JÄMTLAND ROAD-LOG

Lars Karis and Kent Larsson

2:4 MÅLINGEN (Loc. 1, Fig. 1) Outcrops along minor road about 1 km ESE of the Näcksta farms, 2.5 km east of Hackås. Topographical map sheet 18 E, Hackås NO 697970/143675.



Figure 1. Simplified geological map of central Jämtland based on one of the areas currently being prepared by the Geological Survey of Sweden. The boundary between the Autochthon and Lower Allochthon is not indicated.

At locality (a) on Fig. 2 (redrawn with minor modifications from Thorslund 1940, p. 63, Fig. 37), on the north side of the road, grey-green and dark Middle Cambrian shales with occasional limestone lenses are overlain by bituminous limestones and black shales with an upper Middle Cambrian (<u>Paradoxides forchhammeri</u> Stage) and Upper Cambrian (<u>Agnostus pisiformis</u>, <u>Olenus</u> and <u>Parabolina spinulosa</u> zones) fauna. Lower Ordovician limestones overlie the <u>P. spinulosa</u> Zone stinkstones. Following the section about 20 m to the south-east along the road, these limestones are downfolded into the Middle Cambrian shales. The hinge of the syncline in the limestones is well exposed with a fold axis N 20^o E, a steep west limb, a flat east limb and development of a prominent cleavage.

About 50 m south-east along the road, the P. spinulosa Zone is overlain by Lower Ordovician bedded limestones and Middle Ordovician limestone-pebble conglomerates. At locality (b) of Fig. 2, the irregular surface of the granitic Precambrian basement is exposed. The palaeorelief appears to have been in the order of 15-20 m in the Målingen area, with Cambrian shales filling the deeper pockets in the basement and Ordovician limestones, conglomerates and mudstones being deposited on the higher parts. Locally, on the east side of the road (east of Högtjärn), marly shales and limestones equivalent to the Dalby Limestone were deposited directly on the weathered granitic basement. These relationships are interpreted as indicating the existence of an archipelago in the Målingen area from the Middle Cambrian to the Late Ordovician which caused extensive deposition and reworking of the Ordovician strata. On the road to locality (c) of Fig. 2 are a number of small exposures of Cambrian shales and stinkstones ranging in age into the P. spinulosa Zone.

At locality (c) along the north shore of Målingen, dark Cambrian shales are overlain by Lockne conglomerates. Clasts in the latter are usually composed of Lower Ordovician limestones; they decrease in size upwards and pass into the so-called 'Loftarstone' within the Lockne formation (Thorslund 1940), a fine to medium-grained calcareous sandstone derived from the Lower Ordovician limestones and underlying granitic basement.







Figure 2. Geology of the area around Målingen. From Gee & Kumpulainen 1980.

2:5 KLOXÅSEN (Loc. 3, Fig. 1) Exposures along the road at the Kloxåsen farm. Topographical map sheet 18 E Hackås NO 698430/144445.



Figure 3. Section through the Lower Ordovician at Kolxåsen (after Tjernvik 1956). Road section through Middle and Upper Cambrian shales overlain by Lower Ordovician Latorp Limestone and Töyen Shale. The stratigraphy of the Ordovician rocks occur in NW-SE trending synclines which plunge at about 5⁰ to the northwest. The area is situated on the south-western slope of the Lockne basement high.

In addition to the index species, the Zone of Megistaspis (Varvaspis) planilimbata has yielded Megalaspides (Lannacus) nericiensis Wiman, Promegalaspides (Borogothus) stenorhachis (Angelin), Niobella bohlini Tjernvik, Cyclopyge gallica Tjernvik and other trilobites (Tjernvik 1956).

2:6 TAND (Loc. 2, Fig. 1) Road cuts on the north side of the mainroad (81), about 11 km south of Brunflo. Topographical map sheet 18 E Hackås SO 698910/144355.

The Precambrian basement surface in the Lockne area is approximately 70 m higher than the peneplain to the south-west and north-east. Various Ordovician sediments were deposited on this basement high and the conglomeratic facies contains clasts of most of the underlying units, including basement lihtologies, Cambrian shales and stinkstones, and Lower and Middle Ordovician limestones.

The Tand locality comprises two sections 200 m apart. These two sections demonstrate the upper Kundan—lower Aserien sequence and the type of deformation commonly found at the transition zone between the Autochthon and Lower Allochthon.

The westernmost road-cut exposes steeply dipping beds of reddishbrown Holen and Segerstad Limestones. The exact level of the Lower—Middle Ordovician boundary is not determined, but it may be assumed to occur within a 1.33 m thick limestone sequence between the last occurrence of the Kundan Megistaspis (Megistaspidella) gigas and the earliest Aserian Asaphus (Neoasaphus) platyurus. The Segerstad Limestone consists of reddish-brown, bedded and nodular, fine-grained limestone with occasional coarsegrained limestone beds. Some haematite-stained discontinuity surfaces are developed. The top of the sequence consists of a polymict conglomerate, the Kullstaberg Conglomerate. This unit forms a significant intraformational horizon in many parts of the Lockne area. The pebbles consists of red and grey Lower/Middle Ordovician limestones and Precambrian granite, all in a reddishbrown, calcareous matrix. The exposed Aserian sequence measures about 4 m in thickness.

The second, easternmost road-cut demonstrates beds of Skärlöv, Seby and Dalby ages. The eastern half of the section comprises a slightly overturned sequence which is overthrust onto a brecciated granite. The oldest unit in this part of the section is a reddish-brown nodular limestone with grey intercalations. This unit may be comparable to the Skärlöv Limestone. The contact between this unit and the beds immediately west of it occurs in badly dislocated strata. The top of the Skärlöv Limestone is concordant with a dark grey, coarse-grained, fossiliferous limestone with haematite-stained stromatolites. The rich trilobite fauna, including Illaenus chiron, Pseudomegalaspis patagiata, Pseudobasilicus? brachyrachis, combined with the lithological properties, indicate a Seby age of this unit. It is succeeded by a thin, grey limestone and 0.5 m of nodular, reddish-brown, finegrained limestone. Their stratigraphical position is uncertain, but they can probably also be referred to the Seby Limestone. The uppermost (eastern) part of the inverted sequence consists of a polymict conglomerate containing pebbles of reddish-brown and grey limestone and granite. The pebble size increases upwards. This unit can be referred to the Lockne Conglomerate.

The western part of the section exhibits a grey, dense limestone

comprising the eastern limb of a small N-S anticline. Overlying this limestone is a strongly polymict conglomerate which partly seems to cut into the limestone. This conglomerate contains pebbles and boulders of grey limestone, alum shale, granite and dolerite. The largest boulder observed is 24 x 15 cm in crosssection. The matrix of the conglomerate is grey and calcareous. No fossils indicating the age of the described westernmost part of the road-cut have, so far, been found, but the strata may be assumed to belong to the Dalby Beds.

3:1 BRUNFLO (Loc. 4, Fig. 1) Section along the main road E 75 in the north-western part of Brunflo. Topographical map sheet 18 E Hackås NO 699793/144980.

This is the only section through a lower part of the Holen Limestone easily accessible at present. The very locally flat-lying grey nodular calcilutite with subordinate bedded units represent an interval 1.8-c. 6 m above the Lanna/Holen boundary, previously exposed in additional sections towards the east. The exposed interval belongs to the basal part of the Zone of <u>Asaphus</u> (<u>Asaphus</u>) expansus and the overlying Zone of A. (A.) 'raniceps'.

The fauna at the base of the section is dominated by trilobites including <u>Asaphus</u> (<u>A.</u>) <u>expansus</u> and closely related species, <u>Ptychopyge augustifrons</u>, <u>Niobella</u> sp. and ostracodes such as <u>Glossomorphites</u>, <u>Aulacopsis</u> and <u>Conchoprimitia</u>. The Zone of <u>A</u>. (<u>A</u>.) '<u>raniceps</u>' contains trilobites, cephalopods, brachiopods, bryozoans and ostracodes.

3:2 LUNNE (Loc. 5, Fig. 1) Quarry on the hill-top Lundbomberget, about 2 km north-east of Brunflo church. Topographical map sheet 18 F Bräcke NV 699700/145320.

This abandoned quarry cut in slightly undulating Ordovician strata exposes a section from the uppermost Kundan, through the Aserian Segerstad Limestone, Lasnamägian Seby and Folkeslunda Limestones and is terminated by the polymict Lockne Conglomerate of upper Dalby age. Most of the Folkeslunda Limestone and the conglomerate are accessible in a narrow trench. Immediately above, on the top of the hill, some small exposures of the Dalbyan 'Loftastone' sandstone have been observed previously. Nowadays only loose boulders can be seen. The exposed sequence demonstrates clearly the weak folding and overthrusting which may be seen in this part of the Autochthon. Some small overthrusts are visible on one of the walls in the middle of the quarry. Many bedding planes also show slickensides which indicate W-NW tectonic direction.



Figure 4. Section of the upper Segerstad and Seby Limestones in the Lunne section to show the distribution of stromatolitic algal mats (from Larsson 1973).

Description of the section (from the top downwards) (see also F	⁻ig. 4	1;
Jaanusson, Larsson & Karis, Fig. 1)		
Lockne Conglomerate 2.0 m + Polymict conglomerate with pebbles of Lower/Middle Ordo- vician limestone and Precambrian granite. The size and sphaerocity of the pebbles increase upwards. The matrix is dark grey and calcareous	2.0	m
Folkeslunda Limestone 0.99 m Grev to dark grev, fine-grained limestone	0.99	m

Seby Limestone 2.22 m (c) Finely nodular, fine-grained, variegated pale reddish-brown to reddish-grey limestone 1.36 m (b) Grey, thick-bedded, coarse-grained limestone with stromatolites. Two dessiccation surfaces occur, 5 and 20 cm from the top. The top is a smooth discontinuity surface 0.20 m (a) Grey to brownish-grey, thick-bedded, coarsegrained limestone with numerous stromatolites strongly stained with haematite. Numerous dessication surfaces occur. The lower boundary is formed by Macrofauna of (b) and (a): Illaenus chiron, Pseudobasilicus? brachyrachis, Pseudomegalaspis sp., Pseudo-asaphus tecticaudatus, Plectasaphus plicicostis, Asaphus (Neoasaphus) sp., Remopleurides sp., Lituites sp., 'Conorthoceras' conicum, Ancistroceras sp. Segerstad Limestone 6.12 m Vikarby Limestone. Grey and red mottled, coarse-grained limestone, rich in haematite-stained stromatolites. The uppermost surface is irregular with overhanging portions. Parts of the surface show dessication polygons with cephalopods arranged along the cracks. The lower boundary is very rough and irregular. It is covered by a stromatolitic algal mat stained by haematite. Illaenus planifrons, Remopleurides sp., Geisonoceras? centrale, Cameroceras sp., Dorsolinevites dispar. 0.30 m Kårgärde Limestone. Alternating beds of reddish-brown, fine-grained, bedded and nodular limestone. The uppermost bedding surface is rough and irregular with overhanging portions. Irregular, haematite-stained discontinuity surfaces occur 2.30, 5.28 and 5.30 m below The two lowermost surfaces are covered by the top. small stromatolitic domes, intensely haematite The lowermost boundary of the Segerstad stained. Limestone is placed immediately above the last find of Megistaspis (M.) gigas. Asaphus (Neoasaphus) platyurus, Remopleurides sp., Angelinoceras latum, 'Orthoceras' nilssoni 5.82 m Holen Limestone 0.8 m +

3:3 ÖRÅN (Loc. 6, Fig. 1) Section along the western side of the stream Örån, approximately 100 m south of the bridge on the Storhögen road. Topographical map sheet 19 F Häggenås NV 703003/ 146255.

Scattered outcrops of the same units as those exposed in the main section occur in the vicinity clearly indicating a continuous

isoclinal (shales) open (massive limestone) fold system approximately parallel to the stream. The sequence here is generally younging eastwards. In the partly excavated section three formations are exposed, in ascending order the Örå Shale, Slandrom Limestone and Kogsta Siltstone. There is a general dip of strata towards the south-west and the Örå Shale occupies the larger part of the section.

The Örå Shale has an estimated thickness of 9 m, of which approximately 6 m is exposed in this section. This unit, or parts of it, is repeated several times in the slope, and twice in the exposed section. The upper boundary is obliterated by a thrusted fold axis. The Örå Shale is here very fossiliferous throughout. There is a strong domination of graptolites and inarticulate brachiopods in the lower part but a mixture of graptolites and trilobites (Triarthrus) in the upper 2 m of the unit.

The most common graptolites are <u>Dicranograptus clingani</u>, <u>Amplexo-graptus vasae</u>, <u>Corynoides sp.</u>, <u>Amplexograptus cf. pulchellus</u>, <u>Climagraptus cf. brevis</u>, <u>Neurograptus margaritatus</u>, <u>Orthograptus</u> sp. and <u>Climacograptus bicornis</u>. The most common trilobites are <u>Triarthrus linnarssoni and Triarthrus skutensis</u>. It should also be noted that four very thin metabentonites occur in the lower part of the Örå Shale.

Above the disturbed contact there follows a very thin (less than 10 cm) strongly compressed black shale and the Slandrom Limestone. The Örån section is one of the best exposures of this unit. The basal part is nodular calcilutite, 0.6 m thick, with argillaceous intercalations followed by bedded calcilutites with shaly interbeds and a grey, finely nodular calcilutite. The uppermost metre of the unit is again a bedded calcilutite. Very few fossils have been found in this formation although <u>Tretaspis</u> cf. <u>seticornis</u> has been recorded from the uppermost part.

The contact with the overlying poorly exposed Kogsta Siltstone is sharp and is probably tectonic. No fossils have been found in this unit at this locality. 3:4 HÖGFORS (Loc. 7, Fig. 1) River exposures about 3 km southeast of Häggenås church. Topographical map sheet 19 F Häggenås NV 70295/14542.

Large exposures of flat-lying and folded autochthonous Lower and Middle Ordovician limestones occur around the River Hårkan below the dam at Högfors. The river has cut down several metres into the limestone.

The limestones are mainly grey, but some reddish tints are present in the lower Segerstad and upper Kundan Limestone. Most beds are calcilutitic. The macrofauna is very sparse and so far only one specimen of <u>Asaphus (Neoasaphus) platyurus</u> has been found, indicating the presence of the Segerstad Limestone. Of special interest is the presence of oncolites. These attain a diameter up to 6 cm and are formed around small limestone fragments and are strongly stained with haematite. Some beds are almost completely composed of the oncolites. At the bottom of the oncolite-bearing horizon some stromatolitic algal mats have been observed. One deeply corroded discontinuity surface forms the top of the basal oncolitebearing bed.

South of the visited exposure, dislocated beds of Dalby Limestone and Middle-Upper Cambrian shales occur. The latter are overthrust onto the limestones.

3:5 RANNASEN (Loc. 8, Fig. 1) Quarry, about 3.5 km NE of Östersund. Topographical map sheet 19 E Östersund NO 701020/144425.

This operational quarry is cut in a folded and faulted sequence, composed predominantly of quartzites, dark shales and mudstones which belong to the Kyrkås Formation of Ashgill and possibly of early Silurian age. The exposed sequence is about 35 m thick. The lower part of the sequence includes two prominent dark mudstone units, 1.30 m and 3.30 m, separated by two beds, 0.75 and 0.17 m thick, of a lighter calcareous siltstone. The upper half of the quarried sequence is composed of massive quartzite and alternating beds of dark shale and quartzite. The Kyrkås Formation shows a variety of sedimentary structures characteristic of shallow water environments. The lower mudstone contains bedding surfaces with mudcracks, ripple marks and load casts. A thin conglomeratic horizon occurs within this mudstone with pebbles of quartz and granite. This bed is no longer exposed. The quartzites are commonly cross-bedded.

The lower mudstone unit has yielded Hirnantian fossils, including the trilobites <u>Dalmanitina</u> (<u>Mucronaspis</u>) <u>mucronata</u> and <u>Brongniartella platynota</u>, <u>Leptaenopoma trifidium</u> and other brachiopods, lamellibranchs, cephalopods and hyolithids. The upper mudstone has yielded <u>Climacograptus</u>, which were previously thought to be of early Silurian age (Thorslund in Thorslund & Jaanusson 1960). Current studies on these graptolites show that the age relationship of the upper Kyrkås Beds remains open.

3:6 LUGNVIK (Loc. 9, Fig. 1) Exposures at the railway, about 2 km north of central Östersund. Topographical map sheet 19 E Östersund SO 701057/144156.

In this area, north of Östersund, a new traffic system (road and railway) was constructed from 1976 to 1978, giving excellent exposures of the bedrock over large areas. In the remaining section on the railway the uppermost Andersö Shale and the Örå Shale are exposed in a gently folded sequence. The temporary sections exposed an almost complete sequence from the Isö Limestone (southwest Lugnvik) to the Öglunda Limestone (north-west Lugnvik) in a distance of approximately 1 km.

The two units in the visited section are very similar in lithology, although the Örå Shale is richer in minor silts and carbonates. The boundary between these two units has been placed at the base of the thickest metabentonite occurring in this section. Thus the Andersö Shale has a wider stratigraphic range here than on the islands of Frösön, Andersön and Norderön, where a limestone unit (Dalby equivalent) separates the two.

The beds below the metabentonite are at present poorly exposed and strongly compressed. In the Örå Shale, however, very fossiliferous

beds occur and contain the same fauna as in the Örån section but with additional elements including hyolithids, inarticulate brachiopods (common in some beds) and sponge spicules.

The Slandrom Limestone is completely absent here; in sections towards the north-west the shaly siltstone sequence continues into the Zone of Pleurograptus linearis within the Kogsta Siltstone.

4:1 EDE (Loc. 10, Fig. 1) Exposures on the south-eastern side of a small hill, about 1 km south-east of Offerdal church. Topographical map sheet 19 E Östersund NV 704020/141115.

This is the type locality for the Ede Quartzite (Thorslund in Thorslund & Jaanusson 1960). The quartzite is well exposed towards the top of the hill which is capped by the Silurian Berge Limestone. The dark Ashgill Kogsta Siltstone underlies the quartzite. The sequence dips gently north-west and is folded and cleaved. It is thought to be thrust over the Berge Limestone which is exposed at the road along the eastern base of the hill (Thorslund in Thorslund & Jaanusson 1960).

The Ede Quartzite is composed of 2-3 m of bluish-grey and white quartzites which pass upwards into calcareous sandstones with thin shales. The latter in turn pass gradationally into the Berge Limestone which contains a Lower Llandovery fauna. The crossbedded and ripple-bedded Ede Quartzite contains corals and brachiopods in the calcareous upper part but has not as yet yielded a diagnostic fauna. Transitional relationships with the Berge Limestone suggest an early Llandovery age.

The dark shales and mudstones of the Kogsta Siltstone underlying the Ede Quartzite contain thin sandy beds and laminations in the uppermost part. A number of pale grey, thin laminations are composed of talus from porphyritic rocks. The contact between the Kogsta Siltstone and the Ede Quartzite is sharp and the latter concordantly overlies the shales. A Hirnantian fauna occurs 1-6 m below this contact with, mostly decalcified, brachiopods, trilobites and crinoid ossicles. 4:2 MÖRSIL (Loc. 11, Fig. 1) Roadsection on E 75, about 4 km east of Mörsil. Topographical map sheet 19 D Are SO 702430/149590.

This exposure shows a typical development of the Lower to Middle Ordovician turbidites of the Föllinge Formation, each cycle consisting of 8-40 cm coarse silt and sand grading in to 2-10 cm fine silt and clay (shale). It also demonstrates the style of deformation in this unit, with gentle N 20^o W plunging folds. In general the beds young north-eastwards.

Rare pendant didymograptids in the eastern part of the section indicate a stratigraphic interval of the <u>Didymograptus bifidus</u>— <u>D. murchisoni</u> zones.