SCANIA

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GEOLOGICAL SETTING

Scania is the southernmost province of Sweden, lying on the boundary between the Fennoscandian Shield and west central Europe. The buffer zone is known as the Fennoscandian Boundary Zone and extends in a NW-SE direction through Scania.

Much of the Early Palaeozoic was tectonically quiet, and Cambrian to middle Silurian deposits were laterally uniform. Considerable faulting occurred during the Ludlow and a thick pile of Colonus Shale accumulated in an elongated trough. Tension and volcanism around the Permo-Carboniferous boundary led to the formation of very numerous dolerite dykes trending NW-SE to WNW-ESE. Subaerial remains of this event have been completely removed. New tectonic activity throughout much of the Mesozoic led to sedimentation over various parts of Scania. A second volcanic event started around the early-middle Jurassic and resulted in numerous basaltic necks, mostly in central Scania. Here the early Jurassic landsurface is now exposed, revealing pockets of residual kaolin and volcanic remains. The geology is much more complex than can be shown on a small-scale map, and due to the Quaternary cover is known only in outline in many areas.

The following text has gained from data and comments given by Kristina Lindholm, Anita Löfgren, Ragnar Nilsson, and Valdar Jaanusson.

The Ordovician of Scania (Fig. 2) belongs to a south-west Scandinavian confacies belt characterized by graptolite shales. It overlies the Upper Cambrian alum shale, which is dominated by olenid and agnostid trilobites and almost devoid of distinctly benthic faunas. The Ordovician is normally some 150-200 m thick.

Dictyonema Shale and Ceratopyge Beds (Tremadoc) Continuous sedimentation appears to have occurred at least locally at the Cambrian-Ordovician transition. The base of the Ordovician is marked by the Dictyonema Shale; although its alum shale is similar to that of the underlying shale, there is a striking contrast in fauna content. The monotonous trilobite faunas of the Upper Cambrian indicate adverse bottom conditions

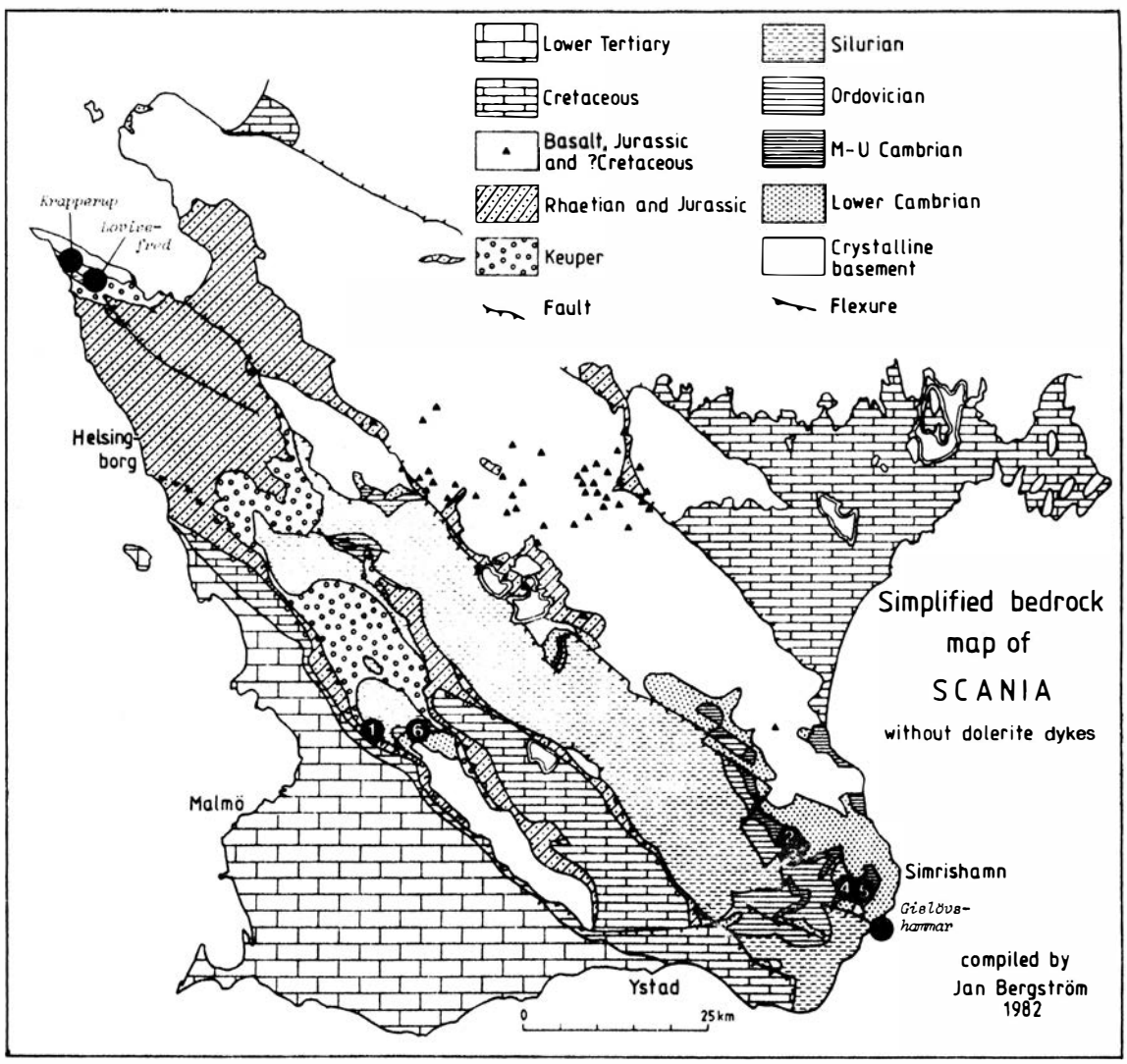

Figure 1. Bedrock map of Scania. The numerous Permo-Carboniferous dolerite dykes, trending NW-SE, are omitted for clarity. Excursion stops marked with white number in filled circle: 1, Department of Geology, Lund; 2, Flagabro; 3, Killeröd; 4, Tommarp; 5, Jerrestad; 6, Fågelsång. Krapperup, Lovisefred and Gislövshammar are sites for important borings referred to in the text.

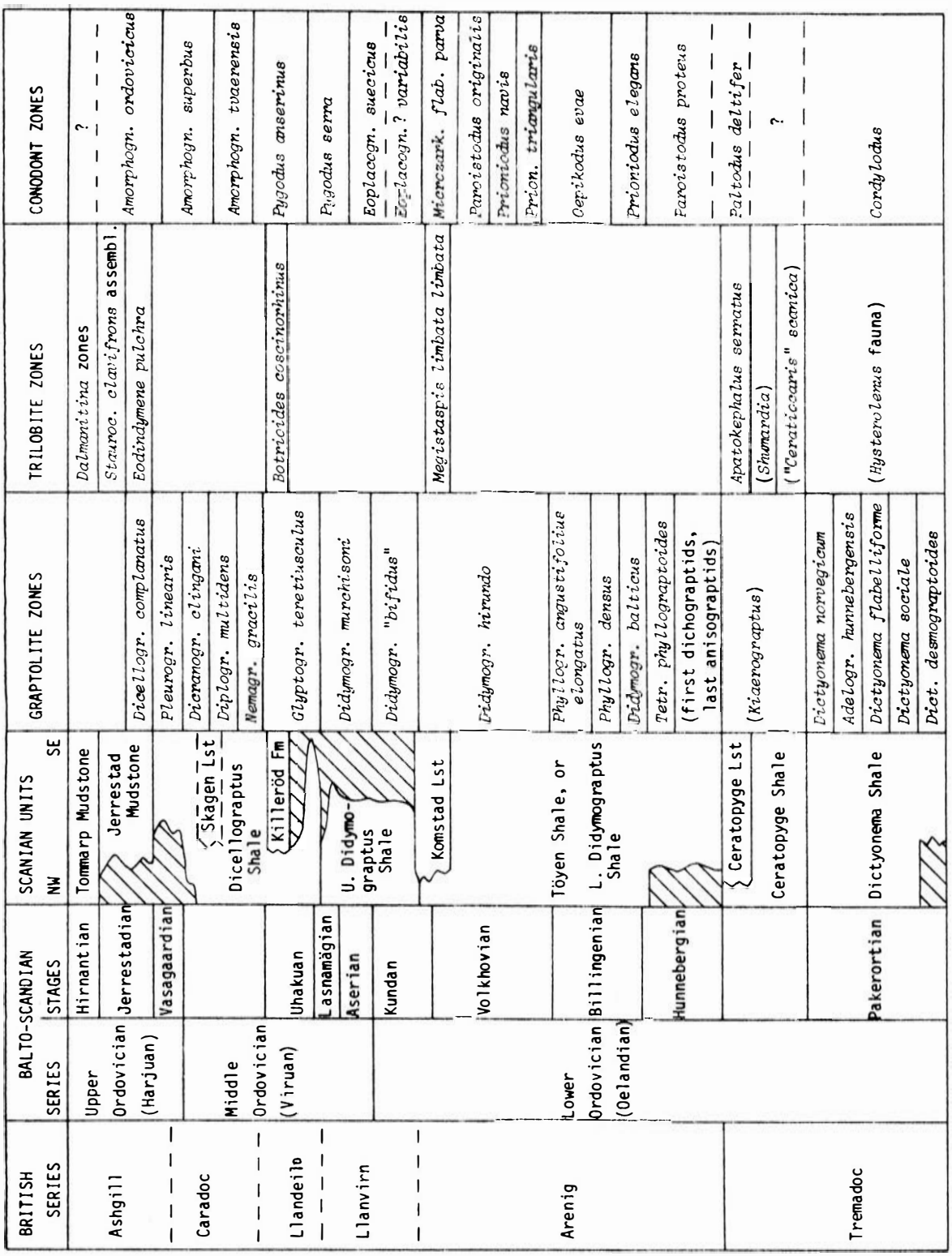

Figure 2. The Ordovician of Scania.

with only rare benthic invertebrates. The Dictyonema Shale carries a much more varied fauna, including dendroid graptolites (Dictyonema spp, Clonograptus tenellus, Adelograptus hunnebergensis, Bryograptus kjerulfi) and a benthos of inarticulate brachiopods, various trilobites (e.g. Hysterolenus toernquisti) and conodonts.

The Dictyonema Shale varies in thickness from 5.3 to 16.5 m, the highest value being found at Gislövshammar in the extreme south-east corner of Scania. It is rich in silica and contains kerogen and pyrite with some uranium. The Dictyonema Shale is particularly rich in vanadium, which reaches up to 4500 ppm. This may have been organically enriched as some living organisms (holothurians) can enrich vanadium up to 280 000 times relative to sea water.

The top few tens of centimetres of the alum shale sequence lack graptolites but are rich in the crustacean "Ceratiocaris" scanica Moberg & Segerberg in addition to brachiopods. This unit is regarded as the base of the Ceratopyge Limestone and Shale. At Fågelsång east of Lund the alum shale is overlain by a shale with a thin limestone band. The limestone contains an interesting trilobite fauna which includes Shumardia dicksoni Moberg, Ceratopyge forficula (Sars), Symphysurus angustatus (Sars & Boeck), Euloma ornatum Angelin, and Orometopus elatifrons (Angelin).

The top of the Ceratopyge Beds is normally developed as the Ceratopyge Limestone, which is around 0.25-1.0 m thick. This limestone is grey and microcrystalline, with splintery fracture, and is rich in pyrite. The fauna includes Geragnostus sidenbladhi urceolatus (Moberg & Segerberg), Shumardia dicksoni, Ceratopyge forficula, Apatokephalus serratus (Boeck), Niobe insignis Linnarsson, Niobella obsoleta (Linnarsson), Symphysurus angustatus, Nileus limbatus Brögger, Euloma ornatum, Harpides rugosus (Sars & Boeck), and Orometopus elatifrons.

Evidence from the Krapperup drilling in north-west Scania indicates that where the sequence is less condensed it may consist of grey graptolite shale with Kiaerograptus sp (Kristina Lindholm, unpublished).

Lower Didymograptus Shale or Tøyen Shale (Arenig) The graptolite shale unit overlying the Ceratopyge Beds has long been known as the Lower Didymograptus Shale, a name now regarded as a synonym of Tøyen Shale. The latter term was introduced for the corresponding sequence in the Oslo area. There is considerable variation in the development of this unit in Scania; the sequence is incomplete and measures only a few metres in the Fågelsång area (Hede 1951), while 75 m in the drillcore from Krapperup in northwestern Scania apparently represents only part of the Lower Didymograptus Shale of that area (Kristina Lindholm, unpublished). Other areas tend to be intermediate in thickness. As in the overlying parts of the Ordovician, there is considerable variation inside Scania not only in thickness but also in faunal composition. The zonation of the basal part of the sequence is currently poorly understood. There seems to be a lowest interval with Dictyonema sp and the last anisograptid fauna, overlain by one with the earliest dichograptid fauna, both of which correspond to the Megistaspis (Ekeraspis) armata Zone in the trilobite zonal system (Kristina Lindholm, unpublished).

The subsequent zones generally occur in graptolite shales. The Tetragraptus phyllograptoides Zone is poor in fossils (Tjernvik 1960), but the zones of Didymograptus balticus, Phyllograptus densus, P. augustifolius elongatus, and Didymograptus hirundo contain varied graptolite faunas. The zones of T. phyllograptoides and P. densus are missing at Fågelsång. In north-west Scania (Lovisefred drillcore) the D. hirundo Zone has yielded an Australasian graptolite fauna with species of Isograptus, Pseudisograptus, Maeandrograptus, and Apiograptus indicative of the Yapeenian Stage in Australia (Ragnar Nilsson, unpublished).

Komstad Limestone (Arenig-Llanvirn boundary) The Lower Didymograptus Shale (Tøyen Shale) is normally overlain by the Komstad Limestone, which may be considered as a tongue of the northern and north-eastern orthoceratite limestone. The Komstad Limestone thins accordingly in a westerly direction from around 10 m in south-east Scania to 2 m at Fågelsång. In the Lovisefred drilling core in north-west Scania the Komstad Limestone is not developed (Ragnar Nilsson, unpublished). The trilobite fauna in the Komstad Limestone includes species of Megistaspis (Megistaspis), Asaphus (Asaphus), Ptychopyge, Cyclopyge, Raymondaspis,

Illaenus, Cyrtometopus, and Pterygometopus. Cephalopods are common. This fauna is badly in need of revision but is regarded to indicate the zones of Megistaspis (Megistaspis) limbata limbata (formerly called the Zone of Asaphus lepidurus) and Asaphus (Asaphus) expansus. The position relative to the boundary between the D. hirundo and D. 'bifidus' zones is debatable. However, the limestone appears to range from the Zone of Microzarkokodina flabellum parva to the lowest part of the Zone of Eoplacognathus? variabilis in the conodont zonal scheme (Anita Löfgren, Ragnar Hedvall and Sara Nyman, unpublished).

Upper Didymograptus Shale (Llanvirn) The Komstad Limestone is succeeded by the Upper Didymograptus Shale. This unit is encompassed within the zones of D. 'bifidus' and Didymograptus murchisoni (Pterograptus elegans Zone in north-west Scania). The Upper Didymograptus Shale is best developed in north-west Scania where it measures 49.5 m in the Lovisefred drillcore (Ragnar Nilsson, unpublished). The unit decreases to 18 or 16 m at Fågelsång. In south-east Scania there is a break on top of the Komstad Limestone, the Upper Didymograptus Shale measuring only 1.2 m at Flagabro and missing at Tommarp. The D. 'bifidus' Zone has not been reported in south-east Scania, and in places the whole Upper Didymograptus Shale is missing. In the latter case the Glyptograptus teretiusculus Zone equivalents (Killeröd Formation) rest directly on the Komstad Limestone. The break has its greatest known extent on Bornholm to the south-east, where beds belonging to the upper part of the Diplograptus multidens Zone rest on the Komstad Limestone (S.M. Bergstrom & Nilsson 1974). In addition to many graptolite species, the Upper Didymograptus Shale has yielded a number of inarticulate brachiopods together with phyllocarids, sponge spicules and conodonts in the shales (e.g. Hede 1951).

Dicellograptus Shale (Llandeilo-Caradoc) This was formerly divided into Lower and Middle Dicellograptus Shale, but is here taken as one unit consisting of graptolite shales with siltstones and thin limestone beds. Although the shales are dominated by graptolites, they also contain a shelly fauna (Hadding 1913; Nilsson 1952, 1960). The Dicellograptus Shale is about 62 m thick at Fågelsång (Hede 1951; Nilsson 1977) and around 40 m at Lovisefred (Ragnar Nilsson, unpublished). In south-east Scania equivalents to parts of the G. teretiusculus Zone are developed

as a thin sequence of alternating limestone and mudstone beds. These beds were formerly termed the Coscinorhinus or Bronni beds (after the trilobite Botryoides coscinorhinus (Angelin) which is regarded as a senior synonym of B. bronni (Sars & Boeck), but a more appropriate term is needed. At Killeröd the basal bed, which belongs to the top of the Pygodus serra Zone, is conglomeratic and contains chamosite ooids. The remainder of the formation has yielded a conodont fauna of the lower part of the Pygodus anserinus Zone (S.M. Bergström 1973).

The Diplograptus multidens Zone is characterized by a number of thin, metabentonite beds and associated silicification of mudstones, resulting in the so-called Sularp shale. The Sularp shale has a comparatively rich shelly fauna including trilobites such as Asaphus (Neoasaphus) ludibundus Törnquist, Platycalymene dilatata(Tullberg), Lonchodomas "rostratus" (Sars) and Cnemidopyge costata (Boeck), brachiopods such as Onniella bancrofti M. Lindström and Sericoidea restricta (Hadding), further ostracodes, molluscs, machaeridians, and echinoderms (Lindström 1953). Graptolites are few.

In south-east Scania a thin limestone unit is developed, bounded by shales belonging to the D. multidens and Dicranograptus clingani zones respectively. This limestone has previously been termed the Ampyx limestone (after a species of Lonchodomas) but is actually a tongue of the Skagen Limestone developed to the north. The Skagen Limestone is overlain by the Cystoid shale with a shelly fauna including the echinoderms Heliocrinites granatum (Wahlenberg), Echinosphaerites? sp and Haplosphaeronis oblonga (Angelin).

The Pleurograptus linearis Zone is represented by graptolite shale in south-east Scania but seems to be absent in the Fågelsång area and in north-west Scania. In the latter area the hiatus also comprises the Jerrestadian and probably part of the D. clingani Zone.

Jerrestad and Tommarp Mudstones (Ashgill) These mudstones form one lithological unit representing the top of the Ordovician. Despite detailed work the thickness is still poorly known. It is around 45 m in the Fågelsång area (Glimberg 1961; Grahn 1978; Nilsson 1977, 1979) but

decreases to 9 m or less in north-west Scania, where the Jerrestad Mudstone appears to be absent (Ragnar Nilsson, unpublished). The basal part of the Jerrestad Mudstone was formerly termed the Upper Dicellograptus Shale. The fauna contains several zonal indices including Dicellograptus complanatus and Nankinolithus granulata (Wahlenberg) in western Scania and Opsimasaphus latus (Angelin), Lonchodomas portlocki (Barrande) and Eodindymene pulchra (Olin) in south-east Scania (e.g. Kielan 1959; Regnéll 1960). Nilsson (1977) listed 114 species from this level.

Higher parts of the Jerrestad Tommarp Mudstone unit contain a poorer fauna, graptolites in particular being virtually absent (Nilsson 1979). The zonation appears to be strongly influenced by local ecological conditions. Thus the Staurocephalus clavifrons Zone is difficult to delimit from the Eodindymene pulchra Zone and from the Dalmanitina beds. The latter have been separated into three zones, viz. the Dalmanitina (Mucronaspis) olini Zone, the Dalmanitina (M.) mucronata Zone, and the Brongniartella platynota Zone. The two forms of Dalmanitina (Mucronaspis) as well as Brongniartella platynota (Dalman) may be strongly influenced by local ecological conditions. D. olini Temple is missing in Västergötland although there is probably no hiatus. B. platynota appears to be a shallow-water species occurring at slightly different levels and with varying frequency. The author found it at Nyhamnsläge (close to Klapperup) in north-west Scania, where the corresponding 'zone' has been regarded as absent, and possibly below the Dalmanitina beds in the Ulunda Mudstone in Västergötland.

1:1 DEPARTMENT OF GEOLOGY, LUND UNIVERSITY Due to the Quarternary cover, exposures of Ordovician rocks are generally both rare and small. In order to give a more complete picure of the local Ordovician, Mr. Ragnar Nilsson and Ms. Kristina Lindholm of the Department will demonstrate interesting drillcore material whose results have not yet been published.

2:1 FLAGABRO (Figs. 3, 4) The base of the Ordovician (Tremadoc) is accessible along a small rivulet at the farm Flagabro, run by Mr. Julius Jönsson. Just east of a small bridge there is the 1 m thick, grey-coloured and calcilutitic Ceratopyge Limestone, which forms the top of the Tremadoc. This limestone has yielded a fauna including trilobites (Ceratopyge forficula, Euloma ornatum, and Symphysurus augustatus) and brachiopods (Tjernvik 1958). The limestone is underlain by a thin sheet of dark Ceratopyge Shale with the phyllocarid crustacean Ceratiocaris and brachiopods. This is in turn underlain by the 11 m thick Dictyonema Shale, an alum shale forming the base of the Tremadoc. This shale is highly bituminous and contains concretions of stinkstone (= bituminous limestone), baryte and pyrite. The total carbon content is 11% and the sulphur content is 2%, while the uranium content is low, only some 50-60 g/t (0.005%). The Dictyonema Shale is known for its content of vanadium (around 0.4%); a water-filled digging 100 m NE of the bridge is the remains of an attempt at extraction. The fauna is dominated by Dictyonema, but the upper part, exposed at Flagabro, is poorly fossiliferous. Towards the south-west the section is terminated by a Permo-

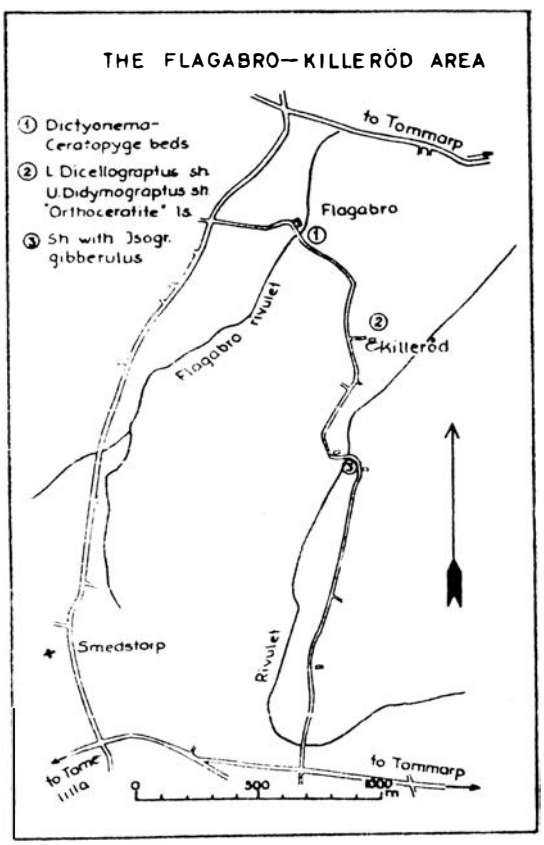

Figure 3. Map of Flagabro-Killeröd area (from Tjernvik in Regnéll 1960)

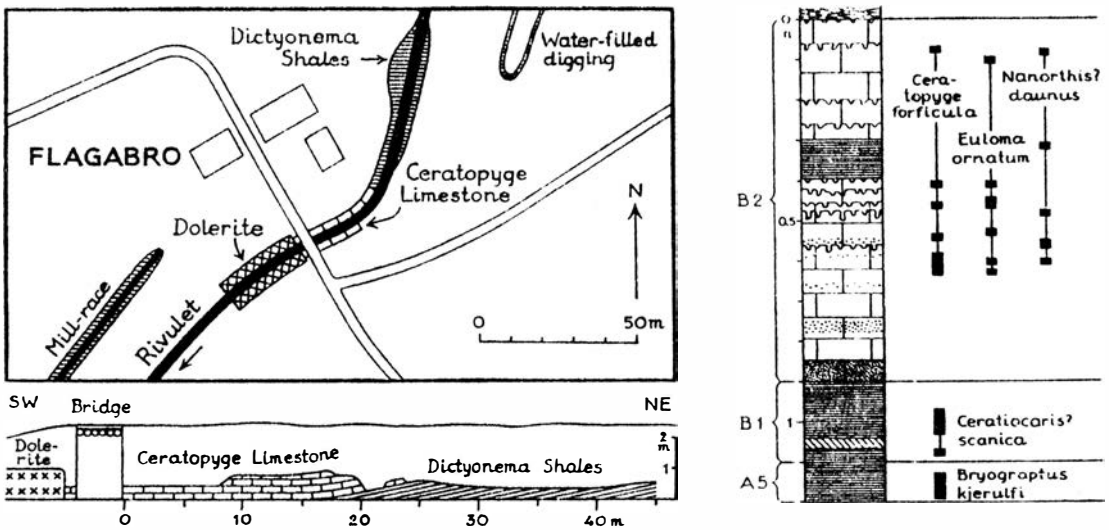

Figure 4. Map of exposures at Flagabro Farm and section through the top of the Tremadoc. A5, top of Dictyonema Shale; B1 Ceratopyge Shale; B2 Ceratopyge Limestone. (From Tjernvik 1958)

Carboniferous dolerite dyke just on the other side of the bridge.

2:2 KILLERÖD (Figs. 5, 6) Some 550 m SSE of Flagabro is a small limestone quarry at Killeröd. The limestone overlies 23 m of Lower Didymograptus Shale (Tøyen Shale; Tjernvik 1960), which in turn overlies the Ceratopyge Limestone. The limestone itself belongs to the Upper Arenig and is called the Komstad Limestone. Here, in its type area, it is around 10 m thick and is considered to be a tongue of the thick orthoceratite limestone characteristic of Öland, Gotland and south-central Sweden. It thins to the west to around 2 m east of Lund. Tectonic disturbances are seen in the western wall of the quarry at Killeröd, and in the north-east the limestone is bounded by a 27 m wide Permo-Carboniferous dolerite dyke. Fossils are rare and poorly preserved but include trilobites and orthoconic cephalopods.

On the north-west side of the dolerite dyke is a small exposure of a condensed sequence overlying the Komstad Limestone (Nilsson 1952; S.M. Bergström 1973; S.M. Bergström & Nilsson 1974). At the base is 1.2 m of Upper Didymograptus Shale (Fig. 5) overlain by 0.12 m of similar Lower Dicellograptus Shale. This sequence is fairly rich in graptolites, including species of Didymograptus, Glyptograptus and

Climacograptus. There are also brachiopods and conodonts. The top of the sequence is formed by 0.7 m of so-called Bronni beds, which are only distinguished in south-east Scania (Nilsson 1952; S.M. Bergström 1974). The rocks are alternating grey mudstones and hard, grey, finely crystalline limestones and contain a number of trilobites and brachiopods.

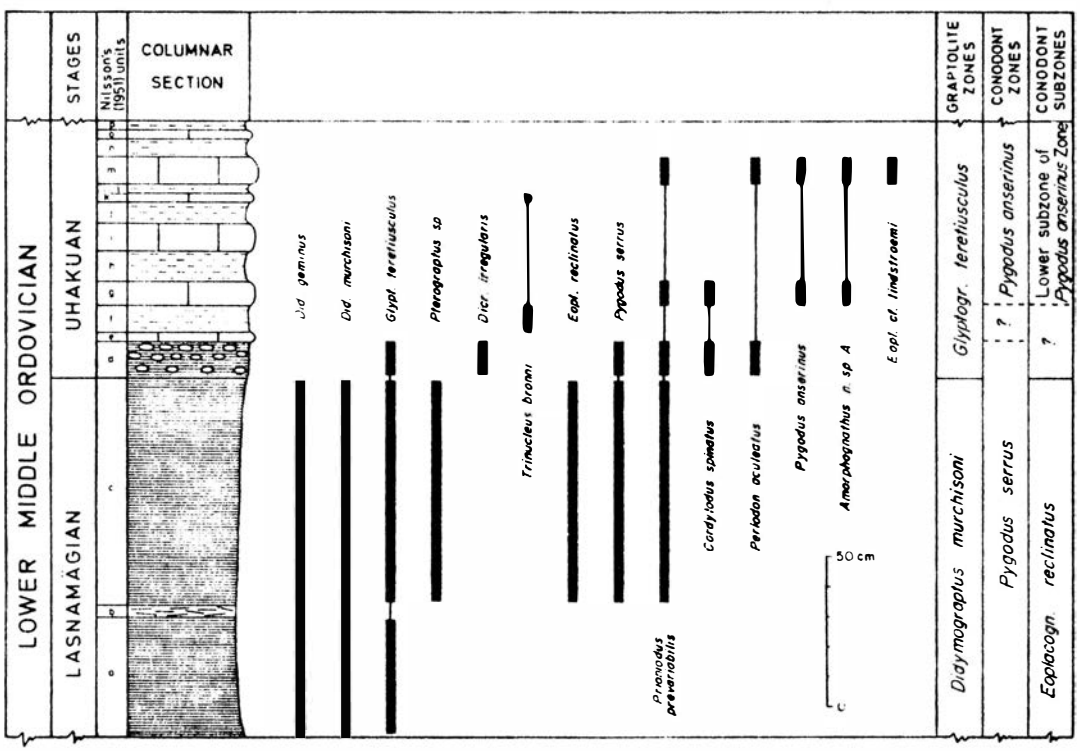

Figure 5. Lithologies, zonation and vertical distribution of selected fossils in the Killeröd section through lower Middle Ordovician strata. Trinucleus bronni stands for Botrioides coscinorhinus (Angelin). (From S.M. Bergström 1973)

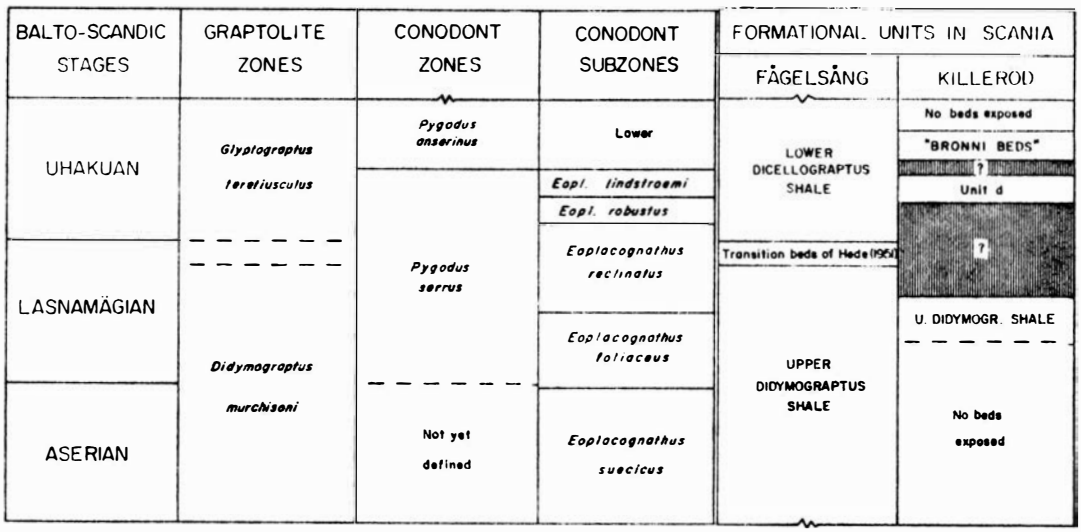

Figure 6. Comparison between lower Middle Ordovician stratigraphy at Killeröd and Fågelsång to illustrate the incomplete and condensed state of the Killeröd sequence. 'Bronni beds' are now recognized as the Killeröd Formation (beds d-p in Fig. 4). (From S.M. Bergström 1973)

2:3 TOMMARP (Fig. 7) On the south side of Jerrestad rivulet, south-

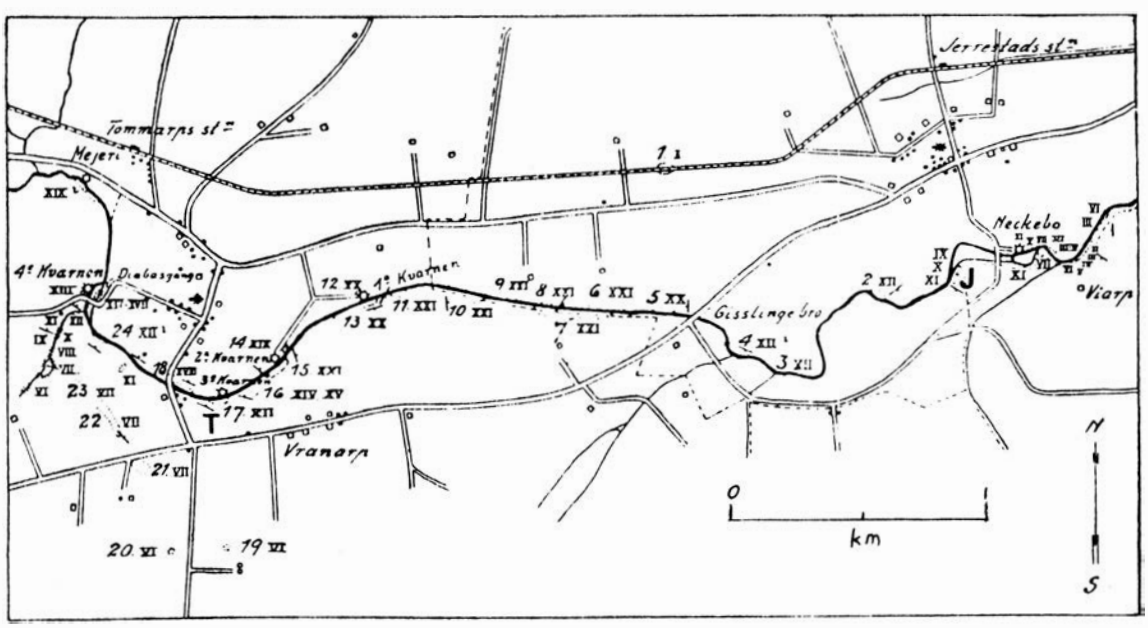

Figure 7. Map of sections along the Tommarpsån stream. T, stop 4 at Tommarp; J, stop 5 at Jerrestad. (From Moberg 1910)

east of Tommarp Church is an exposure of the hard, grey, poorly bedded Tommarp Mudstone (Dalmanitina beds). Fossils are rare but include Dalmanitina olini Temple. A section from a temporary exposure in Tommarp Mudstone west of Tommarp Church was described by Grahn (1978).

2:4 JERRESTAD A small road extending south from the church in Jerrestad ends at a bridge over the Jerrestad rivulet. Over the bridge and about 150 m west along the rivulet is a small section in the upper part of the (middle) Dicellograptus Shale, the Pleurograptus linearis Zone.

3:1 FÅGELSÅNG (Fig. 8) Ordovician graptolite shale is exposed along the Sularp rivulet in the classical Fågelsång area east of Lund. The exposures of the entire area were described in connection with the International Geological Congress in Stockholm 1910 (Moberg 1910). At the mouth of the Fågelsång rivulet is an exposure of Sandby Shale (Upper Didymograptus Shale) yielding graptolites, phyllocarids and inarticulate brachiopods. A few hundred metres further east along the Sularp rivulet are exposures of (lower and middle) Dicello-

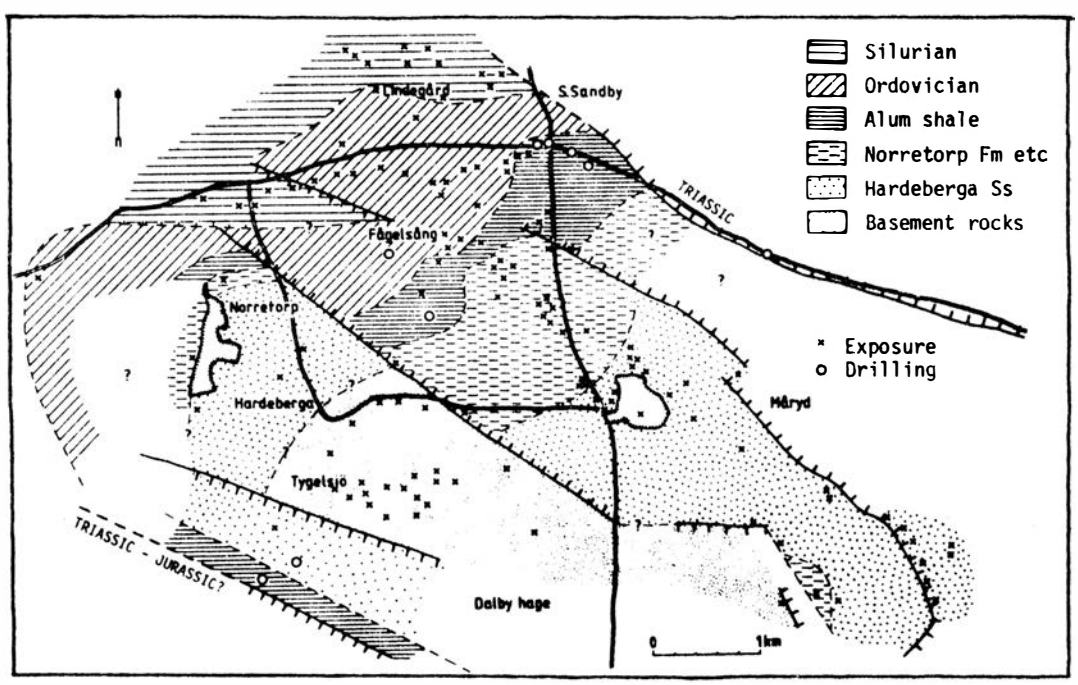

Figure 8. Geology around stop 6 at Fågelsång on the north-west end of Romleåsen Horst.

graptus Shale which yield graptolites and, more rarely, some shelly fossils. The base of the Nemagraptus gracilis Zone is marked by a phosphorite bed. Metabentonites occur, particularly in the Diplograptus multidens Zone.