at the top of the Hedmark Group.

The evolution of the Hedmark Group’s basin is characterized by a late Riphean (?) to Vendian phase with block faulting, coarse-clastic sedimentation and episodic basal volcanic rocks, replaced by a late Vendian to early Cambrian phase with slow submergence and deposition of mature sands. This latter phase introduced the Lower Palaeozoic epicontinental sedimentation on the Baltoscandian craton.

A similar evolution is revealed by the allochthonous sequences in Valdres (Nickelsen 1974) and northern Jämtland (Gee et al. 1974). However, none of these sequences contain volcanic units. The presence of basalt in the Hedmark Group indicates that the original position of its basin was rather far west on the Baltoscandian craton. The riffing phase of the Iapetus Ocean is considered to be reflected by dolerite dyke swarms in the Särv Nappe and equivalent nappe units in the Central Scandinavian Caledonides (Gee 1975, 1977, 1978, Claesson 1976, Krill 1980, Kumpulainen 1980). The eastward displacement of the Särv Nappe exceeds 250 km (Kumpulainen 1980). The Hedmark Group’s basin has been located east of the ‘Särv basin’ (Nystuen & Kumpulainen 1981) and may have been formed as an aulacogen relative to the central rift axis farther west (see Dickinson 1974, p. 16). The basalt eruptions probably denote the stage of maximum crustal attenuation along the failed arm.

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