THE SEQUENCE IN THE AUTOCHTHON OF JÄMTLAND

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LOWER ORDOVICIAN (OELANDIAN)

Latorp Limestone No Tremadoc rocks have been recorded in the autochthonous sequence, and the lowermost Arenig Latorp Limestone rests directly on Upper Cambrian shales. At Kloxåsen (road log, Fig. 3) and Tossåsen the limestone comprises almost the whole Hunnebergian Stage (Tjernvik 1956) whereas in the Flåsjön area, northern Jämtland, the limestone below the Töyen Shale is thin and restricted to the Lower Hunnebergian Zone of Megistaspis (Ekeraspis) armata. In the Flåsjön area the Latorp Limestone, of late Billingenian age and developed as calcilutite with intercalations of grey shale, continues above the Töyen Shale (based on conodont data; Löfgren 1978). This may also be the case in some other areas.

Töyen Shale The shale is developed throughout the autochthonous outcrop area, but varies in vertical extent. The lowermost graptolite zone is the Zone of Tetragraptus phyllograptoides in the Kalkberget section, Flåsjön area, and the Zone of Didymograptus balticus at Skålan in the Åsarna area. In several other sections (Kloxåsen, Tossåsen) the shale seems to begin in the Zone of Phyllograptus densus. At Kalkberget the upper boundary of the shale is within the Billingen Stage, whereas at Kloxåsen the boundary appears to coincide with the base of the Volkhovian Lanna Limestone (Löfgren 1978).

Lanna Limestone In the autochthonous sequence the Lanna Limestone is developed almost everywhere as a uniform sequence of thick-bedded, grey to pale red calcilutites, 8 to 15 m thick. The Zone of Megistaspis (Megistaspis) lata has been proved at the base of the unit. In the Brunflo area the topmost beds of the unit are grey and calcarenitic, and

have yielded Dysplanus acutigenia Jaanusson and other trilobites which indicate the Zone of Megistaspis (Megistaspis) limbata limbata, which corresponds to the East Baltic Zone of Asaphus (Asaphus) lepidurus. Löfgren (1978) described the conodont succession of the Lanna equivalents in several sections; according to the conodont zonation the Lanna Limestone corresponds to the Havsnäs Limestone and the lower part of the Flåsjö Limestone in the Kalkberget sections of the Flåsjö area.

Holen Limestone Over almost the whole autochthonous outcrop area two lithostratigraphical members can be distinguished in the Holen Limestone, a lower member, consisting of grey, nodular limestone with irregular argillaceous intercalations (Flåsjö Limestone in Löfgren 1978) and an upper member, composed of thick bedded calcilutite, grey in the lower part, pale red in the middle and red in the upper part (Järvsand Limestone in Löfgren 1978, definition of the top uncertain). The nodular limestone has yielded a rich fauna of the Zone of Asaphus (Asaphus) expansus. The upper member is less fossiliferous and has not yet been studied in detail except for conodonts (Löfgren 1978). The uppermost beds have yielded Megistaspis (Megistaspidella) gigas in several localities.

MIDDLE ORDOVICIAN (VIRUAN)

Segerstad Limestone The autochthonous basal Middle Ordovician of Jämtland shows many similarities to the contemporaneous strata of the Siljan District. Thus, both subdivisions of the Segerstad Limestone distinguished in the Siljan (i.e. the lower Kårgärde Limestone and the upper Vikarby Limestone) are present in Jämtland (Larsson 1973). The zones of Angelinoceras latum and Illaenus planifrons may also be distinguished. The Kårgärde Limestone cannot be separated lithologically from the underlying Kunda Holen Limestone, but as in the Siljan District, two distinct trilobite faunas characterize the Lower/Middle Ordovician boundary (i.e. Megistaspis (Megistaspidella) gigas at the top of the Holen Limestone, and Asaphus (Neoasaphus) platyurus at the base of the Segerstad Limestone). Commonly these two trilobite species occur accumulated into distinct, narrow bands. In all principal districts of Jämtland, the boundary interval between these two faunas amounts to

about 0.5 m.

The Kårgärde Limestone consists of an intensely reddish-brown calcarenitic calcilutite, while the Vikarby Limestone is mostly composed of variegated, recrystallised calcarenites. Irregular grains of chamosite are characteristic. The boundary between the two members is generally developed as an irregular discontinuity surface showing overhanging portions. The limestone beneath is generally bleached. A local intraformational conglomerate, the Kullstaberg Conglomerate, is developed in the Lockne area. This polymict conglomerate appears in the upper part of the Kårgärde Member and rapidly varies in thickness laterally.

Both members of the Segerstad Limestone exhibit numerous discontinuity surfaces. These appear as irregular haematite-stained surfaces, and are frequently developed as mud crack surfaces. Such surfaces are particularly abundant in the Vikarby Member.

Stromatolites also form a characteristic feature of the Segerstad Limestone (Larsson 1973). These are developed above the discontinuity surfaces with fossil fragments and appear as algal mats or laterally linked domes. The Vikarby Member is particularly rich in stromatolites. Oncolites have recently been proved in the Segerstad Limestone at Högfors, north-east of Östersund.

The Kårgärde Limestone is generally poor in macrofossils, except for some thin accumulations of trilobites and cephalopods. The Vikarby Limestone occasionally shows coquina-like accumulations of trilobites and cephalopods. Many cephalopods of this limestone have been drifted onto the mud cracked surfaces and are arranged along the polygonal pattern of these surfaces.

Skärlöv Limestone The Skärlöv Limestone consists of nodular to finely nodular, reddish-brown calcilutites. The unit is well represented in southern Jämtland, while it is considerably reduced in the Lockne area and totally absent in the Brunflo area (Fig. 1). In the Lockne area, the lower boundary coincides with a discontinuity surface. The Skärlöv Limestone is very poor in macrofossils.

Seby Limestone In the Brunflo area, the lower division of the Seby Limestone is lithologically indistinguishable from the underlying Aserian Vikarby Limestone. The Skärlöv Limestone is not developed in the area, and the Seby and Vikarby Limestone are in direct contact. Thus the Aserian/Lasnamägian boundary can only be defined by means of faunal criteria (Larsson 1973). Illaenus planifrons and Geisonoceras? centrale occur immediately below and Illaenus chiron above the discontinuity surface separating the two units. This surface is partly developed as a mud crack surface with overhanging portions.

The lower division of the Seby Limestone can be defined as a mottled, partly sparitic calcarenite, with mud crack surfaces and stromatolites. This development is found both in the Brunflo and the Lockne area. In the former area, the upper divisions of the Seby Limestone are developed as grey calcarenites with stromatolites, but without the haematite staining typical for the lower division. The higher divisions are also more argillaceous and show fewer discontinuity surfaces. Probably this reflects increased water depth towards the end of the deposition of the Seby Limestone.

In southernmost Jämtland, the Seby Limestone is somewhat differently developed as the lower divisions consist of reddish-brown and mottled fine-grained limestone without stromatolites. In the upper part, reddish-brown, nodular, fine-grained beds and thick-bedded calcarenites with haematite-stained stromatolites dominate.

The Seby Limestone has yielded a rich fauna comparable to the faunas found on Öland and in the Siljan districts. Among the trilobites are Illaenus chiron, Pseudobasilicus? brachyrachis and Pseudoasaphus tecticaudatus. Species of Remopleurides are also common.

Folkeslunda Limestone The most complete development of the Folkeslunda Limestone is found in southern Jämtland, while it is much reduced in the Brunflo area, and probably missing in the Lockne area. This is probably the result of erosional events in Kukrusean time when the higher areas of the Autochthon were severely denuded. Compared to the Siljan district, the Folkeslunda Limestone in Jämtland is much finer grained, and most of the formation consists of grey, calcilutitic

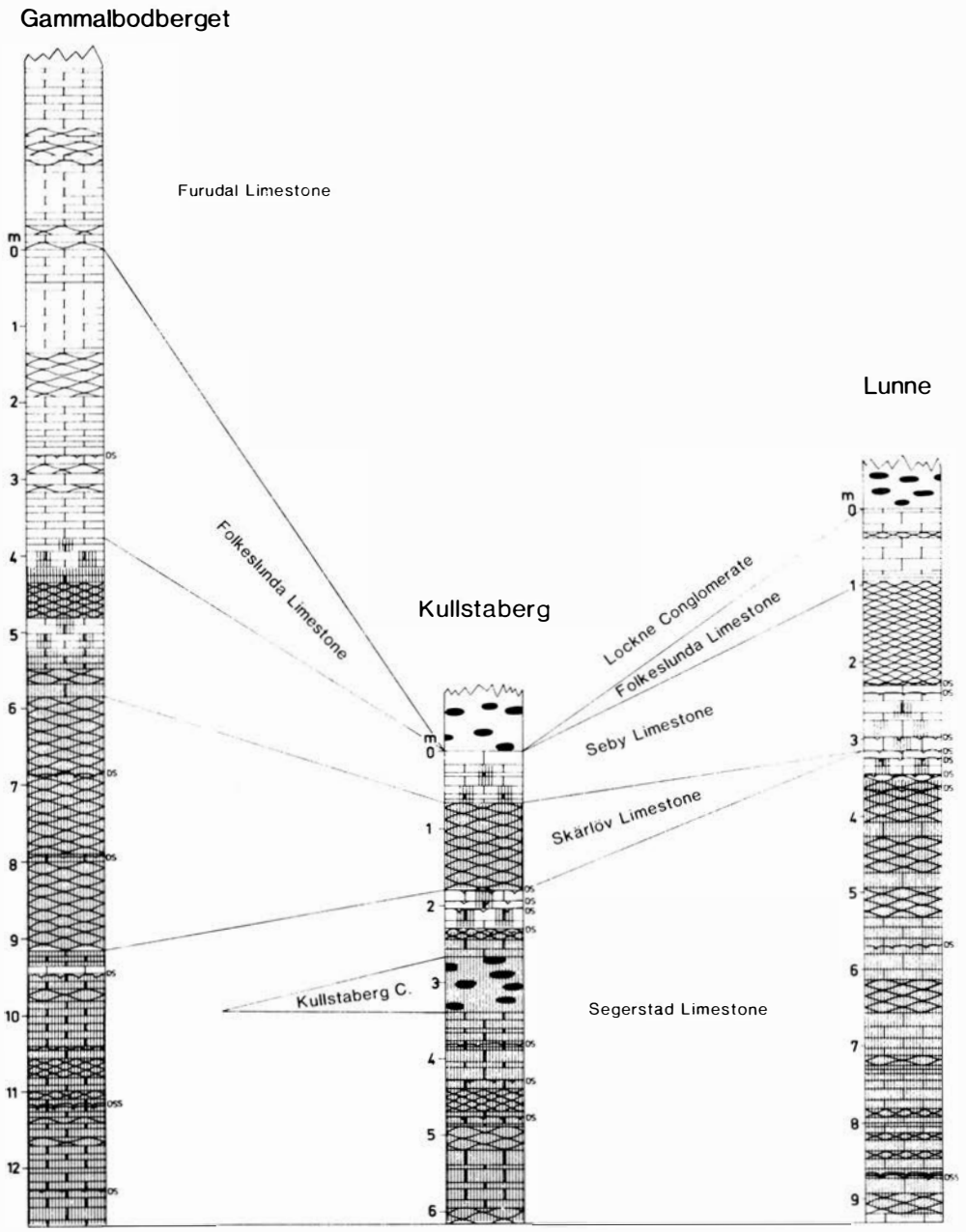

Figure 1. A comparison of the Aserian, Lasnamägian and Uhakuan beds in the Åsarna (Gammalbodberget), Lockne (Kullstaberg) and Brunflo (Lunne) areas (after Larsson 1973).

limestones. The upper limit of the formation is drawn on palaeontological criteria (i.e. where Euprimites effusus disappears) as the lithology is the same as the succeeding Furudal Limestone.

Occasionally some beds are rich in macrofossils, including Illaenus chiron, Pseudomegalaspis patagiata, Plectasaphus plicicostis and Paraceraurus cf. exsul.

Furudal and lower Dalby Limestones In the autochthonous sequence the Furudal and lower Dalby Limestones are preserved only in the Åsarna area in the south-west and the Häggenås area in the north. Between these two areas, erosion prior to the deposition of the Lockne Conglomerate has removed deposits of Uhakuan and Kukrusean age, although in places these may never have been deposited. To the south and north of these areas the Lower Allochthon rests on older autochthonous beds.

In the Åsarna and Häggenås areas the Furudal-lower Dalby limestone are developed as a monotonous sequence of grey, thick-bedded calcilutites, poor in macrofossils. In the Storhallen section of the Åsarna area the Lockne Conglomerate rests on limestones which yield conodonts of the Subzone of Prioniodus gerdae (S. Bergström, pers. comm.). In the uppermost metre Echinosphaerites aurantium is a fairly common macrofossil. In other localities of the Åsarna area (e.g. Gammalbodberget; Fig. 1) the Lockne Conglomerate rests on the Furudal Limestone. At Högfors, Häggenås area, a Furudal-Dalby calcilutite sequence, about 18 m thick, reaches into the middle part of the Dalby Limestone. In this area no Lockne Conglomerate has been observed. The uppermost 2 m of the exposed Dalby Limestone has yielded Echinosphaerites aurantium, Asaphus (Neoasaphus) ludibundus, Illaenus sphaericus and other macrofossils.

Lockne Conglomerate and the upper Dalby Limestone The Lockne Conglomerate at the base of the upper Dalby Limestone is a spectacular unit in the autochthonous sequence. It is a polymict conglomerate of appreciable but variable thickness, in places even containing large boulders derived from the crystalline basement. It is mostly overlain by a thin unit of a distinctive calcareous sandstone, locally termed 'Loftarsten'. The conglomerate can be followed from the northernmost exposures of the Brunflo Bay area in the north to the Åsarna area in the south. It has not been observed in the lower Allochthon as usually defined.

The base of the Lockne conglomerate is at various levels. In the Åsarna area it overlies Dalby beds of the Subzone of Prioniodus gerdae, in the northern part of its distributional area the Folkeslunda Limestone, and in the vicinity of the Lockne high it frequently rests on the Lanna Limestone. In some sections (e.g. Lillå and Hackås) the conglomerate,

with a red, haematitic clay at the base, fills channels up to 2-3 m deep eroded into the Lanna Limestone (L. Karis, unpublished). At Målingen a discontinuous section, 800 m long (stop 2:4), shows the conglomerate to overlie various levels, such as the Lower Ordovician Latorp Limestone, Middle and Upper Cambrian shales, and locally (no longer exposed) even weathered crystalline basement. In the Tandsbyn area, the central area of the Lockne high, it rests on crystalline basement; the geology of this area in general, and the Lockne conglomerate in particular, has been described in detail by Thorslund (1940). The distribution of the conglomerate was clearly associated with the Lockne high which formed an emergent area during the early Middle Ordovician.

The limestone beds above the conglomerate commonly yield conodonts of the Subzone of Prioniodus gerdae (S. Bergström, pers. comm.), indicating that the Lockne conglomerate was of approximately the same age over the whole of its distributional area.

The upper Dalby beds tend to be developed as a high calcium limestone immediately above the conglomerate. Higher up these beds consist mostly of grey, nodular, argillaceous limestone with intercalations of mudstone. The appearance of this rock is similar to that of approximately contemporaneous beds in the Oslo district. The lower metre of the upper Dalby beds is normally very rich in fossils, including Asaphus (Neoasaphus) ludibundus Törnquist, Cnemidopyge costata (Boeck), and Echinosphaerites aurantium (Gyllenhaal).

The Örå Shale In the autochthonous sequence the development of the Örå Shale (Upper Chasmops Beds in Thorslund 1940) is similar to that in the Lower Allochthon except that limestone beds are more numerous; in some sections (e.g. at the Slandrom rivulet) dark limestone is the dominant rock type at least in the upper part of the formation. The boundary between the Dalby and Örå beds is poorly exposed but appears to be transitional. The shelly fossils obtained from the autochthonous Örå beds are almost exclusively from the upper part of the formation and include Toxochasmops extensa (Boeck) and Tretaspis ceriodes (Angelin).

UPPER ORDOVICIAN (HARJUAN)

Slandrom Limestone This formation, about 5 m thick at its type locality, the Slandrom rivulet, consists of a hard, dark, very fine grained, finely nodular limestone, and some bedded limestone intercalated with thin layers of black shale. In the autochthonous sequence the formation also occurs in the central Lockne area where it forms the top of the preserved sequence. The limestone is poorly fossiliferous. Tretaspis seticornis has been recorded from the upper part.

Fjäcka Shale The youngest beds preserved in the autochthonous sequence, in the area around Slandrom, belong to the Fjäcka Shale, developed as black shale with beds or lenses of black limestone. The shale has at best been poorly exposed and at present is scarcely accessible. A few identifiable graptolites found indicate the Zone of Pleurograptus linearis.